PROCEEDINGS

OF THE

FIFTY-SECOND ANNUAL CONVENTION

OF THE

American Railway Engineering Association

HELD AT THE

PALMER HOUSE, CHICAGO, ILLINOIS

March 17, 18 and 19, 1953

VOLUME 54

59 East Van Buren Street
Chicago, 5, Illinois

BOARD OF DIRECTION

President

C. J. Geyer, Vice President, Construction and Maintenance, The Chesapeake & Ohio Railway, Huntington 1, W. Va.

Vice Presidents

C. G. Grove, Chief Engineer, Western Region, Pennsylvania Railroad, Chicago 6.

G. W. Miller, Engineer Maintenance of Way, Canadian Pacific Railway, Toronto 1, Ont.

Past Presidents

H. S. Loeffler, Assistant Chief Engineer, Great Northern Railway, St. Paul 1, Minn.

T. A. Blair, Chief Engineer System, Atchison, Topeka & Santa Fe Railway, Chicago 4

Directors

R. P. Hart, Chief Operating Officer, Missouri Pacific Lines, St. Louis 3, Mo.

Clark Hungerford, President, St. Louis–San Francisco Railway, St. Louis 1, Mo.

W. J. Hedley, Assistant Chief Engineer, Wabash Railroad, St. Louis 1, Mo.

G. M. O'Rourke, Assistant Engineer Maintenance of Way, Illinois Central Railroad, Chicago 5.

W. C. Perkins, Chief Engineer, Union Pacific Railroad, Omaha 2, Neb.

R. J. Gammie, Chief Engineer, Texas & Pacific Railway, Dallas 2, Tex.

L. L. Adams, Chief Engineer, Louisville & Nashville Railroad, Louisville 1, Ky.

A. N. Laird, Chief Engineer, Grand Trunk Western Railroad, Detroit 26, Mich.

M. H. Dick, Editor, Railway Engineering and Maintenance, Chicago 3, Ill.

E. E. Mayo, Chief Engineer, Southern Pacific Company, San Francisco 5, Cal.

S. R. Hursh, Assistant Chief Engineer—Maintenance, Pennsylvania Railroad, Philadelphia 4, Pa.

Ray McBrian, Engineer of Standards and Research, Denver & Rio Grande Western Railroad, Denver 1, Colo.

Treasurer

A. B. Hillman, Chief Engineer, Belt Railway of Chicago; Chicago & Western Indiana Railroad, Chicago 5.

Secretary

Neal D. Howard, 59 E. Van Buren Street, Chicago 5.

Assistant Secretary

E. G. Gehrke, 59 East Van Buren Sreet, Chicago 5.

NUMERICAL INDEX TO COMMITTEE REPORTS

TABLE OF CONTENTS

PROCEEDINGS

MEMOIRS

Advance Report of

Committee 15—Iron and Steel Structures
American Railway Engineering Association

Rigid Frame Analysis for Members of Variable Moment of Inertia, Directed Especially Towards Floorbeam Hanger Frames and Counterweight Trusses—Analytical and Experimental Studies

CONTENTS

Advance Report of

Committee 15—Iron and Steel Structures

Assignment 4

Stress Distribution in Bridge Frames

(a) Floorbeam Hangers

(b) Counterweight Trusses of Bascule Bridges

Rigid Frame Analysis for Members of Variable Moment of Inertia, Directed Especially Towards Floorbeam Hanger Frames and Counterweight Trusses—Analytical and Experimental Studies

FOREWORD

The research project on stresses in bridge frames consists of the investigation of the causes and remedies for the fatigue failures in floorbeam hangers in railway bridges and in the counterweight trusses of heel-trunnion bascule bridges. It is being conducted at the Purdue University Engineering Experiment Station under the direction of L. T. Wyly, research professor of structural engineering and head of department. Administration is by Dr. A. A. Potter, director of the Engineering Experiment Station and dean of engineering, and by Professor R. B. Wiley, head of the School of Civil Engineering and Engineering Mechanics. The program is sponsored financially by the Association of American Railroads. It was initiated upon the recommendation of AREA Committee 15—Iron and Steel Structures, and is supervised by the Subcommittee on Stress Distribution in Bridge Frames.* This is a cooperative project, and the research staff of the Association of American Railroads, under the general direction of G. M. Magee, research engineer, and E. J. Ruble, structural engineer, assists in and advises regarding the work.

DIGEST

This report, consisting of five parts, presents a general method of analysis of rigid frames composed of members having a variable section, developed during the progress of the work on the AAR Floorbeam Hanger Investigation being conducted by Purdue University with the assistance of the AAR research office and under the direction of AREA Committee 15. The method is directed especially towards frames composed of floorbeams and their hangers, and towards the counterweight trusses of bascule bridges, but it is applicable to any type of rigid frame or truss, whether of steel or concrete or other structural material. The report also presents the results of laboratory studies on bridge frame models by the Purdue University staff, and of field studies on the counterweight trusses of heel-trunnion bascule bridges by the AAR research staff.

* Subcommittee: C. H. Sandberg (chairman), J. F. Marsh, J. E. Bernhardt, E. S. Birkenwald, J. C. Bridgefarmer, F. M. Masters, N. M. Newmark, G. L. Staley, C. Earl Webb, L. T. Wyly.

The measurements obtained in the field investigations of stress distribution in floorbeam hangers in the railway bridges of the Illinois Central Railway at Galena, Ill., in 1947, of the Missouri–Kansas–Texas Railway at Erie, Kans., in 1948 and 1950, and the Santa Fe Railway at Ponca City, Okla., in 1949, have all made plain that a satisfactory method of analysis must take into account such factors as variation of the section of the member, width of member, the influence of brackets and gussets, and the effect of shear distortion on the bending in the member.[1, 2]

Starting in 1949, laboratory studies on scale model frames representing floorbeams and hangers having the above features have been under way at Purdue in connection with this project. As a result of these field and laboratory studies a general method of analysis has been developed which is believed to be satisfactory in results and which is quick and easy in application. This method is presented in Parts 1 to 4, incl., of this report. It is shown in Parts 2, 3, and 4 that the stresses computed by this method agree with the measured stresses in floorbeam hanger frames and counterweight trusses.

Part 1

Part 1 defines the problem and presents in detailed outline form the equivalent gusset method of rigid frame analysis. This part also gives simple examples showing detailed analyses of bending in a floorbeam hanger frame and of secondary stresses in a simple truss. The appendix to this part gives the derivation of the basic equations and integrals and graphs to facilitate the computations of slope deflection constants.

Part 2

Part 2 applies the method of analysis of a rigid frame to the calculation of the primary and secondary stresses in the counterweight trusses of the Illinois Central Railway heel-trunnion bascule bridge over the South Branch of the Chicago River at Chicago, Ill., the largest bridge of this type ever built. Comparison is made of calculated stresses with the stresses in this structure measured by the AAR research staff, and a close agreement is found between the two. This analysis shows that the range of stress at the critical sections of this bridge is about 31,000 psi on the gross section, varying from about 1000 psi in tension in the closed position to 32,000 psi in tension in the open position on the lower side of truss member 32–36.

Part 2 also reports on fatigue tests in the laboratory on single-lap joints connected by bolts in full bearing and without clamping. The results, summarized in the S–N curve of Fig. 23, show much lower fatigue strength than has heretofore been reported for double-lap joints. Since the connections of the members to gussets at the critical points of the heel-trunnion bascule counterweight trusses are usually single-lap joints, it is likely that the results of Fig. 23 would apply in case of rivets with low clamping force, or none at all.

Part 3

Part 3 presents the results of a comprehensive experimental study of bending stresses in small laboratory models of floorbeam hanger frames, together with an analytical treatment. Evidence is given showing that rotation of the ends of a truss member due to shearing deformation of the web inside the truss joint may seriously increase the bending stresses in the member, in extreme cases as much as 100 percent. This rotation is labeled

[1] A Study of the Behavior of Floorbeam Hangers. Static and Dynamic Stress Measurements on the Illinois Central Railroad Bridge at Galena, Ill. AREA Proceedings 1950, Vol. 51, p. 51.

[2] A Further Study of the Behavior of Floorbeam Hangers. Static Stress Measurements on the A.T. & S.F. Railway Bridge near Ponca City, Okla., AREA Bulletin 495, June-July 1951.

"shear slope" here. When the effects of this shear slope are added to the bending stresses computed by the equivalent gusset method, practically perfect agreement is found with measured stresses.

Evidence of the existence of and effect of this shear slope was first discovered by Wyly, Scott, and Cox in their test of the MKT railway bridge at Erie, Kan., in 1948. Since its effect is of considerable quantitative significance, Mr. Cox has studied it in some detail.

To study the behavior of floorbeam and hanger frames independent of their interaction with other bridge members, a series of model frames was constructed and tested under controlled laboratory conditions at Purdue University. The tested models have members similar in cross section to members of the prototype frames, and the model floorbeam and hangers are connected in the conventional manner. The model hangers are of a wide-flange, thin-web section. Tests on these frames led to the testing of three supplementary specimens, each designed to isolate one of the variables contributing to hanger bending stress in the model frames.

The purposes of this paper are three-fold; they are:

1. To describe the design and testing of the model frames and supplementary specimens.
2. To give the results of tests on these model frames and specimens.
3. To develop a procedure for analysis which accounts, in all cases, for the measured stresses.

All strain measurements were made using SR–4 resistance gages.

"Stresscoat" brittle lacquer was used in some instances to show the direction of principal planes. Slopes were measured by using a mirror and reflected scale image arrangement.

The data secured from these tests were analyzed to determine the action of floorbeam hanger frames with respect to (a) how the load is transferred from the floorbeam to the hanger, and (b) bending stress caused in the hanger.

A brief summary of results from analysis of the test data is as follows:

1. Floorbeam hanger bending depends upon two major factors:
   - (a) Rigid frame action between floorbeam and hangers. (See Fig. 39, Steps I, II, IIa).
   - (b) Additional rotation of the lower end of the hanger due to shear deformation in the hanger web opposite the floorbeam connection. This effect from shear slope is shown in Fig. 28.
2. Shear slope occurs in a thin web structural member when its load is delivered through a connection to one flange only. The length of this connection has a direct bearing on the magnitude of the shear slope. (See Fig. 28).
3. Shear slope can be computed and included with a rigid frame analysis. This is done in Figs. 36 and 37.
4. In all the frames tested, measured hanger bending stress greatly exceeded the computed value based on rigid frame action alone. Two frames showed measured stress 100 percent greater than the computed value, this excess being caused by shear slope.
5. Bending will be induced in a tension member when a short length of one flange is restrained by a gusset or reinforcement, such as occurs when connecting a transverse member. Such bending is shown in Fig. 13, where the intermediate

floorbeam connection upsets the hanger stress. The effect is shown independent of frame action in Fig. 17.

Part 4

Part 4 is a report on a laboratory test made on a scale model of a bridge hanger crossframe. The model is a monolithic frame cut from a solid block of 24 ST aluminum. (See Fig. 2). The frame represents a boundary case of the foregoing study of the effect of shear slope on bending stresses in a floorbeam hanger frame. Here the web thickness has been increased until it equals the flange width. In addition to being a boundary case of a hanger crossframe this study also indicates the shear slope effect in solid prismatic members.

The results of the test show that the shear slope phenomenon exists even in solid members and its effect accounts for an increase of as much as 14½ percent of the measured moment in the hangers.

The proposed modified slope deflection analysis plus the effects of shear slope yielded results which are in close agreement with the measured values. Except at points of localized stress concentrations, the stresses obtained by this analysis agree within 1 percent with the measured stresses.

Part 5

Part 5 of this report contains a description and analysis of test data obtained on the counterweight truss members of five different heel-trunnion-type bascule bridges having concrete counterweights. The tests were conducted on this type of bridge as a result of the failure of the counterweight truss member of a bascule bridge on the Great Northern Railway in 1948, which focused attention on this type of structure.

An analytical study of this type of movable bridge indicated that the only member subjected to high stresses would be the member between the concrete counterweight and the counterweight trunnion pin. The study indicated further that the maximum stress would occur near the concrete counterweight on the underside of the member. The stresses in this member are not due to train operation, but result from moving the bridge from the closed to the open position. The results of the tests indicate that the stress in this member is appreciably greater than that indicated by the commonly accepted methods of analysis.

The tests were conducted by the AAR research staff at the request of the particular railroads and the salaries and expenses of the AAR staff were borne entirely by each railroad.

The stresses were measured with SR–4 wire resistance gages with a static strain indicator in three of the bridges tested, while dynamic strain gage equipment was used in the other two bridges to measure the static stresses, as well as the stresses resulting from the vibrations induced in the counterweight trusses by operating the bridges.

A brief summary of the analysis and results on each bridge is as follows:

1. The Peoria & Pekin Union Railway double-track bridge, having a span of 160 ft, was built in 1909, and it is estimated that it had been opened about 25,000 times up to the time of the test in 1948. A maximum static stress of 40,530 psi was recorded on the gross section in the principal member (See Fig. 1).
2. The Illinois Central Railroad double-track bridge, having a present span of 219 ft 4 in, was originally built in 1917, but had been moved, rebuilt, and

reinforced in 1930. It is estimated that the bridge had been opened about 20,000 times up to the time of the test in 1949. A maximum static stress of 23,640 psi was recorded on the gross section in the principal member at the end of the reinforcement. (See Figs. 2 and 3).

3. The Baltimore & Ohio Railroad double-track bridge, having a span of 235 ft, was built in 1914, and it is estimated that it had been opened about 86,000 times prior to the time of the test in 1950. A maximum static stress of 42,750 psi was recorded on the gross section of the principal member on a section inside the gusset plates of the south truss. A fatigue failure had developed in the principal member of the north truss at about the same location where the maximum stress was measured. (See Figs. 4 to 10, incl.).
4. The Chicago & North Western three-track bridge, having a span of 186 ft, was built in 1916, and it is estimated that it had been opened about 15,000 times to the time of the test in 1950. A maximum static stress of 38,850 psi was recorded on the gross section in the principal member. A maximum dynamic stress of 4200 psi, caused by application of the brakes or applying power to start the movement of the bridge, was recorded, which is about 11 percent of the recorded static stress. (See Figs. 11 to 15, incl.).
5. The Texas & Pacific Railway double-track bridge, having a span of 145 ft, was built in 1922 and had additional reinforcement placed on the principal member at that time. It is estimated that the bridge had been opened about 42,000 times up to the time of the test in 1951. A maximum stress of 33,300 psi was recorded on the gross section of the principal member at the end of the reinforcement. (See Figs. 16 and 17).
6. Laboratory fatigue tests conducted on various riveted joints within recent years are summarized on Figs. 18 and 19. These diagrams indicate that a structural joint subjected to a stress range varying from about zero to 40,000 psi will be subject to fatigue failure after about 50,000 cycles, or if the stress varies from 20,000 psi tension to 20,000 psi compression, a range of 40,000 psi, failure should occur after about 70,000 cycles. These results are for double-lap joints. For fatigue tests on single-lap joints see Fig. 23 of Part 2.

Part 1

The Equivalent Joint Method of Rigid Frame Analysis Modification of Slope Deflection by Successive Approximations

By L. T. Wyly*

Introduction

In order to evaluate properly stress measurements taken either in the field or in the laboratory and in order to generalize upon these measurements, it is necessary to have available a method of analysis which takes into account the significant factors and which will yield computed stresses agreeing at least reasonably well with the measured stresses. The stress measurements made in the field for this project have demonstrated that the following factors exert a significant influence on stress distribution in floorbeam hangers:

1. Any variation in the effective section of the member, including gussets, brackets, splice and reinforcing material, diaphragms, etc.
2. The rotation of the member locally due to shear distortion in the web of the member or of the diaphragm, especially where floorbeams are connected to one side of the member.

In many cases the quantitative significance of the above factors is large. See for example Fig. 17, p. 57, AREA Bulletin 495.

Specifications For a Method of Analysis

The main specifications for a satisfactory method of frame analysis are:

Purpose:	Interpretation of test results. Guide in writing specifications. Tool for check of special designs.
Requirements:	Correct results; must check actual stresses as measured in the field. Easy and quick in use. Should provide checks on mathematical work.
Problem:	Variable I. Shear deflection.
Solution:	Equivalent gussets and clear spans. Curves for moment coefficients. Successive approximations.

The Problem

Common forms of construction of steel members with corresponding types of variation of moment of inertia along the member are illustrated in Fig. 1. In certain cases the moment of inertia at the end of the member may be considered to jump more or less suddenly to a large value. See for example the lower end of the hanger in Fig. 1 (a), or the end of the concrete member where it enters the joint in Fig. 1 (d). It has been customary to consider that the member has a moment of inertia of infinity at such points,

* Research professor of structural engineering and head of department, Purdue University.

and the analysis has often been made on this basis. In other cases, however, the gusset at the end will give a stiffness several times that of the member but certainly not an infinite stiffness. See for example the upper end of the hangers in Fig. 1 (a) or (b), or the left-hand end of the truss member in Fig. 1 (c). A criterion is needed here for the designer's guidance in deciding when a finite value of I is to be used. The basis for such a criterion is given in Fig. 2, to which attention is directed.

A member AB on simple supports is assumed having a variation of I as shown. This member carries a bending moment M_A at the end A of the member. If the gusset is infinitely stiff, there will be no change in slope in the distance kL between the end of the member at A and the right-hand edge of the gusset. If the gusset yields there will be a change in slope, say $\Delta\theta_A$, between the end of the member A and this inside edge of the gusset. The gusset whose stiffness is great enough to make this change in slope $\Delta\theta_A$ negligible may then be used as an equivalent gusset having the same practical effect on the analysis as would be expected from a gusset having an I approaching infinity. For a concrete member, by the same line of reasoning, an equivalent joint may be selected instead of an equivalent gusset. The curves in Fig. 2 show that this angle $\Delta\theta_A$ decreases as the reciprocal of r, where r is the ratio of the moment of inertia of the gusset plus member (since the member usually runs into the joint) inside the gusset, compared to the moment of inertia of the clear member between the gussets. There are obviously other effects on the stresses produced by a change in r, but the largest effect is that just stated. The value of r which may be used in a given case is at present a matter of judgment and its precise value must wait on experimental investigation. Meantime, the value of $r = 5$ is suggested by the author as the minimum to be used in selecting an equivalent gusset. This term is designated "r_e" in this paper.

Where the reinforcing material added to the member near the ends causes the moment of inertia of the member to increase gradually, this variation will have to be taken into account for any realistic analysis. This is the more common case for steel members. It should be borne in mind that a number of other details besides gussets will effectively increase the I of the member, such as splice plates, stay plates, clip or connection angles if long enough, fills, etc. This is particularly true in most steel members over a certain size. In such cases the variation of I may be obtained by using an equivalent gusset having a stiffness of r_eI on the end, followed by a short section of member having a varying I. See for example Fig. 1 (c).

The actual values of I at the ends of the member should be obtained by computations made from the design or shop details. Pending an experimental study, the neutral axis to be used for computing the I of details and reinforcing material may be assumed to coincide with the neutral axis of the member. A graph should be plotted showing the actual variation of I at each end of the member.

Analysis

While slope deflection or moment distribution constants can be computed for any variation of I in a member, this process is quite tedious and not economical of a designer's time. Where only one variation of I occurs at a given end of member, the functions can be reduced to graphs or tables. Most of the variations of I in steel members can be reduced to either a straight-line function, as shown in Fig. 1 (c) just inside the gusset at the right end, or to a cubic function represented by Fig. 1 (a) at the top of the hanger. Graphs are included in this paper for the straight-line variation. The values for the cubic variation may be taken from tables and graphs published previously by others. In the first case, the necessary integrals are included in the Appendix of this paper. (See p. 37).

The procedure of analysis proposed here is based upon the assumption that the material inside the equivalent gusset block, which is usually the structural joint, may be considered to be undeformed, and that all significant bending takes place in the clear length of the member between these joints. The effect of any distortion within these joints may then be added on after the above analysis has been completed.

Effect of Distortion Within the Joints

The magnitude and effect upon bending in the member of distortion within the truss joints in the hanger frames have been studied experimentally and analytically on scale models in the laboratory by J. W. Cox and are reported in Part 3. A limiting case of this action in members of rectangular cross section has been studied by M. B. Scott and W. J. Grady, and is reported in Part 4.

The stress distribution to be expected inside the built-up section composed of large gussets connecting several members in a truss joint, where the center of gravity of the gusset material is a considerable distance from the center of gravity of the truss member, is a question upon which little actual information is available. Since this stress distribution may have an appreciable effect upon bending in the member, it is suggested that a thorough and well planned experimental investigation of this question may well be considered.

For monolithic frames, such as the model tested by Scott and Grady, there will be an additional local stress concentration at the inside corner where the hanger joins the floorbeam. This would be expected to occur in concrete frames also.

Previous Work

In 1936 the author presented the above modification of the slope deflection method and applied it to rigid frames of reinforced concrete.[3] In 1945 it was again presented as an application to floorbeam hanger frames.[4] Both of these analyses were by direct solution, which is very tedious, and both neglected the effect of distortion within the joints. Solution by the method of approximations was presented at the annual meeting of the ASCE, January 20, 1949. It has not been published, but has been taught in graduate courses by Professor J. M. Hayes and the author during the past three years.

The criterion for selecting equivalent gussets or joints given in this paper and the experimental and analytical study of the effect of distortion within the joints on the stresses in the members given in Part 3 by Mr. Cox are presented for the first time in this report.

Analysis by the Equivalent Joint Method

Notes on Conventional Method of Analysis

Consider joint A of Fig. 5 outlining the conventional or standard method of analysis of a frame by slope deflection using successive approximations.

Span Length

1. Rotation of joint A occurs under the action of the unbalanced joint moment, ΣM_{FA}: i.e., the algebraic sum of the fixed beam end moments of all members entering the joint.
2. The magnitude of rotation θ_A depends on the bending in the members throughout the clear spans (L for example) and is assumed not to be appreciably affected by the small amount of distortion of the material within the joint itself.

[3] Jour. Am. Concrete Inst., Sept. Oct. 1936, pp. 767-770. Discussion of Analysis of Multiple-Span Rigid Frame Bridges, by G. A. Maney.

[4] Two problems in Bridge Design, by L. T. Wyly, Proceedings AREA, Vol. 47, 1946, p. 697.

3. For the above reasons it is generally conceded that the clear span length L should be used in computing the I/L of the member.

Deficiencies of the Standard Method

1. At the face of the support (edge of the joint) the joint rotation Θ_A displaces the member AB transversely to its axis an amount Δ_{1ab} (See Fig. 6(a)), setting up moments in the member which are not considered in the conventional procedure.

2. To satisfy the conditions of static equilibrium it is the sum of all moments at the joint center J_A which must add up to zero; not the sum of moments at the faces of supports as is assumed in the conventional procedure. This is to say that the moment about the joint center of the shears acting on the joint faces must also be taken into account.

Modification

The modification consists in computing the additional or secondary bending moments induced by the transverse displacements Δ_{1ab}, etc., at the ends of the members (i.e., at the face of the equivalent joints), and the additional bending moments induced by the added joint rotation Θ_{2A}, etc., which occur as a result of the action of the shears and the secondary displacement moments on the faces of the joint. See Figs. 6 and 7, 9 and 10. When these secondary bending moments have been added to those obtained by the conventional analysis, a rational procedure is obtained which may be carried to any desired degree of refinement.

When there is summed up, about a given joint center, say J_A, the moments due to the above Δ_1 displacements and the moments due to the shears acting at the faces of the joint, an unbalanced moment results, $\Sigma M_2 J_A$. This moment produces a further rotation and will cause added bending moments in the members at the faces of the supports. These computations are most expeditiously performed by successive approximations, which enable the designer to see from the start how important these additional stresses may be for his problem, and also enable him to see the quantitative effect of any variable. Outlines of procedure and numerical examples are given for rigid frame without side sway and secondary stress problems. The procedure for the case of side sway or of wind stress in tall buildings is similar. In most cases one step of correction will be all that is needed, as will be demonstrated.

Examples

The first example given is the analysis of a floorbeam hanger frame with members of constant I, shown in Professor Shedd's excellent text[5]. See Figs. 13, 14 and 15. The upper ends of the hangers are assumed fixed. Some detailed information on this question was obtained in the Missouri-Kansas-Texas railway bridge investigation at Erie, Kan., and will be given in a subsequent report on this bridge.

The second example given is the secondary stress analysis of a heavy loading frame where the ends of the members have a large increase in I due to the gussets and other details. See Figs. 16, 17, 18 and 19.

[5] Structural Design in Steel, by T. C. Shedd. 1934 Ed., pp. 461 to 479, incl., and Plates VIII and IX.

Outline of Procedure

Example 1. Rigid frame of Fig. 13.

Step 1. Compute moments by conventional method, using clear span for fixed beam end moments and for I/L. See Fig. 5.
Compute Θ_{1KA} by approximations. Compute Θ_{1KB}

Step 2a. Compute moments $M_2 \frac{\Delta}{L}$. See Fig. 6 and Fig. 14.

Step 2b. Compute unbalanced moment $\Sigma M_2 J_A$ by adding algebraically the moments at joint center J_A due to the shear at faces of the joints and the above moments $M_2 \frac{\Delta}{L}{}_{AB}$. See Fig. 7 (a) (b).

Compute additional joint rotations Θ_{2KA} and Θ_{2KB} due to the above unbalanced joint moments. See Fig. 7 (c) (d) and Fig. 14.
Compute moments $M_2\ \Theta$ due to these additional joint rotations Θ_{2K}. See Fig. 7 (e) and Fig. 14.

Summary. Check for convergence and equilibrium by summarizing all moments about joint centers. Discrepancy shown in Fig. 14 is 0.8 ft k.

Step 3. If necessary, above process may be repeated until discrepancy is small enough to be ignored. This will usually be unnecessary.

Shear Slope. Compute shear slope at ends of hanger, and moments due to shear slope, and add to above. This operation is not included here, but is treated in Part 3.

Example 2. Secondary stresses in truss of Fig. 16.
Compute slope deflection beam constants for the member Ab. See Appendix, Fig. A, 7, 8. These may also be obtained closely from published tables and curves.

Step 1. Compute Θ_{1A}, true value, by the conventional method, using c-c lengths for computing Δ/L and clear span lengths for I/L. See Fig. 8.
Compute secondary bending moments M_1. See Fig. 17.

Step 2a. Compute moments $M_2\frac{\Delta}{L}$. See Fig. 9 and Fig. 17.

Step 2b. Compute unbalanced moment $M_2 J_A$ by adding algebraically the moments at joint centers due to the shears on face of joint computed in Step 1 and Step 2(a) and above $M_2\frac{\Delta}{L}$ moments. See Fig. 10.

Compute additional joint rotation Θ_{2KA} due to this unbalanced joint moment. See Fig. 10. Compute moments $M_2\Theta$. See Fig. 10 and Fig. 14.

Summary. Check for convergence and stability by summing moments about joint center for all moments and shears computed in Steps 1 and 2.

Comments

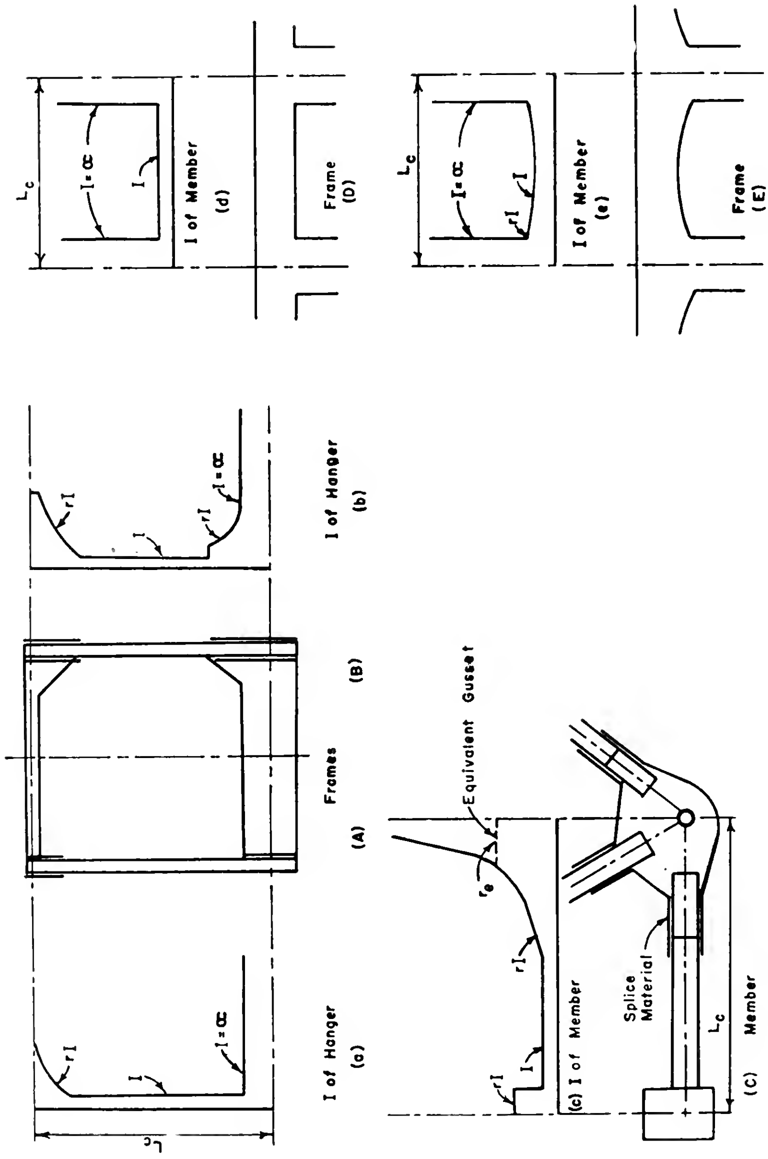
Fig. 15 shows a comparison of the bending moments in the hanger of Fig. 13 as obtained by the equivalent gusset method here presented and as obtained by the clear span and the c-c procedures. It should be noted that the equivalent gusset method gives a maximum moment about 18 percent greater than the clear span method. See footnote reference 4, p. 716. A bracket on the floorbeam would directly increase the bending in the hanger.

Fig. 18 is a graph showing for the frame of Fig. 16 the total moments obtained at the end of each approximation up to 4½ steps. Fig. 19 shows comparison between the bending moments and unit stresses in bending as obtained by the equivalent gusset method, by the c-c method, and by the clear span method, in the frame of Fig. 16. It also gives the moments obtained by the equivalent gusset method after 2 steps and after 4½ steps. The following conclusions are drawn:

1. The equivalent gusset method gives moments at A_b 33 percent greater and at AB 15 percent less than the clear span method.
2. The equivalent gusset method gives moments at A_b 75 percent greater and at BA 18 percent greater than the c-c method.
3. The increase in moment due to added approximations after 2 steps have been used is negligible.

Acknowledgments

The integrals and the chart curves for Fig. A6 were computed by Paul E. Chen and checked by S. J. Bhatt. The application of successive approximations to the solution of secondary stress problems by slope deflection was introduced by Professor George A. Maney in his original development: Secondary Stresses and other Problems in Rigid Frames, Bulletin No. 1, Engineering Studies, University of Minnesota, 1915. The application of successive approximations to the solution of rigid frames with and without side sway was introduced by Professor Maney and John E. Goldberg in: Simplified Methods for the Analysis of Multiple Joint Rigid Frames, Bulletin Northwestern University, 1932. The latter includes the Maney–Goldberg method of wind stress analysis.



VARIATION OF I IN STRUCTURAL MEMBERS

FIGURE 1

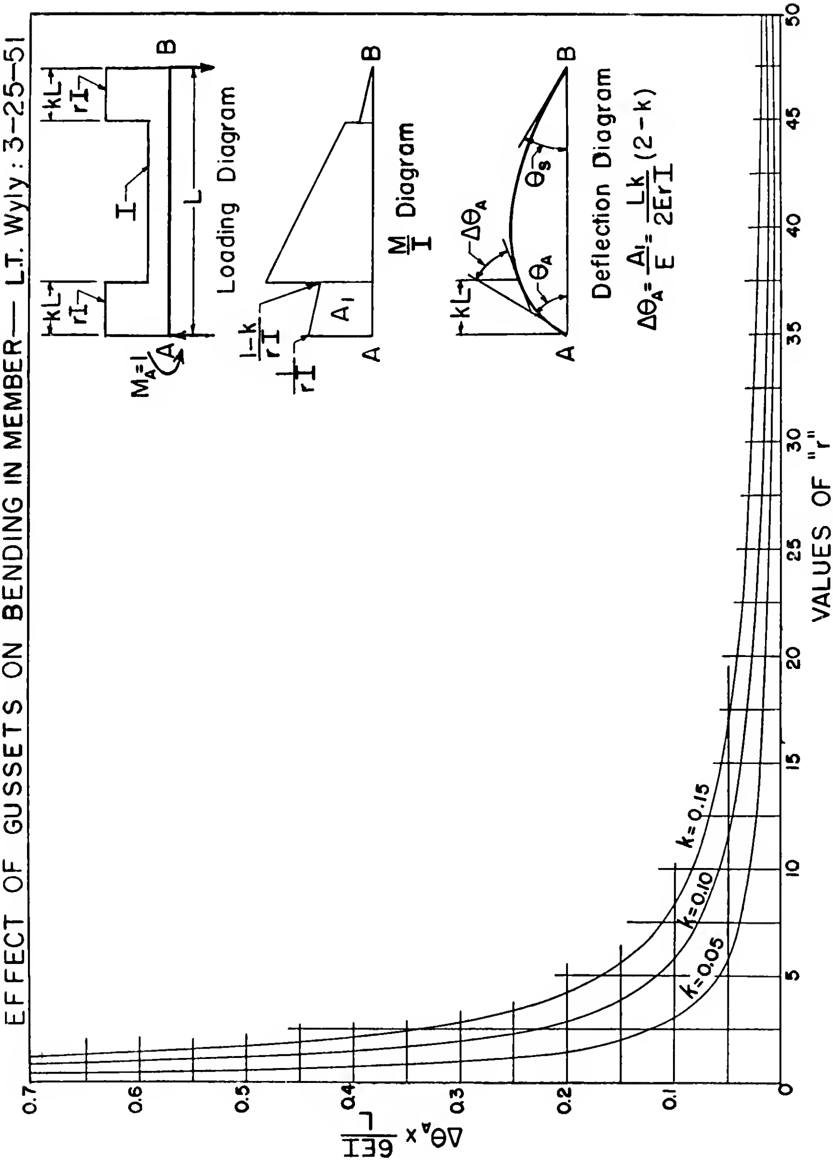
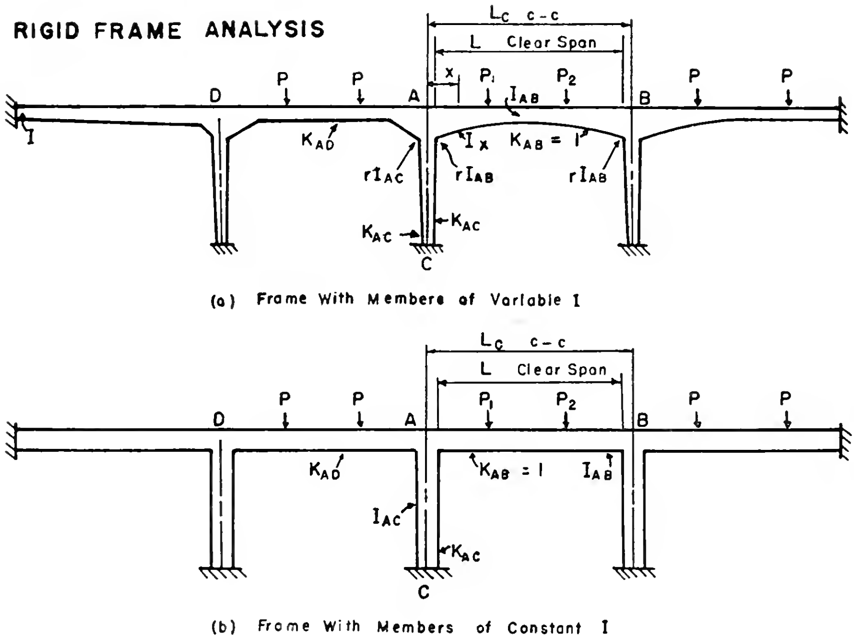

EFFECT OF GUSSETS ON BENDING IN MEMBER— L.T. Wyly: 3-25-51
Loading Diagram
M Diagram
I
Deflection Diagram
ΔθA = A1/E = Lk/2ErI (2-k)
k=0.15
k=0.10
k=0.05
VALUES OF "r"
ΔθA x 6EI/L

FIGURE 2



(a) Frame With Members of Variable I

(b) Frame With Members of Constant I

Notation:

K = Relative I/L where I/L of some member as AB is taken as unity.

ΣK_A = Sum of K values for all members entering Joint A.

M_{FAB} = Fixed beam end moment at A in member AB computed for clear span L.

ΣM_{FA} = Algebaic sum of fixed beam end moments at A for members entering joint A.

Fig. 3 FRAME & LOADS

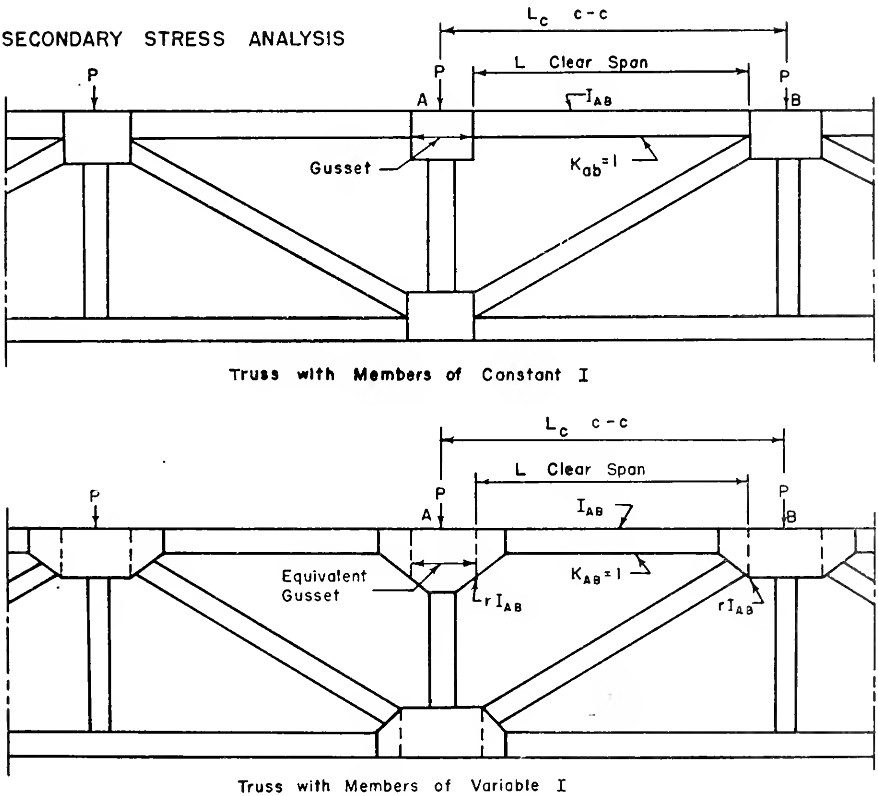
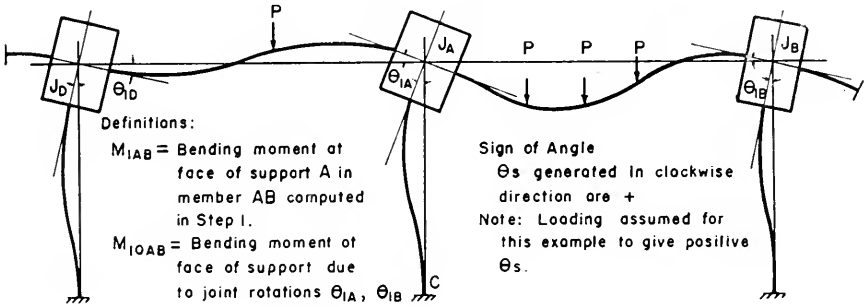


Fig. 4 TRUSS WITH LOADS

RIGID FRAME ANALYSIS Frame of Fig. 3 No Side Sway

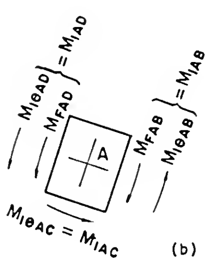
STEP I Conventional Solution

Given: M_F values Required: θ_I, M_I, V_I values



(a) Deflection Diagram for θ_I

Note: See Appendix for derivation of equations



Assumed Equilibrium Conditions

$$\Sigma M_{FA} + M_{I\theta AB} + M_{I\theta AC} + M_{I\theta AD} = 0$$

$$M_{IAB} + M_{IAC} + M_{IAD} = 0$$

Sign of Moments

Moments tending to rotate the joint clockwise are +

(b) Conditions for $\Sigma M = 0$ at Faces of Supports of Joint J_A

Constant I

$$M_{IAB} = +M_{FAB} + K_{AB}\,(-2\theta_{IKA} - \theta_{IKB})$$

$$M_{IAC} = \qquad + K_{AC}\,(-2\theta_{IKA})$$

$$M_{IAD} = -M_{FAD} + K_{AD}\,(-2\theta_{IKA} - \theta_{IKD})$$

$$0 = \Sigma M_{FA} - 2\Sigma K_A(\theta_{IKA}) - \Sigma(K_{Ai}\,\theta_{Ii})$$

Variable I

$$M_{IAB} = +M_{FAB} + K_{AB}\,(-C_{AB}\,\theta_{IKA} - C'\,\theta_{IKB})$$

$$M_{IAC} = \qquad + K_{AC}\,(-C_{AC}\,\theta_{IKA})$$

$$M_{IAD} = -M_{FAD} + K_{AD}\,(-C_{AD}\,\theta_{IKA} - C'\,\theta_{IKD})$$

$$0 = \Sigma M_{FA} - \Sigma K_A C_A\,(\theta_{IKA}) - \Sigma(K_{Ai}C'\theta_{IKi})$$

(c) Joint Equation for $\Sigma M_{IA} = 0$

FIGURE 5

RIGID FRAME ANALYSIS Frame of Fig. 3 No Side Sway

STEP I Conventional Solution Continued

Constant I

$$\theta_{IKA} = \frac{\Sigma M_{FA}}{2\Sigma K_A} - \frac{K_{AB}\theta_{IKB}}{2\Sigma K_A} - \frac{K_{AD}\theta_{IKD}}{2\Sigma K_A}$$

$$= \frac{\Sigma M_{FA}}{2\Sigma K_A} - \frac{\Sigma(K_{Ai}\theta_{Ii})}{2\Sigma K_A} \quad \text{Relative Value}$$

$$\theta_{IA} = \theta_{IKA} \div 2E\frac{I}{L}AB \quad \text{True Value}$$

$$\theta_{IKB} = \frac{\Sigma M_{FB}}{2\Sigma K_B} - \frac{\Sigma(K_{Bi}\theta_{IKi})}{2\Sigma K_B}$$

Variable I

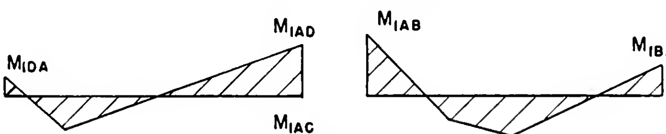
$$\theta_{IKA} = \frac{\Sigma M_{FA}}{\Sigma K_A C_A} - \frac{K_{AB}C'\theta_{IKB}}{\Sigma K_A C_A} - \frac{K_{AD}C'\theta_{IKD}}{\Sigma K_A C_A}$$

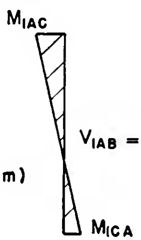
$$= \frac{\Sigma M_{FA}}{\Sigma K_A C_A} - \frac{\Sigma(K_{Ai}C'\theta_{IKi})}{\Sigma K_A C_A} \quad \text{Relative Value}$$

$$\theta_{IA} = \theta_{IKA} \div 2E\frac{I}{L}AB \quad \text{True Value}$$

$$\theta_{IKB} = \frac{\Sigma M_{FB}}{\Sigma K_B C_B} - \frac{\Sigma(K_{Bi}C'\theta_{IKi})}{\Sigma K_B C_B}$$

(d) Calculation of θ_{IK} by Approximations





Notation

V_S = Shear in simple beam AB with clear span L

$$V_{IAB} = V_S + \frac{M_{IAB} + M_{IBA}}{L} \quad \text{(Algebraic Sum)}$$

$$V_{IAB} = V_S + \frac{M_{IAB} + M_{IBA}}{L} \quad \text{(Algebraic Sum)}$$

Constant I

$$M_{IAB} = M_{FAB} + K_{AB}(-2\theta_{IKA} - \theta_{IKB})$$
$$M_{IBA} = M_{FBA} + K_{AB}(-\theta_{IKA} - 2\theta_{IKB})$$

Variable I

$$M_{IAB} = M_{FAB} + K_{AB}(-C_{AB}\theta_{IKA} - C'\theta_{IKB})$$
$$M_{IBA} = M_{FBA} + K_{AB}(-C'\theta_{IKA} - C_{BA}\theta_{IKB})$$

(e) Moment Diagram

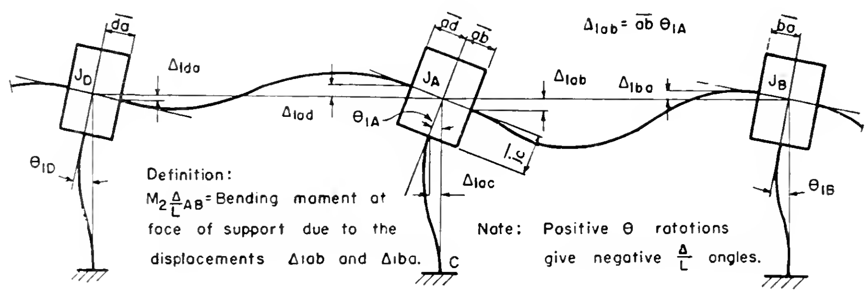
Note: Conventional solution (Step I) gives moments at face of supports.

FIGURE 5 Completed

RIGID FRAME ANALYSIS Frame of Fig. 3 No Side Sway

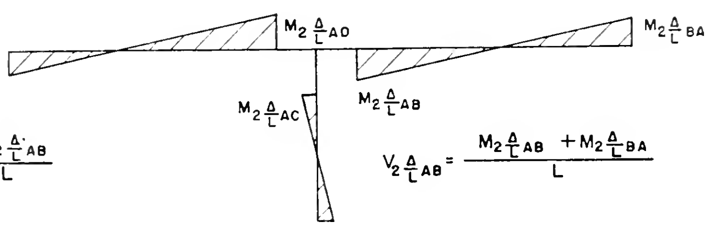
STEP 2(a) Moments from Displacements at Faces of Supports

Given: θ_{IK} values Required: $M_2\frac{\Delta}{L}$



Definition:
$M_2\frac{\Delta}{L}AB$ = Bending moment at face of support due to the displacements Δlab and Δlba.

Note: Positive θ rotations give negative $\frac{\Delta}{L}$ angles.



$$V_2\frac{\Delta}{L} = \frac{2M_2\frac{\Delta}{L}AB}{L}$$

$$V_2\frac{\Delta}{L}AB = \frac{M_2\frac{\Delta}{L}AB + M_2\frac{\Delta}{L}BA}{L}$$

Constant I

$$M_2\frac{\Delta}{L}AB = 2E\frac{I}{L}AB\left[3\left[-\frac{\Delta_{lab}+\Delta_{lba}}{L}\right]\right]$$

$$= K_{AB}\left[3\left[-\frac{\overline{ab}\theta_{IKA}+\overline{ba}\theta_{IKB}}{L}\right]\right]$$

$$M_2\frac{\Delta}{L}BA = M_2\frac{\Delta}{L}AB$$

Variable I

$$M_2\frac{\Delta}{L}AB = 2E\frac{I}{L}AB\left[\left[C_{AB}+C'\right]\left[-\frac{\Delta_{lab}+\Delta_{lba}}{L}\right]\right]$$

$$= K_{AB}\left[-\frac{[C_{AB}+C']}{L}\left[\overline{ab}\theta_{IKA}+\overline{ba}\theta_{IKB}\right]\right]$$

$$M_2\frac{\Delta}{L}BA = K_{AB}\left[-\frac{[C'+C_{BA}]}{L}\left[\overline{ab}\theta_{IKA}+\overline{ba}\theta_{IKB}\right]\right]$$

$$= \frac{C'+C_{BA}}{C_{AB}+C'} \times M_2\frac{\Delta}{L}AB$$

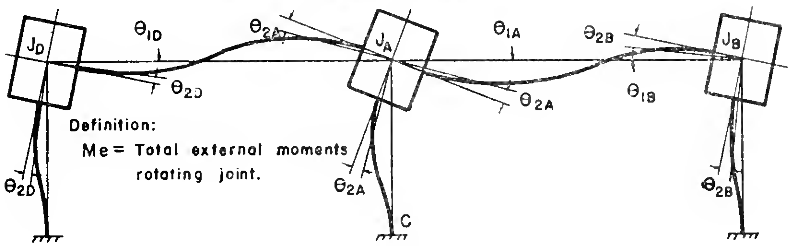
(b) Moment Increments $M_2\frac{\Delta}{L}$

FIGURE 6

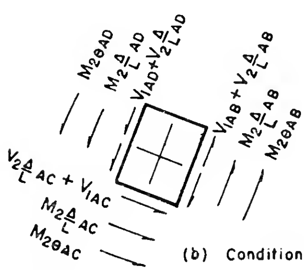
RIGID FRAME ANALYSIS Frame of Fig. 3 No Side Sway

STEP 2(b) Moments from Additional Rotations

Given: V_{1A}, $M_2\frac{\Delta}{L}$, $V_2\frac{\Delta}{L}$ values Required: θ_2, $M_{2\theta}$, $V_{2\theta}$



(a) Deflection Diagram for θ_2



Assumed Equilibrium Conditions

$$\left.\begin{array}{l} \Sigma M_2 J_A + M_{2\theta AB} + M_{2\theta AC} + M_{2\theta AD} = 0 \\ \Sigma M_2 J_A = M_2 J_{AB} + M_2 J_{AC} + M_2 J_{AD} \\ M_2 J_{AB} = M_2 \frac{\Delta}{L}_{AB} + \overline{ab}(V_{1AB} + V_2 \frac{\Delta}{L}_{AB}) \end{array}\right\}$$ Algebraic Summations

(b) Conditions for $\Sigma M = 0$ about Joint Center J_A

Constant I

$M_e = \Sigma M_2 J_A$

$M_{2\theta AB} = K_{AB}(-2\theta_{2KA} - \theta_{2KB})$

$M_{2\theta AC} = K_{AC}(-2\theta_{2KA})$

$M_{2\theta AD} = K_{AD}(2\theta_{2KA} - \theta_{2KD})$

$\theta = \Sigma M_2 J_A - \Sigma 2K_A(\theta_{2KA}) - \Sigma(K_{Ai}\theta_{2i})$

Variable I

$M_e = \Sigma M_2 J_A$

$M_{2\theta AB} = K_{AB}(-C_{AB}\theta_{2KA} - C'\theta_{2KB})$

$M_{2\theta AC} = K_{AC}(-C_{AC}\theta_{2KA})$

$M_{2\theta AD} = K_{AD}(-C_{AD}\theta_{2KA} - C'\theta_{2KD})$

$\theta = \Sigma M_2 J_A - \Sigma K_A C_A(\theta_{2KA}) - \Sigma(K_{Ai} C'\theta_{2i})$

(c) Joint Equation for $\Sigma M_{2\theta A} = 0$

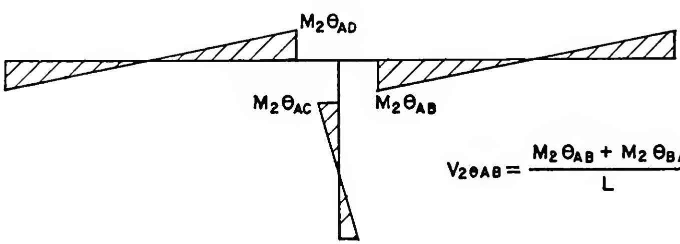
FIGURE 7

RIGID FRAME ANALYSIS Frame of Fig. 3 No Side Sway

STEP 2 (b) Moments from Additional Rotations Continued

$$\left.\begin{aligned} \theta_{2KA} &= \frac{\Sigma M_2 J_A}{2\Sigma K_A} - \frac{\Sigma(K_{Ai}\theta_{2i})}{2\Sigma K_A} \\ \theta_{2KB} &= \frac{\Sigma M_2 J_B}{2\Sigma K_B} - \frac{\Sigma(K_{Bi}\theta_{2i})}{2\Sigma K_B} \end{aligned}\right\} \text{ Relative Values } \left\{\begin{aligned} \theta_{2KA} &= \frac{\Sigma M_2 J_A}{\Sigma K_A C_A} - \frac{\Sigma(K_{Ai}C'\theta_{2i})}{\Sigma K_A C_A} \\ \theta_{2KB} &= \frac{\Sigma M_2 J_B}{\Sigma K_B C_B} - \frac{\Sigma(K_{Bi}C'\theta_{2i})}{\Sigma K_B C_B} \end{aligned}\right.$$

(d) Calculation of $\theta_2 K$ by Approximations



$$V_{2\theta AB} = \frac{M_2\theta_{AB} + M_2\theta_{BA}}{L}$$

Constant I

$$M_{2\theta AB} = K_{AB}\left[-2\theta_{2KA} - \theta_{2KB}\right]$$
$$M_{2\theta BA} = K_{AB}\left[-\theta_{2KA} - 2\theta_{2KB}\right]$$

Variable I

$$M_{2\theta AB} = K_{AB}\left[-C_{AB}\,\theta_{2KA} - C'\theta_{2KB}\right]$$
$$M_{2\theta BA} = K_{AB}\left[-C'\theta_{2KA} - C_{BA}\,\theta_{2KB}\right]$$

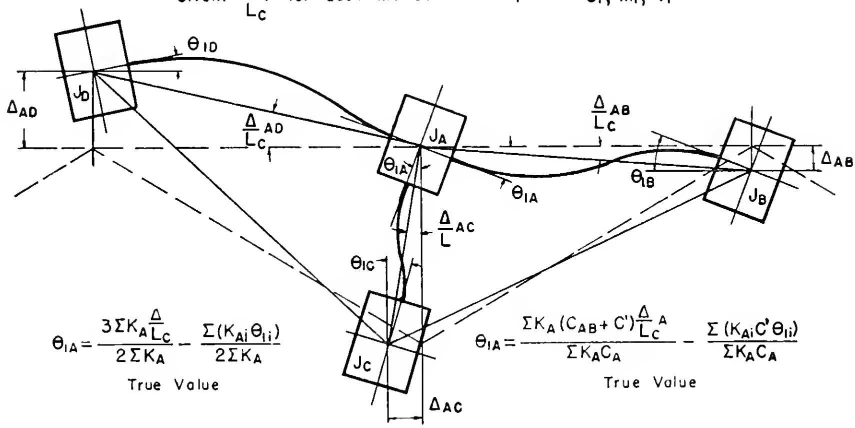
(e) Moment Increments $M_{2\theta}$

FIGURE 7 Completed

SECONDARY STRESS ANALYSIS Frame of Figure 4

STEP I Conventional Solution

Given: $\frac{\Delta_I}{L_C}$ for each Member Required: θ_I, M_I, V_I values



$$\theta_{IA} = \frac{3\Sigma K_A \frac{\Delta}{L_C}}{2\Sigma K_A} - \frac{\Sigma(K_{Ai}\theta_{Ii})}{2\Sigma K_A}$$

True Value

$$\theta_{IA} = \frac{\Sigma K_A (C_{AB}+C')\frac{\Delta}{L_C}A}{\Sigma K_A C_A} - \frac{\Sigma(K_{Ai}C'\theta_{Ii})}{\Sigma K_A C_A}$$

True Value

Constant I

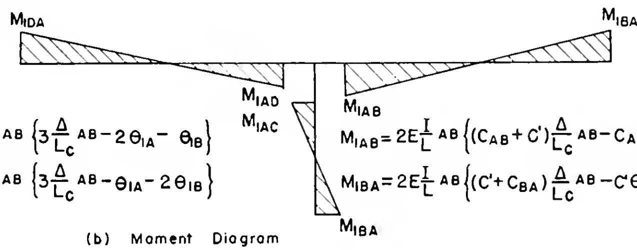
$$M_{IKAB} = K_{AB}\left\{3\frac{\Delta}{L_C}AB - 2\theta_{IA} - \theta_{IB}\right\}$$
$$M_{IKAC} = K_{AC}\left\{3\frac{\Delta}{L_C}AC - 2\theta_{IA} - \theta_{IC}\right\}$$
$$M_{IKAD} = K_{AD}\left\{3\frac{\Delta}{L_C}AD - 2\theta_{IA} - \theta_{ID}\right\}$$
$$0 = \Sigma K_A 3\frac{\Delta}{L}A - 2\Sigma K_A(\theta_{IA}) - \Sigma(K_{AI}\theta_I)$$

Variable I

$$M_{IKAB} = K_{AB}\left\{(C_{AB}+C')\frac{\Delta}{L_C}AB - C_{AB}\theta_{IA} - C'\theta_{IB}\right\}$$
$$M_{IKAC} = K_{AC}\left\{(C_{AC}+C')\frac{\Delta}{L_C}AC - C_{AC}\theta_{IA} - C'\theta_{IC}\right\}$$
$$M_{IKAD} = K_{AD}\left\{(C_{AD}+C')\frac{\Delta}{L_C}AD - C_{AD}\theta_{IA} - C'\theta_{ID}\right\}$$
$$0 = \Sigma K_A(C_A+C')\frac{\Delta}{L_C}A - \Sigma K_A C_A(\theta_{IA}) - \Sigma(K_{Ai}C'\theta_{Ii})$$

Joint Equation for $\Sigma M_A = 0$

(a) Deflection Diagram and θ_I Computations



$$M_{IAB} = 2E\frac{I}{L}AB\left\{3\frac{\Delta}{L_C}AB - 2\theta_{IA} - \theta_{IB}\right\}$$
$$M_{IBA} \;\; 2E\frac{I}{L}AB\left\{3\frac{\Delta}{L_C}AB - \theta_{IA} - 2\theta_{IB}\right\}$$

$$M_{IAB} = 2E\frac{I}{L}AB\left\{(C_{AB}+C')\frac{\Delta}{L_C}AB - C_{AB}\theta_{IA} - C'\theta_{IB}\right\}$$
$$M_{IBA} = 2E\frac{I}{L}AB\left\{(C'+C_{BA})\frac{\Delta}{L_C}AB - C'\theta_{IA} - C_{BA}\theta_{IB}\right\}$$

(b) Moment Diagram

Note: Conventional Solution (Step I) gives moments at faces of supports.

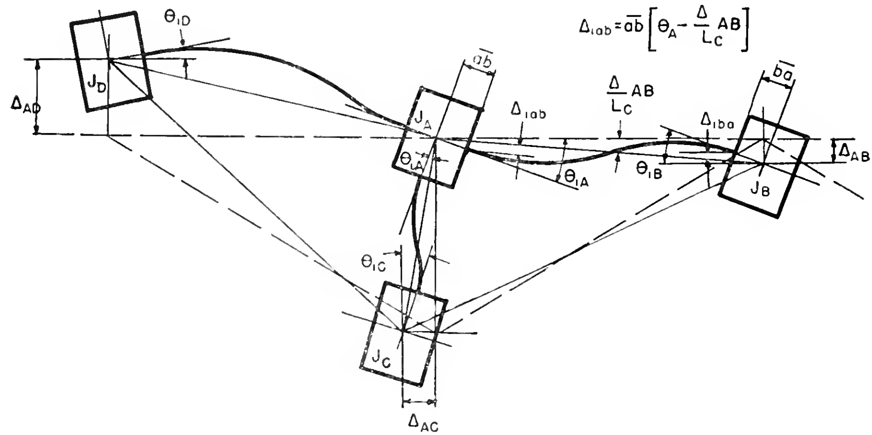
FIGURE 8

SECONDARY STRESS ANALYSIS Frame of Figure 4

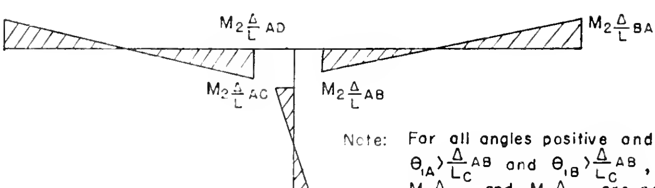
STEP 2(a) Moments from Displacements at Faces of Supports

Given: $\frac{\Delta}{L_C}$ for each member; θ_1, Δ_1 for each joint

Required: $M_2\frac{\Delta}{L}$ for each member



(a) Deflection Diagram at End of Step I



Note: For all angles positive and $\theta_{1A} > \frac{\Delta}{L_C}AB$ and $\theta_{1B} > \frac{\Delta}{L_C}AB$, $M_2\frac{\Delta}{L}AB$ and $M_2\frac{\Delta}{L}BA$ are negative

Constant I

$$M_2\frac{\Delta}{L}AB = 2E\frac{I}{L}\left\{3\left[-\frac{\Delta_{1ab}+\Delta_{1ba}}{L}\right]\right\}$$

$$= 2E\frac{I}{L}\left\{\frac{3}{L}\left[\overline{ab}\left[\frac{\Delta}{L_C}AB-\theta_{1A}\right]+\overline{ba}\left[\frac{\Delta}{L_C}BA-\theta_{1B}\right]\right]\right\}$$

$$M_2\frac{\Delta}{L}BA = M_2\frac{\Delta}{L}AB$$

Variable I

$$M_2\frac{\Delta}{L}AB = 2E\frac{I}{L}AB\left\{\frac{(C_{AB}+C')}{L}\left[\overline{ab}\left[\frac{\Delta}{L_C}AB-\theta_{1A}\right]+\overline{ba}\left[\frac{\Delta}{L_C}BA-\theta_{1B}\right]\right]\right\}$$

$$M_2\frac{\Delta}{L}BA = 2E\frac{I}{L}AB\left\{\frac{(C'+C_{BA})}{L}\left[\overline{ba}\left[\frac{\Delta}{L_C}BA-\theta_{1B}\right]+\overline{ab}\left[\frac{\Delta}{L_C}AB-\theta_{1A}\right]\right]\right\}$$

$$= \frac{C'+C_{BA}}{C_{AB}+C'} \times M_2\frac{\Delta}{L}AB$$

$$V_2\frac{\Delta}{L}AB = \frac{M_2\frac{\Delta}{L}AB + M_2\frac{\Delta}{L}BA}{L}$$

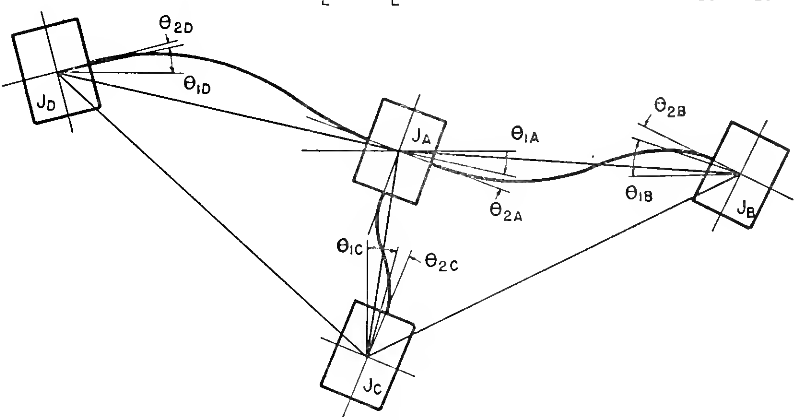
(b) Moment Increments $M_2\frac{\Delta}{L}$

FIGURE 9

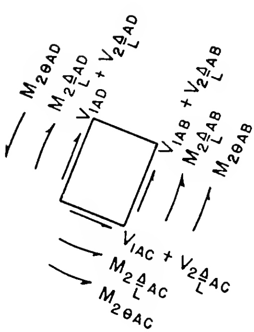
SECONDARY STRESS ANALYSIS Frame of Figure 4

STEP 2 (b) Moments from Additional Rotations

Given: V_1, $M_2\frac{\Delta}{L}$, $V_2\frac{\Delta}{L}$ values Required: θ_2, $M_{2\theta}$, $V_{2\theta}$



(a) Deflection Diagram for θ_2



Assumed Equilibrium Conditions

$$\Sigma M_2 J_A + M_{2\theta AB} + M_{2\theta AC} + M_{2\theta AD} = 0$$
$$\Sigma M_2 J_A = M_2 J_{AB} + M_2 J_{AC} + M_2 J_{AD}$$
$$M_2 J_{AB} = M_2 \tfrac{\Delta}{L}_{AB} + \overline{ab}\left[V_{1AB} + V_2 \tfrac{\Delta}{L}_{AB}\right]$$

} Algebraic Summations

(b) Conditions for $\Sigma M = 0$ at Joint Center J_A

FIGURE 10

SECONDARY STRESS ANALYSIS Frame of Figure 4

STEP 2 (b) Moments from Additional Rotations Continued

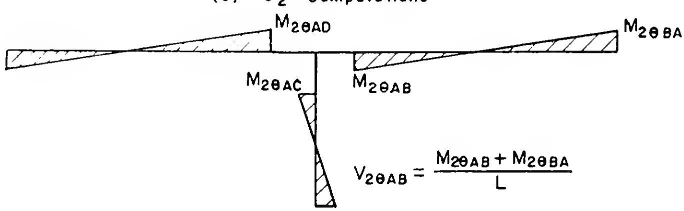
Constant I

$$\theta_{2KA} = \frac{\Sigma M_2 J_A}{2\Sigma K_A} - \frac{\Sigma (K_{Ai}\theta_{2i})}{2\Sigma K_A} \quad \text{Relative value}$$

Variable I

$$\left.\begin{aligned} \theta_{2KA} &= \frac{\Sigma M_2 J_A}{\Sigma K_A C_A} - \frac{\Sigma (K_{Ai} C' \theta_{2Ki})}{\Sigma K_A C_A} \\ O_{2KB} &= \frac{\Sigma M_2 J_B}{\Sigma K_B C_B} - \frac{\Sigma (K_{Bi} C' \theta_{2Ki})}{\Sigma K_B C_B} \end{aligned}\right\} \text{Relative Values}$$

(c) θ_2 Computations



$$V_{2\theta AB} = \frac{M_{2\theta AB} + M_{2\theta BA}}{L}$$

Constant I

$$M_{2\theta AB} = K_{AB}(-2\theta_{2KA} - \theta_{2KB})$$

$$M_{2\theta BA} = K_{AB}(-2\theta_{2KB} - \theta_{2KA})$$

Variable I

$$M_{2\theta AB} = K_{AB}(-C_{AB}\theta_{2KA} - C'\theta_{2KB})$$

$$M_{2\theta BA} = K_{AB}(-C'\theta_{2KA} - C_{BA}\theta_{2KB})$$

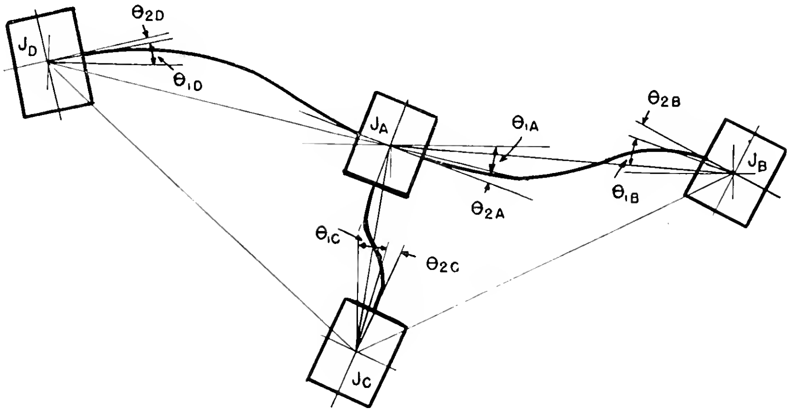
(d) Moment Increments $M_{2\theta}$

FIGURE 10 completed

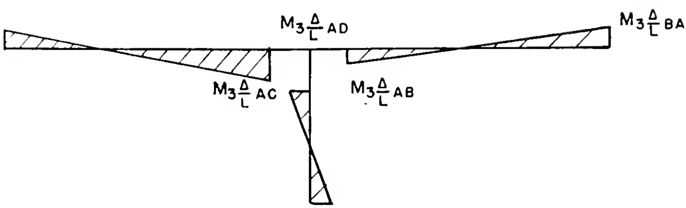
SECONDARY STRESS ANALYSIS Frame of Figure 4

STEP 3(a) Moments from Displacements at Faces of Supports

Given: θ_{2K}, Δ_2 for each joint Required: $M_3\frac{\Delta}{L}$ for each member



(a) Deflection Diagram at Completion of Step 2



Constant I

$$M_3\frac{\Delta}{L}_{AB} = 2E\frac{I}{L}_{AB}\left\{\frac{3}{L}\left[-\frac{\overline{ab}\,\theta_{2KA} + \overline{ba}\,\theta_{2KB}}{2E\frac{I}{L}_{AB}}\right]\right\}$$

$$= K_{AB}\left\{\frac{3}{L}\left[\overline{ab}(-\theta_{2KA}) + \overline{ba}(-\theta_{2KB})\right]\right\}$$

$$M_3\frac{\Delta}{L}_{BA} = M_3\frac{\Delta}{L}_{AB}$$

Variable I

$$M_3\frac{\Delta}{L}_{AB} = \left\{-\frac{(C_{AB}+C')}{L}\left[\overline{ab}(-\theta_{2KA}) + \overline{ba}(-\theta_{2KB})\right]\right\}$$

$$M_3\frac{\Delta}{L}_{BA} = \frac{C'+C_{BA}}{C_{AB}+C'} \times M_3\frac{\Delta}{L}_{AB}$$

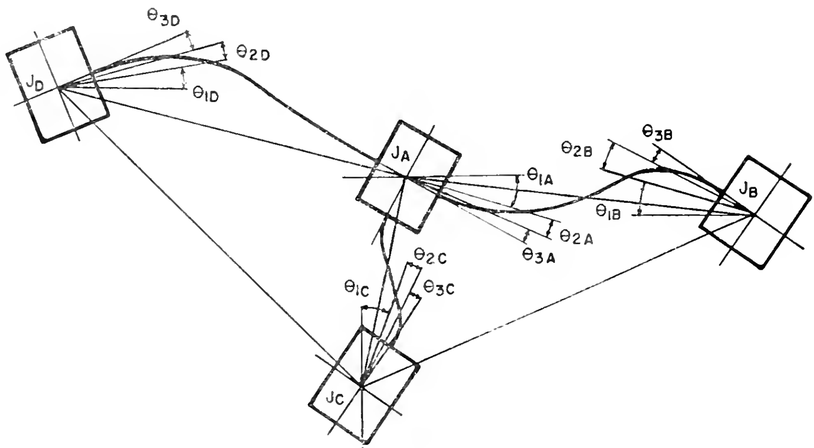
(b) Moment Increments $M_3\frac{\Delta}{L}$

FIGURE 11

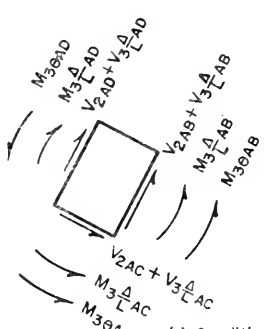
SECONDARY STRESS ANALYSIS Frame of Figure 4

Step 3(b) Moments from Additional Rotations

Given: $V_2, M_2 \frac{\Delta}{L}, V_2$ Required: $\theta_3, M_{3\theta}, V_{3\theta}$



(a) Deflection Diagram for θ_3



Assumed Equilibrium Conditions

$$\Sigma M_3 J_A + M_{3\theta AB} + M_{3\theta AC} + M_{3\theta AD} = 0$$
$$\Sigma M_3 J_A = M_3 J_{AB} + M_3 J_{AC} + M_3 J_{AD}$$
$$M_3 J_{AB} = M_3 \tfrac{\Delta}{L}_{AB} + ab\left[V_{2AB} + V_3 \tfrac{\Delta}{L}_{AB}\right]$$

} Algebraic Summations

(b) Conditions for $\Sigma M = 0$ at Joint Center J_A,

FIGURE 12

SECONDARY STRESS ANALYSIS Frame of Figure 4

Step 3(b) Moments from Additional Rotations Continued

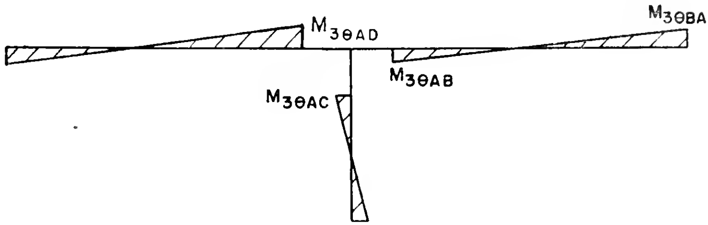
Constant I

$$\theta_{3}K_{A} = \frac{\Sigma M_3 J_A}{2\Sigma K_A} - \frac{\Sigma(K_{Ai}\theta_{3i})}{2\Sigma K_A}$$

Variable I

$$\theta_{3KA} = \frac{\Sigma M_3 J_A}{\Sigma K_A C_A} - \frac{\Sigma(K_{Ai} C' \theta_{3Ki})}{\Sigma K_A C_A}$$

(c) θ_3 Computation by Increments



Constant I

$$M_{3\theta AB} = K_{AB}\left[-2\theta_{3KA} - \theta_{3KB}\right]$$

$$M_{3\theta BA} = K_{AB}\left[-\theta_{3KA} - 2\theta_{2KB}\right]$$

Variable I

$$M_{3\theta AB} = K_{AB}\left[-C_{AB}\theta_{3K} - C'\theta_{3KB}\right]$$

$$M_{3\theta BA} = K_{AB}\left[-C'\theta_{3KA} - C_{BA}\theta_{3KB}\right]$$

(d) Moment Increments $M_{3\theta}$

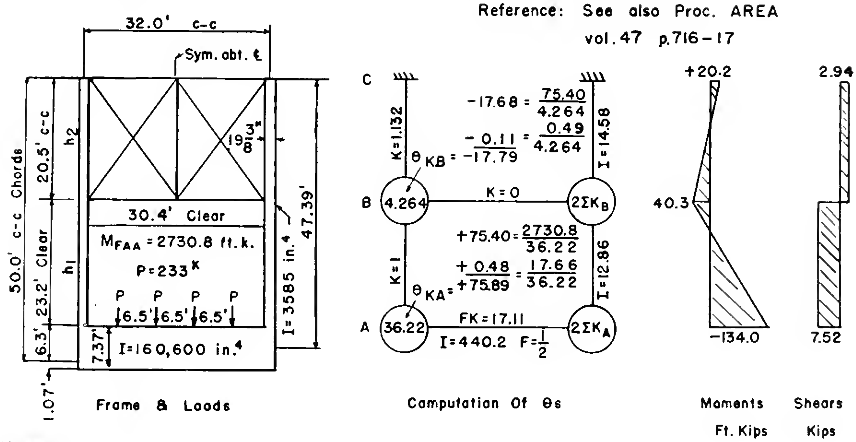
FIGURE 12 Completed

EXAMPLE 1 RIGID FRAME ANALYSIS

STEP 1 Conventional Method Clear Spans

See Figure 5

Reference: See also Proc. AREA vol. 47 p. 716–17



Moments

$M_{AA} = 2730.8 + 17.11(-151.78) = +134.0$ ft.k.

$M_{AB} = 1(+17.79 - 151.78) = 134.0$ ft.k.

$M_{BA} = 1(+35.58 - 75.88) = -40.3$ ft.k.

$M_{BC} = 1.132(+35.58) = +40.3$ ft.k.

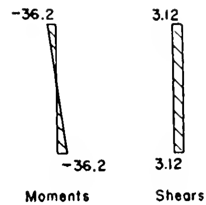
Note: M_{FAA} is computed on clear span assumption. i.e. at the face of Joint A.

FIGURE 13

EXAMPLE I RIGID FRAME ANALYSIS

STEP 2(a) Moments $M_2\frac{\Delta}{L}$ See Figure 6

$$M_2\frac{\Delta}{L}_{AB} = 113 - \frac{3.68 \times 75.89}{23.2} = -36.2'$$

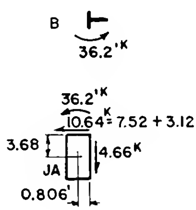


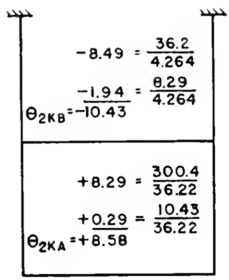
STEP 2(b) Moments $M_{2\theta}$ See Figure 7

$\Sigma M_2 J_A$

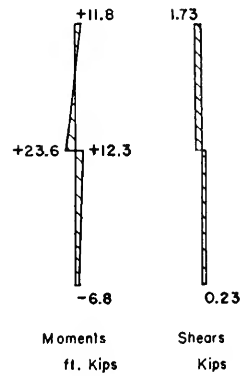
$$466 \times 0.806 = +375.8$$
$$10.64 \times 3.68 = -39.2$$
$$M_2\frac{\Delta}{L} = -36.2$$
$$+300.4'^{K}$$

$\Sigma M_2 J_B$





Computation Of θ's



Moments $M_2\theta$

$$M_{2\theta AA} = 17.11(-17.16) = -293.6'^{K}$$
$$M_{2\theta AB} = 1(-17.16 + 10.43) = -6.8'^{K}$$
$$\Sigma M_{2\theta A} \quad -300.4'^{K}$$
$$\Sigma M_2 J_A \quad +300.4'^{K}$$

Check

$$M_{2\theta BA} = 1(+20.86 - 8.58) = +12.3'^{K}$$
$$M_{2\theta BC} = 1.132(+20.86) = +23.6'^{K}$$
$$+35.9'^{K}$$
$$\Sigma M_2 J_B \quad -36.2'^{K}$$

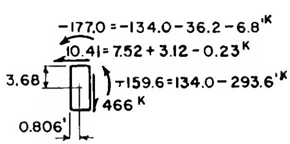
SUMMARY Step 1 + Step 2

Check

ΣM_{JA}

$$\left.\begin{matrix} -177.0'^{K} \\ 10.43 \times 3.68 = -38.4'^{K} \end{matrix}\right\} -215.4'^{K}$$

$$\left.\begin{matrix} -159.6'^{K} \\ 4.66 \times 0.806 = +375.8'^{K} \end{matrix}\right\} +216.2'^{K}$$



Equilibrium Check

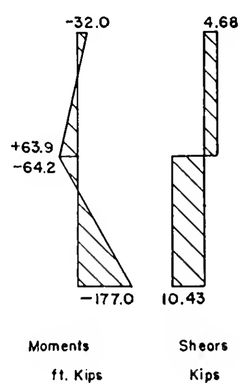
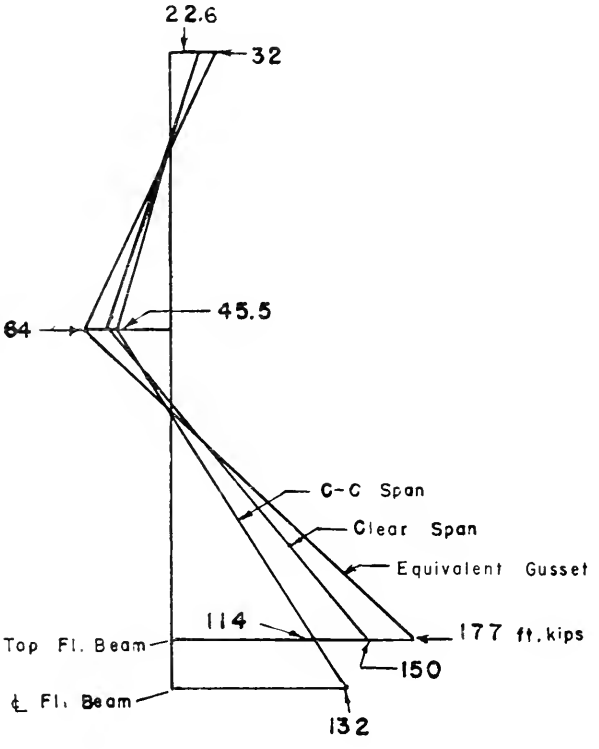


FIGURE 14

RIGID FRAME ANALYSIS

EXAMPLE



COMPARISON OF MOMENTS IN VERTICAL BY DIFFERENT METHODS OF ANALYSIS

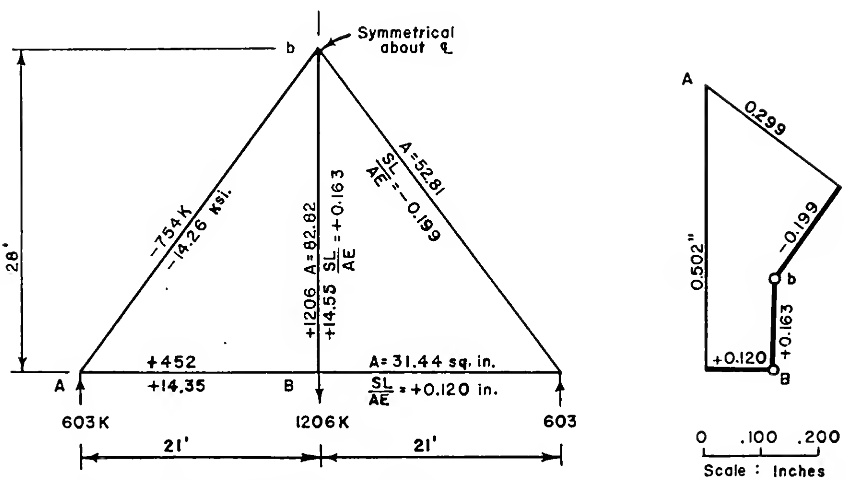
NOTE: Moments shown here for the clear span assumption of $\frac{I}{L}$ are due to a M_{FAA} of 2915.5 ft.k computed on the basis of c–c span.

NOTE: This analysis does not include the effect of shear slope.

FIGURE 15

EXAMPLE 2

SECONDARY STRESSES IN LOADING FRAME



Frame, Loads, Stresses, Deformations

Williot Diagram

FIGURE 16

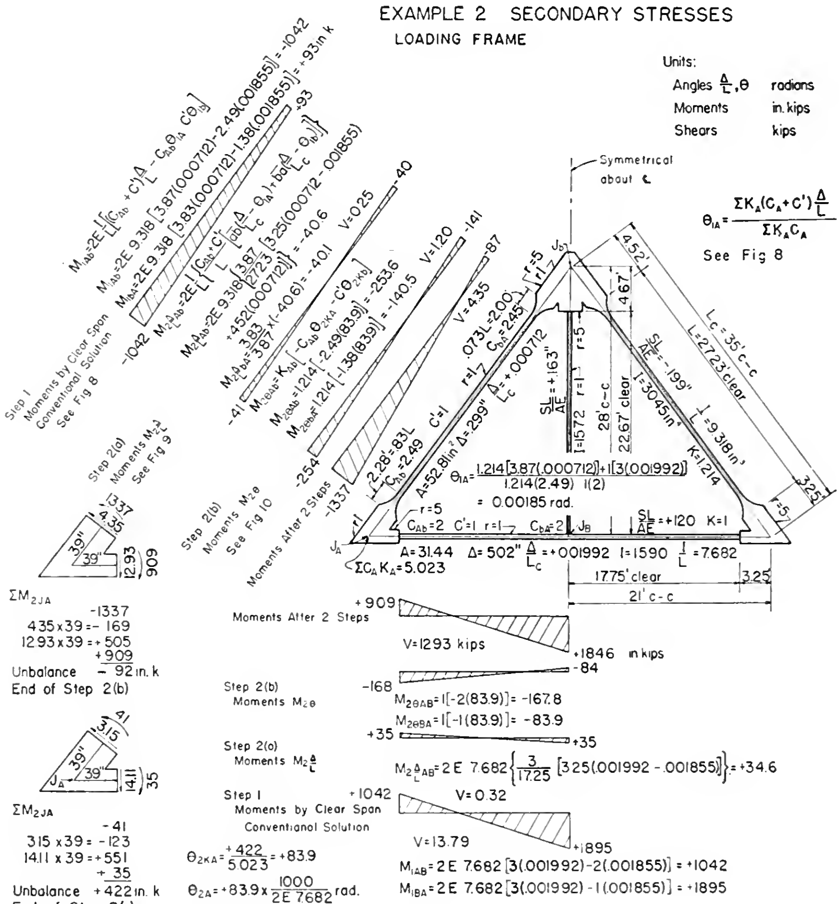
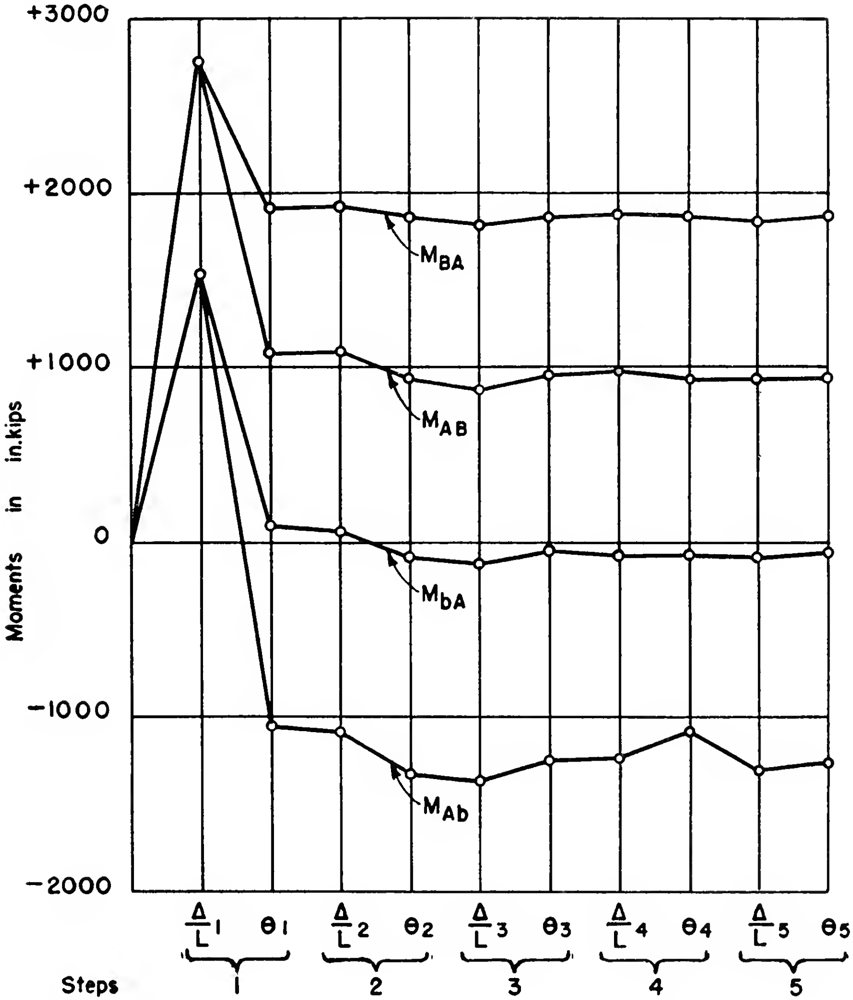

EXAMPLE 2 SECONDARY STRESSES
LOADING FRAME
Units:
Angles Δ/L, θ radians
Moments in. kips
Shears kips
Symmetrical about ℄
See Fig 8
Step 1 Moments by Clear Span Conventional Solution See Fig 8
Step 2(a) Moments M2Δ/L See Fig 9
Step 2(b) Moments M2θ See Fig 10
Moments After 2 Steps
ΣM2JA
-1337
435x39=- 169
12.93x39=+505
+909
Unbalance - 92 in. k
End of Step 2(b)
ΣM2JA
-41
3.15 x39= -123
14.11 x 39=+551
+ 35
Unbalance +422 in. k
End of Step 2(a)
Moments After 2 Steps
V=12.93 kips
+1846 in kips
Step 2(b) Moments M2θ
M2θAB=1[-2(83.9)]= -167.8
M2θBA=1[-1(83.9)]= -83.9
Step 2(a) Moments M2Δ/L
M2ΔAB=2E 7.682{3/17.25 [3.25(.001992-.001855)]}=+34.6
Step 1 Moments by Clear Span Conventional Solution
V=0.32
V=13.79
M1AB=2E 7.682[3(.001992)-2(.001855)]=+1042
M1BA=2E 7.682[3(.001992)-1(.001855)]=+1895
θ2KA=+422/5.023=+83.9
θ2A=+83.9x1000/2E 7.682 rad.
Computation of θ2KA
A=31.44 Δ=.502" Δ/Lc=+.001992 I=1590 I/L=7.682
ΣCAKA=5.023
17.75' clear
21' c-c
Lc=35' c-c
L=27.23' clear
28' c-c
22.67' clear
θ1A=1.214[3.87(.000712)]+1[3(.001992)] / 1.214(2.49) 1(2)
= 0.00185 rad.

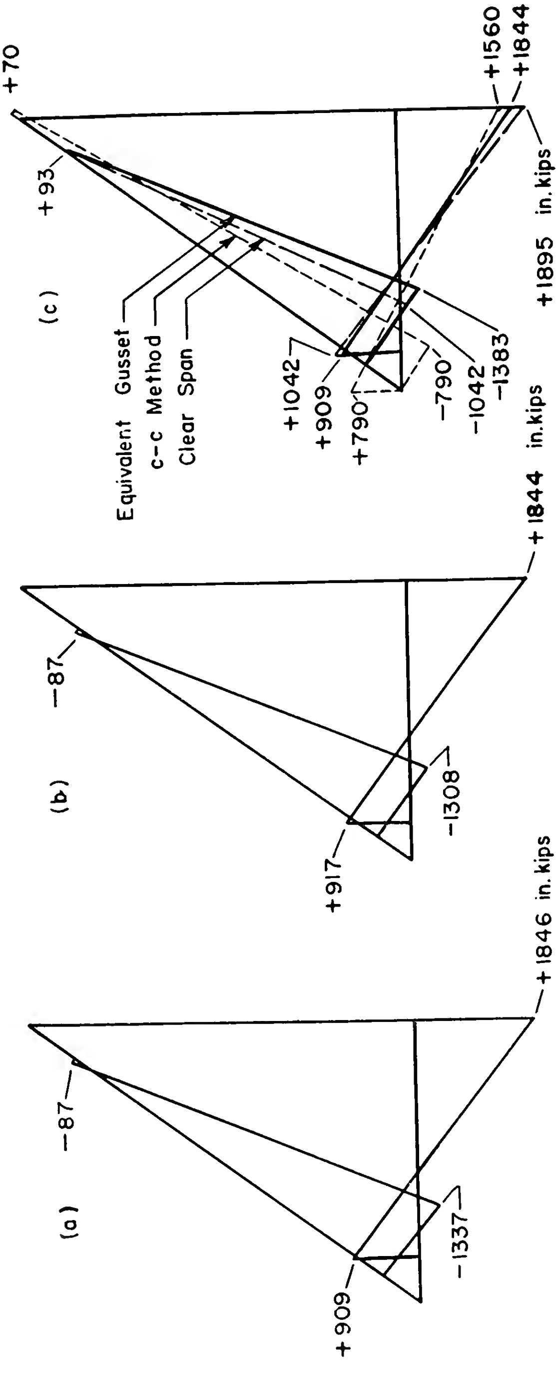
FIG. 17

EXAMPLE 2



ACCURACY OF SUCCESSIVE APPROXIMATIONS

FIGURE 18



Sum Of Moments At End Of 2 Steps

Sum Of Moments At End Of $4\frac{1}{2}$ Steps

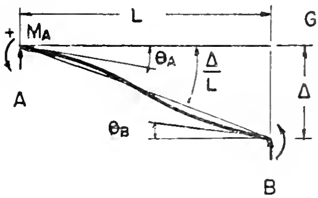
COMPARISON OF MOMENTS BY DIFFERENT METHODS

FIGURE 19

APPENDIX

THE GENERAL FORM OF THE SLOPE DEFLECTION EQUATIONS FOR A BEAM OF VARIABLE I

FUNDAMENTAL EQUATIONS



GENERAL FORM, BEAM OF ANY CROSS SECTION:

$$M_{AB} = \pm M_{FAB} + 2E\frac{I}{L}\left[(C_{AB} + C'_{AB})\frac{\Delta}{L} - C_{AB}\theta_A - C'_{AB}\theta_B\right]$$

$$M_{BA} = \pm M_{FBA} + 2E\frac{I}{L}\left[(C_{BA} + C'_{AB})\frac{\Delta}{L} - C_{BA}\theta_B - C'_{AB}\theta_A\right]$$

USUAL FORM, BEAM OF CONSTANT CROSS SECTION:

$$M_{AB} = \pm M_{FAB} + 2E\frac{I}{L}\left[3\frac{\Delta}{L} - 2\theta_A - \theta_B\right]$$

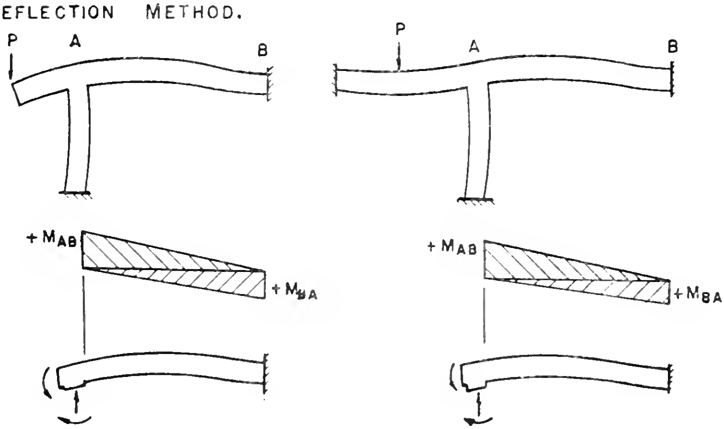
Sign Conventions:

Angles θ & Δ/L are positive when generated in a clockwise direction.

End moments in members are positive when the moments tend to rotate the joint (not the member) in a clockwise direction.

Reference: "Statically Indeterminate Stresses," Parcel & Maney, 2nd. Ed. pp. 147–166.

PICTURE OF POSITIVE BENDING MOMENT AT THE END OF A BEAM FOR SLOPE DEFLECTION METHOD.

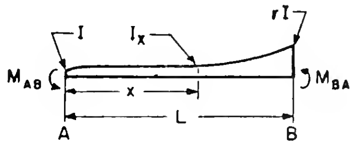


Note : M_{AB} is positive since it tends to rotate joint A (not the member) in a clockwise direction.

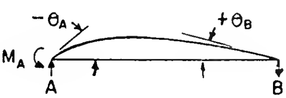
Sugestion: Do not cut member AB free from joint A when determining sign of M_{AB}. Moments are plotted on the Tension Side of the Beam.

FIGURE A1

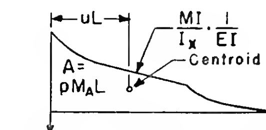
DERIVATION OF THE GENERAL FORM OF THE SLOPE DEFLECTION EQUATIONS



Beam



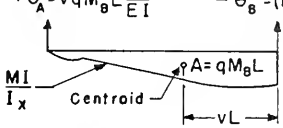
Deflection Diagram



$-\theta_A = (1-u)pM_A L \cdot \frac{1}{EI}$ $\quad +\theta_B = upM_A L \frac{1}{EI}$

Deflection Diagram

$+\theta_A = vqM_B L \frac{1}{EI}$ $\quad -\theta_B = (1-v)qM_B L \frac{1}{EI}$



$$M_{AB} = 2E\frac{I}{L}\left[-C_{AB}\theta_A - C'\theta_B\right]$$

$$M_{BA} = 2E\frac{I}{L}\left[-C'\theta_A - C_{BA}\theta_B\right]$$

Where $C_{AB} = \frac{1-v}{2p(1-u-v)}$

$C' = \frac{v}{2p(1-u-v)}$

and $C_{BA} = \frac{1-u}{2q(1-u-v)}$

$C' = \frac{u}{2q(1-u-v)}$

Equations:

$$\theta_A = \left[vqM_B L - (1-u)pM_A L\right]\frac{1}{EI} \qquad (A)$$

$$\theta_B = \left[upM_A L - (1-v)qM_B L\right]\frac{1}{EI} \qquad (B)$$

Ref: See "Analysis of Rigid Frames," by Amirikian, pp.50–51

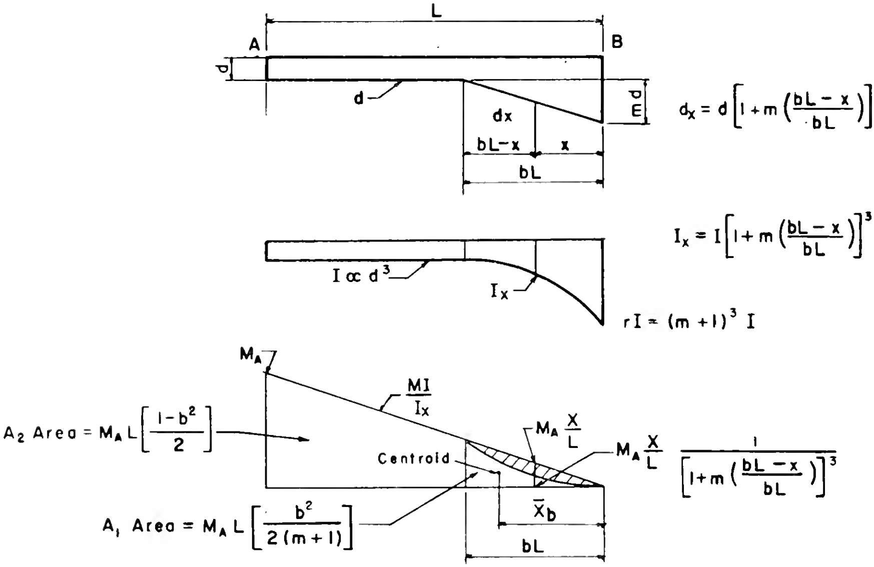
Solving Equations (A) and (B):

$$M_A = \frac{EI\left[-(1-v)\theta_A - v\theta_B\right]}{pL(1-u-v)} \qquad (1)$$

$$M_B = \frac{EI\left[-u\theta_A - (1-u)\theta_B\right]}{qL(1-u-v)} \qquad (2)$$

FIGURE A2

FORMULAS FOR p, q, u, v CUBIC VARIATION OF I



Area under $\frac{MI}{I_x}$ Diagram in Length bL:

$$A_1 = \frac{M_A}{L}\int_0^{bL} \frac{x\,dx}{\left[1+m\left(\frac{bL-x}{bL}\right)\right]^3} = M_A L\left[\frac{b^2}{2(m+1)}\right] \qquad (2a)^*$$

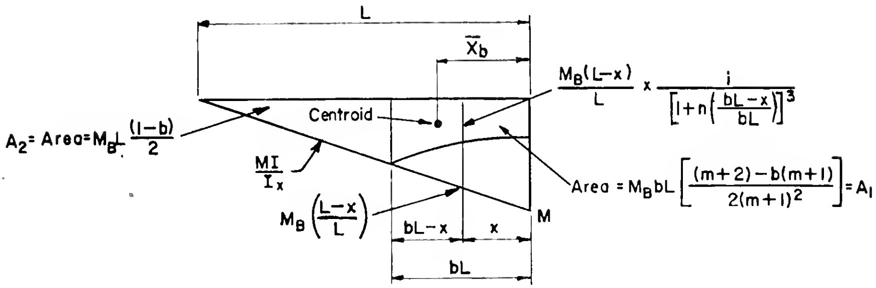
Centroid of Area under $\frac{MI}{I_x}$ Diagram in Length bL:

$$\bar{X}_b = \frac{\frac{M_A}{L}\int_0^{bL} \frac{x^2\,dx}{\left[1+m\left(\frac{bL-x}{bL}\right)\right]^3}}{M_A L\left[\frac{b^2}{2(m+1)}\right]} = bL\,\frac{2(m+1)}{m^3}\left[\text{Log}_e(m+1) + m\,\frac{(m-2)}{2}\right] \qquad (3a)^*$$

* See "Handbook of Frame Constants", p. 30, Published by Portland Cement Association, Chicago, Illinois, 1947, for prior publication.

FIGURE A3

FORMULAS FOR p,q,u,v. CUBIC VARIATION OF I.



Area under $\frac{MI}{I_x}$ diagram in length bL.

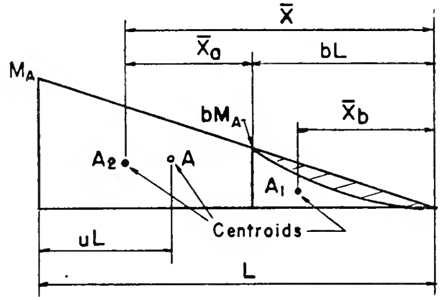
$$A_1 = \frac{M_B}{L}\int_0^{bL} \frac{(L-x)\,dx}{\left[1+m\left(\frac{bL-x}{bL}\right)\right]^3} = M_B bL\left[\frac{(m+2)-b(m+1)}{2(m+1)^2}\right]$$

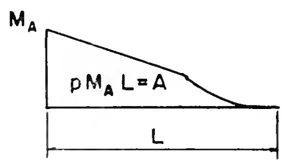
Centroid of area under $\frac{MI}{I_x}$ diagram in length bL.

$$\overline{X}_b = \frac{\frac{M_B}{L}\displaystyle\int_0^{bL} \frac{x(L-x)\,dx}{\left[1+m\left(\frac{bL-x}{bL}\right)\right]^3}}{M_B bL\left[\frac{(m+2)-b(m+1)}{2(m+1)^2}\right]} = \frac{\frac{bL}{2}\left[\frac{1}{m+1}\right] + \frac{b^2L}{m^3}\left[\frac{m(2-m)}{2} - \log_e(m+)\right]}{\frac{(m+2)-b(m+1)}{2(m+1)^2}}$$

FIGURE A4

FORMULAS FOR p, q, u, v CUBIC VARIATION OF I





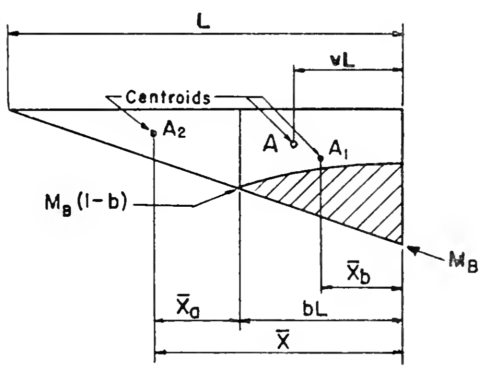
$$\bar{X}_b A_1 + \bar{X} A_2 = L(1-u)A$$

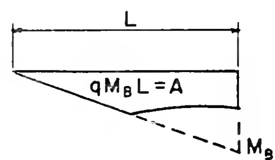
$$u = 1 - \frac{\bar{X}_b A_1 + \bar{X} A_2}{LA}$$

$$p = \frac{m(1-b^2)+1}{2(m+1)}$$

$$\bar{X}_a = \frac{L}{3}\,\frac{(2-b-b^2)}{(1+b)}$$

$$\bar{X} = \frac{2}{3}\,\frac{L(1+b+b^2)}{(1+b)}$$





$$\bar{X}_b A_1 + \bar{X} A_2 = vLA$$

$$v = \frac{\bar{X}_b A_1 + \bar{X} A_2}{AL}$$

$$q = \frac{(1-b)\left[m^2(1-b)+m(2-b)\right]+1}{2(m+1)^2}$$

$$\bar{X}_a = \frac{L(1-b)}{3}$$

$$\bar{X} = \frac{2L}{3}(1+b)$$

FIGURE A5

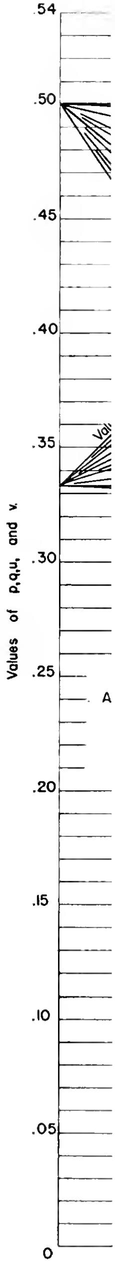

.54
.50
.45
.40
.35
.30
.25
.20
.15
.10
.05
0
Values of p, q, u, and v.
A

CHART FOR VALUES OF p,q,u, AND v LINEAR VARIATION OF I

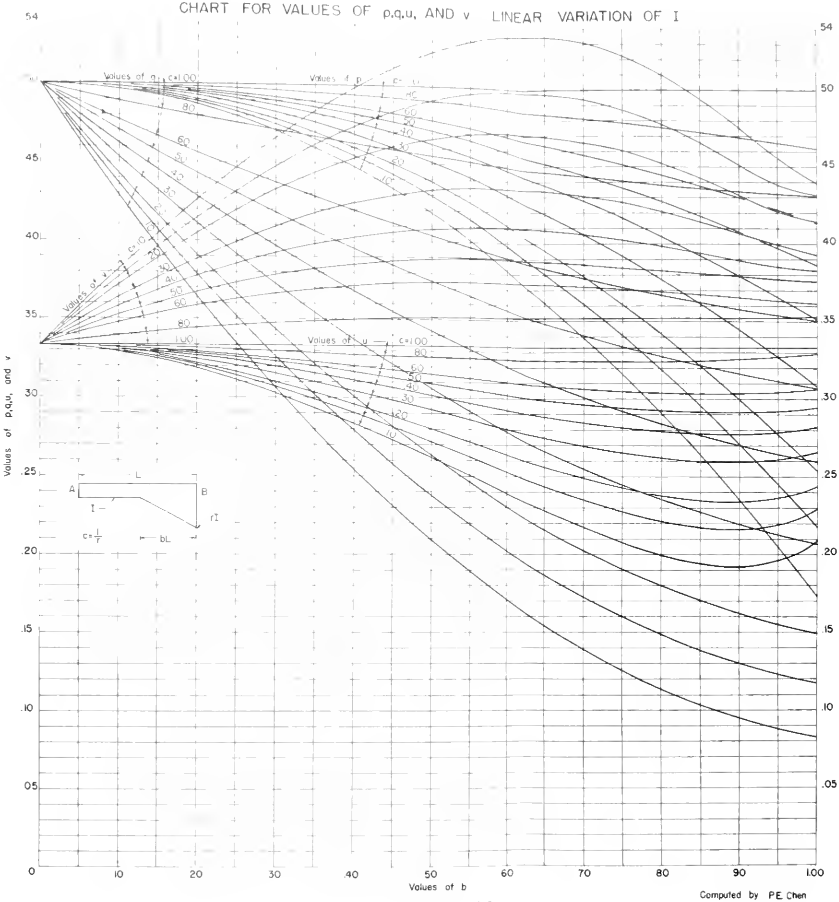
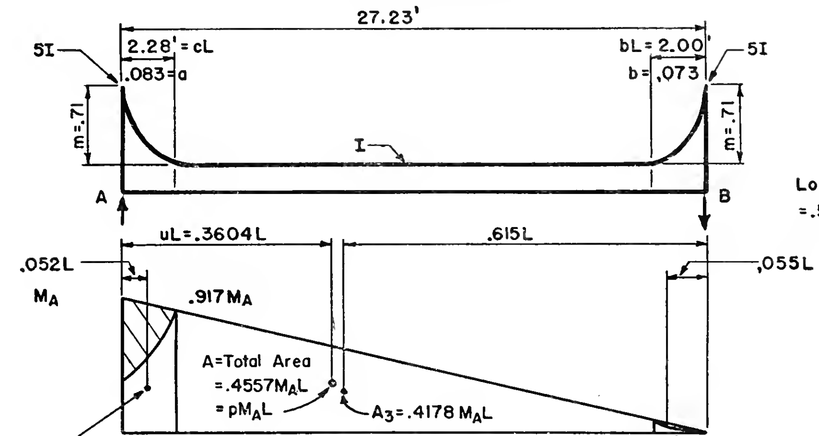


FIGURE A6

Computed by P.E. Chen
Checked by S.J. Bhatt

EXAMPLE 2 SLOPE DEFLECTION CONSTANTS FOR MEMBER Ab



$\log_e 1.71 = .5365$

$$A_2 = M_A L \times .083\left[\frac{2.71 - .083(1.71)}{2(1.71)^2}\right]$$

$$= M_A L \times .0364$$

$$A_1 = M_A L\left[\frac{.073^2}{2(1.71)}\right]$$

$$= .0015 M_A L$$

$$\frac{\bar{X}_a}{L} = \frac{\frac{.083}{3.42} + \frac{.0069}{.3579}\left[\frac{.71(1.29)}{2} - .5365\right]}{\frac{2.71 - .083(1.71)}{2(2.924)}}$$

$$= \frac{.0242 + .0192(.458 - .5365)}{\frac{2.568}{5.848}}$$

$$\frac{X_a}{L} = \frac{.0227}{.4395} = .0516$$

$$\frac{\bar{X}_b}{L} = \frac{.073 \times 3.42}{.358}\left[.5365 + \frac{.71(.71-2)}{2}\right]$$

$$= .699 \times .079 = .055$$

$$\bar{X}_1 = \frac{.844\,L(1.834 + .073)}{3(.917 + .073)} = .542\,L$$

$$\frac{.073}{.615\,L}$$

$$uL \times .4557 M_A L = .0364 M_A L \times .052L = .0019$$

$$.4178 M_A L \times .385L = .1606$$

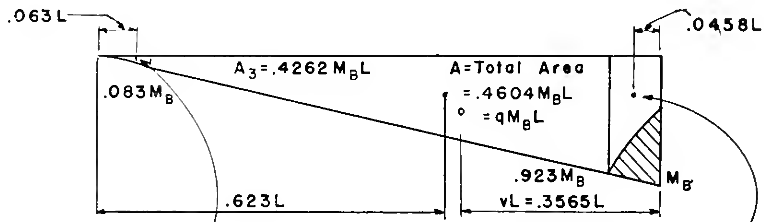
$$.0015 M_A L \times .945L = .0014$$

$$.4557 \qquad .1639 M_A L^2$$

$$uL = \frac{.1639\,L}{.4557} = 0.3604\,L$$

FIGURE A7

EXAMPLE 2 SLOPE DEFLECTION CONSTANTS FOR MEMBER Ab



$A_1 = M_B L\left[\frac{.083^2}{2(1.71)}\right] = M_B L \times .0020$

$A_2 = M_B L \times .073\left[\frac{2.71 - .073(1.71)}{2(1.71)^2}\right] = M_B L \times .0322$

$\frac{X_a}{L} = \frac{2(.71+1)}{.358}\left[.537 + \frac{.71(.71-2)}{2}\right] = .0626$

$X_1 = \frac{.844(1.854+.083)}{3(.927+.083)} = .540L$

$\frac{X_b}{L} = \frac{\frac{.073}{3.42}+\frac{.00533}{.3579}}{.439}\left[\frac{.71(2-.71)}{2} - .5365\right] = \frac{.0213 + .0149(-.079)}{.439} = \frac{+.0201}{.439} = .0458$

$vL \times .4603 M_B L = .0322 M_B L \quad .046L = .0015$

$.4262 M_B L \quad .377L = .1606$

$.0020 M_B L \quad .937L = .0019$

$.4604 \qquad .1640\ M_B L^2$

$vL = \frac{.1640L}{.4604} = .3565L$

Slope Deflection Constants

$p = .4557 \quad u = .3604 \quad 1-u-v = .284$

$q = .4604 \quad v = .3565$

$C_{AB} = \frac{.6435}{.4557 \times .284} = 4.98 \div 2 = 2.49$ $\qquad C' = \frac{.3565}{.1295} = 2.752 \div 2 = 1.376$

$C_{BA} = \frac{.6396}{.4604 \times .284} = 4.90 \div 2 = 2.45$ $\qquad C' = \frac{.3604}{.1306} = 2.76 \div 2 = 1.38$

Reference: See also Charts 79, 80 in "Rigid Frames", L.T. Evans, Edwards Bros, 1938, Ann Arbor, Mich.

FIGURE A8

Part 2

Analysis of Primary and Secondary Stresses in the Counterweight Trusses of a Heel Trunnion Bascule Bridge

By L. T. Wyly* and K. H. Lenzen**

Introduction

A number of failures, all very costly, in the counterweight trusses of the heel-trunnion type bascule bridge, have focused attention upon this type of structure and led to the assignment of the study of this problem to the Subcommittee on Stresses in Bridge Frames of AREA Committee 15. A first objective of such a study was the determination of the stresses in the structure. This consisted of two operations: stress measurement in the field, and the development of a reliable method of computation in the office, guided and checked by the field measurements. Field measurements have been taken by the AAR research staff on five bridges and are reported in Part 5. The method of computation proposed in Part 1 is applied to the 219 ft-4 in span of the Illinois Central Railway bridge W2—43N over the South Branch of the Chicago River. See Fig. 1. Previous to remodeling in 1928, the span was 260 ft and the bridge was the largest and heaviest structure of this type ever built. Fairly complete stress measurements on the counterweight trusses were taken by the AAR research staff in 1949 and are reported on in Part 5.

Method of Stress Analysis

The procedure used in analyzing the counterweight truss of Illinois Central Railway bridge W2—43N is the equivalent gusset method presented in Part 1. The steps used were those shown in Figs. 8 to 12, incl., of that paper.

The following assumptions were made:

1. Joints 35 and 36 are restricted against rotation. The size of the counterweight steel frame members was of about the same magnitude as those of the truss, and the concrete counterweight almost touched the lower flange of 35-36 and was in contact with the flange at the joints. The gussets outside the members of joints 35-36 were buried in the concrete. Therefore, in order for these joints to rotate, the whole counterweight would have to deform. The stiffness of the counterweight is so large as compared to the truss member that the rotation was taken as negligible. This was substantiated by strain measurements on member 35-36 taken by the AAR.
2. Member 35-36 was assumed to carry half the calculated axial load as a result of the concrete encasement. The AAR strain measurements indicated this to be the case.
3. The stiffness of the light secondary truss members was neglected. These were members 36-35′, 34-34′, and 33-34′. The main truss members were at least 200 times as stiff, and in some cases as much as 400 times as stiff. The amount of error due to this omission should be negligible.

---

* Research professor of structural engineering and head of department, Purdue University.
** Instructor in civil engineering and research assistant, Purdue University.

4. In calculating the axial deformation of member, it was assumed that the gross area of member acts throughout the length center-to-center of joints to carry the stress.
5. The equivalent gusset is assumed to begin where the I is five times that of the member, i.e., $r = 5$. No deformation is assumed to occur within the equivalent gusset. Fig. 2 of Part 1 illustrates the effect of this assumption.
6. The weights of steel were computed from shop drawings. The weight and center of gravity of the concrete counterweight were computed from the shop and design drawings. These were assumed to be correct. No information on these weights was found available from either railroad or fabricators.

The procedure used in the calculations is the following:

1. The dead loads of the truss and counterweight and the center of gravity of the counterweight were computed. The loads are shown in Fig. 2.
2. The primary or axial stresses in the members for the closed and fully open condition are shown in Fig. 2.
3. The properties of the members and the slope deflection constants are shown in Figs. 3, 4, and 8.
4. The Williot diagrams were drawn (Figs. 6 and 7) and the values of Δ for each member were scaled from these diagrams. The values of $\frac{SL}{A}$, and $\frac{\Delta}{L_c}$ were then computed. (Fig. 5).
5. The analysis was completed for the closed and fully open positions by following through three complete steps the procedure outlined in Figs. 8 to 12, incl., of Part 1. These computations are shown in Figs. 9 through 17 of Part 2. In all cases the solution was by successive approximations.
6. The variation in stresses from the closed to fully open condition was computed at the gage lines used by the AAR in making strain measurements. The calculated stresses are compared to the measured stresses in Figs. 19 and 20. See Figs. 16 and 17. See also Figs. 2 and 3 of Part 5.

Discussion

In order to calculate the secondary stresses within the counterweight truss of a large bascule bridge it is necessary to refine the method beyond that usually used. The evaluation of the change in I throughout the length of the members, the equivalent gussets, and the slope deflection constants based on a variable I, must be determined. Part 1 presents in the Appendix curves and formulas so that the equivalent gusset and slope deflection constants can be easily found.

Step 1 consists of the usual procedure of calculating the secondary bending moments by slope deflection method, using values of Δ for each member scaled from the Williot diagram and basing I/L on the clear span length. See Fig. 8 of Part 1. The same results would be obtained by moment distribution. Note that these secondary moments occur at the ends of the clear spans of the members, i.e., at the faces of the equivalent gussets. See Fig. 8(b) of Part 1. See also Figs. 10 and 13, Part 2.

Step 2(a) consists of computing the additional bending which occurs in each member due to displacements Δ_{1ab}, etc., at the faces of the equivalent gussets as a result of the joint rotations θ_1 at the end of Step 1. See Fig. 9(a), (b), of Part 1.

Step 2(b) consists first of computing the unbalanced moment ΣM_2J about the center of each joint due to the shears V_1 of Step 1 and $V_2 \frac{\Delta}{L}$ of Step 2(a) and due to moments $M_2 \frac{\Delta}{L}$ and second in computing the moments M_{20} which occur as a result of the above unbalanced joint moments. See Fig. 10 of Part 1.

Ordinarily the analysis would stop at the completion of Step 2(b), when the moments M_1, $M_2 \frac{\Delta}{L}$ and M_{20} would be added up together. In this example the work has been carried through Step 3 to show the small effect of Step 3. It should be noted that for this large bridge the total error in the moments involved in stopping at the end of Step 2(b) would not exceed 8 percent; a value usually sufficiently accurate for design purposes. Note also that the moments at the end of Step 1 are low as much as 25 percent in this bridge.

In Figs. 16 and 17 the total moments for all three steps are shown, together with computed bending stress for extreme fiber and direct stress. The values of gross area A and gross section modulus I/c shown in Fig. 3 are for the main material. Near the ends of the members the unit stresses are affected by material added for splicing, etc., and this has been taken into account in showing the unit stresses.

Comparison of Computed with Measured Stress Changes

The stress measurements taken on this bridge by the AAR research staff necessarily are due to change of stress from one position of opening to another. The stresses shown in Figs. 16 and 17 are computed static stresses at the extreme cases of fully closed and fully opened positions. A comparison of computed with measured stress change during this opening is given in Fig. 19 for member 36-32 at section 1-1 of Fig. 2 of Part 5. The change in stresses is given in Fig. 20 for member 36-34 at section 5-5 of Fig. 3 of Part 5. It will be noted that the agreement is very satisfactory. In the case of member 36-34 the measured stresses are a little smaller than the computed stresses. Inspection of the design details at this point shows that there is probably a little local elastic yielding in the gussets due to the fact that this member is cut outside the joint, and the gussets carrying the bending are relatively narrow. These gussets carry the total bending without any stiffening over a length of about 9 in. This local yielding just outside joint 36 would reduce the bending stress in the member a little, and this probably accounts for the discrepancy between calculated and measured stresses here.

High Local Stress and Range of Stress

The computed and measured stresses considered above are acting on the gross section. The range of stress is greatest at the lower face of 36-32 just at the edge of the gusset at joint 36. At Section 1-1 this stress varies from about 1400 psi in compression in the closed position to about 21,050 psi in tension in the fully open position. At the edge of the gusset at joint 36 the stress at the lower flange of 36-32 is computed to vary from about 2300 psi in tension for the closed position to about 28,800 psi in tension for the open position, as shown in Figs. 16 and 17. Actually, however, the stress at this particular section is considerably greater than the above, since some reinforcing material on the left end of 36-32 is cut at the edge of the gusset. The stress on the gross section probably varies from about 1000 psi in tension for the closed position to about 32,000 psi in tension for the fully open position, giving a range of unit stress on the gross section of about 31,000 psi during the full opening of the bridge. Through the rivet hole near the extreme fiber of this section the strain would be greatly increased, particularly if the rivet bears on the material in the hole. The range of the stress at the lower flange at the edge of the gusset at joint 36 is the greatest of any point in the counterweight truss.

Fatigue Failures

It is not surprising that where fatigue failures in these counterweight trusses have occurred the location of the start of the crack has traditionally been at the lower flange of the member corresponding to 36-32 in this bridge, at the end near the counterweight. It is significant that in at least one case of failure of a railway bascule the fatigue crack started through the rivet hole at the edge of the gusset at the gage line farthest from the neutral axis on the lower flange (see Fig. 21). This is analogous to the location of failure in the floorbeam hangers. It is also not surprising that where the range in unit stresses is as large as it is at the critical points in these counterweight trusses that relatively few cycles are required to produce failures and that there have been a number of failures.

S–N Curves for Riveted Joints

An S-N curve for single lap joints of steel complying with the requirements of A7 steel and connected by bolts transmitting load in full bearing and having no clamping force is shown in Fig. 23, with test results listed in Fig. 22, Table 2. The loading was in tension only[1]. The combination of high rivet bearing in a single lap joint produces very high stress and strain concentrations at the sides of the rivet holes. See for example Fig. 19 and Table 1 of Professor Carter's paper: "Stress Concentration in Built-Up Structural Members"[2].

In Part 5, Fig. 18, the AAR research staff gives an S-N curve for riveted joints symmetrically arranged; i.e., having splice plates on both sides of the main plates. For this condition, as long as the rivet clamping is good, the rivet bearing stress is more or less uniform across the plates and consequently the plates are free from the very high local bearing strains at the contact face of the plate which occur in single lap joints with no clamping. A comparison of these two curves, Fig. 23 of Part 2 and Fig. 18 of Part 5, shows plainly the marked reduction in fatigue strength which occurs due to the bearing stress in a single lap joint, without clamping.

For the bridge studied in this paper, and probably for most other bridges of this type, the gusset connections to the bottom chord member at the point of greatest stress (joint 36 in this case) are rigidly held by embedment in concrete and may be expected to exert a fairly high bearing stress on the rivets connecting the gussets to the member. The connection is usually a single lap connection. In most cases this is probably the critical point of the member so far as fatigue strength is concerned. See Fig. 21.

While it is probably true that the high bearing strain at the side of the holes only occurs when clamping force is low or absent, there is still no way of making sure that the high clamping force is present in the rivets connecting the gussets to the members at the point in question. Furthermore, the tests reported in Fig. 23 were for carefully bored holes free from the local irregularities which frequently occur in ordinary fabricated work even though of fairly high grade and which may be expected to reduce the fatigue strength below that for the bored holes used by Wyly and Carter.

---

1 Progress report to AREA Committee 15, Oct. 17, 1951, by L. T. Wyly and J. W. Carter.

2 AREA Proceedings, Vol. 53, 1952, pp. 22, 23.

It would seem to be on the side of safety, therefore, to base an estimate of the fatigue strength of the member upon the curve given in Fig. 23 for single lap joints with bolts in bearing and without clamping.

Suggested Remedial Measures

The authors of Part 2 believe that the high local stress concentration due to rivet bearing, which is undoubtedly one of the causes of the failure of the critical members of the counterweight trusses in any heel trunion bascule bridge, can be eliminated by the same remedy as is proposed for the floorbeam hangers; i.e., by the replacement under proper controls of the two lines of rivets at the edges of the gussets at the critical point by high-tensile non-bearing bolts. Where the critical members are composed of built channels each having several thicknesses of web plates, as in the case with the bridge analyzed in this report, there might be some question still, since no tests have so far been made where high-tensile bolts have connected several thicknesses of metal to one gusset or splice on one side. For the smaller members, where only one web and one flange angle are involved, the use of bolts should at least defer fatigue failures and may possibly prevent them altogether, where the number of full openings is small.

It should be recognized that in many cases severe local stresses may be present due to poor detailing or other causes which are not revealed by analysis dealing with bending in the vertical plane. For example, local bending in a horizontal plane was found by the AAR in this bridge. This is similar to the local bending found on the tie-plated hangers of the Illinois Central Railway bridge at Galena, Ill.[3] Examination of Figs. 19 and 20 will show that for these laced members a plane section across the member before bending did not remain a plane section after bending. Poor arrangements for carrying counterweight loads into the main trusses, where the counterweight hangs between the trusses, might be more serious.

It is suggested that a program of tests of the action of high clamping bolts, used to connect several thicknesses of plate to a splice or gusset plate located on one side of the member, would be of assistance in this matter.

The authors feel that it may be possible in present bridges to delay or avoid these failures in the future by making careful individual studies for each bridge.

Acknowledgment

Checking of calculations for the dead load weights of steel trusses and concrete counterweight was done by S. J. Bhatt. Checking of calculations for primary stresses, Williot diagrams, basic equations and of secondary moments for Step 1 was done by J. A. Ausbeck and R. F. Thurgood. The specimens and specimen holders for the tests shown in Table 2 and Fig. 23 were generously donated by the Wisconsin Bridge and Iron Co.

[3] AREA Proceedings, Vol. 51, 1950, p. 51.

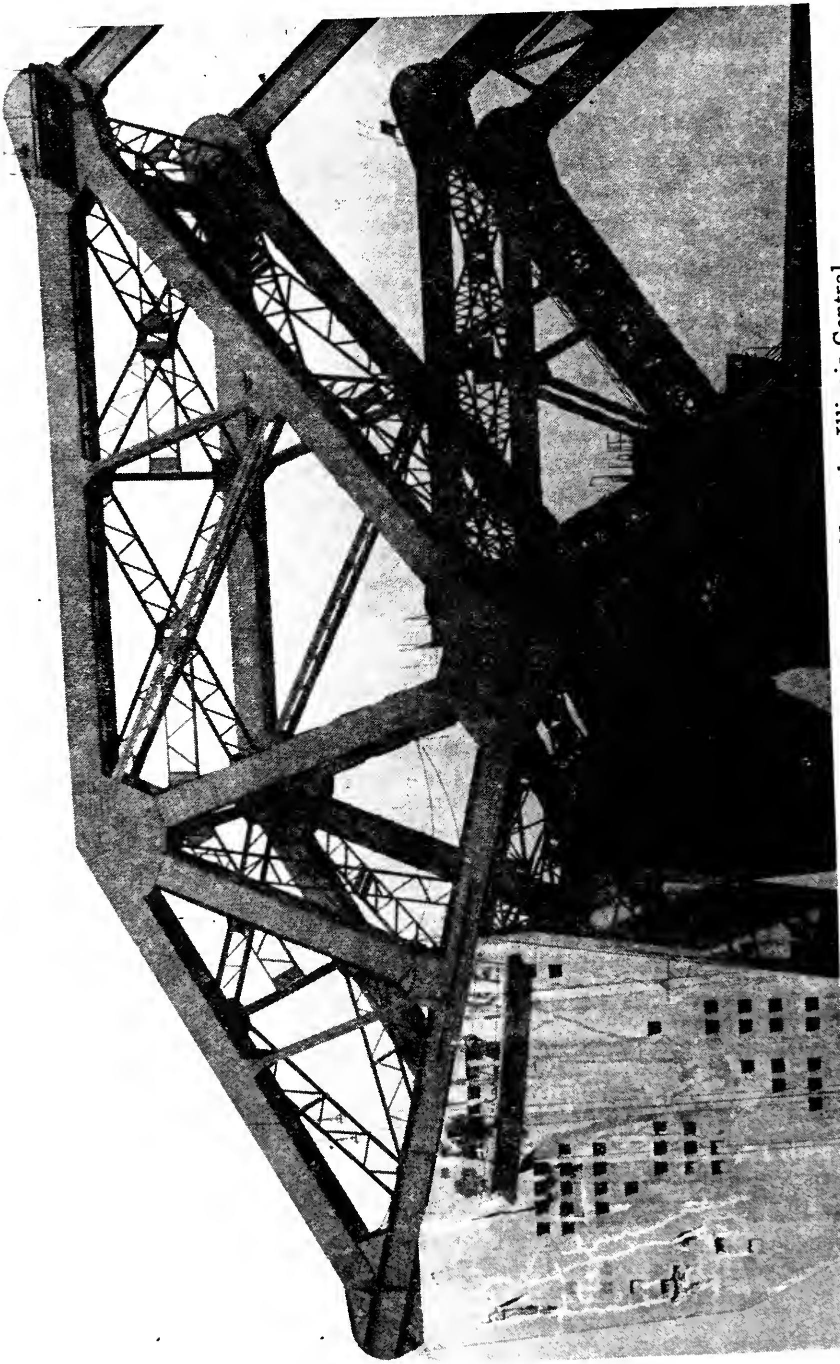


Fig. 1—Photograph of bascule bridge No. W2–43 N on the Illinois Central.

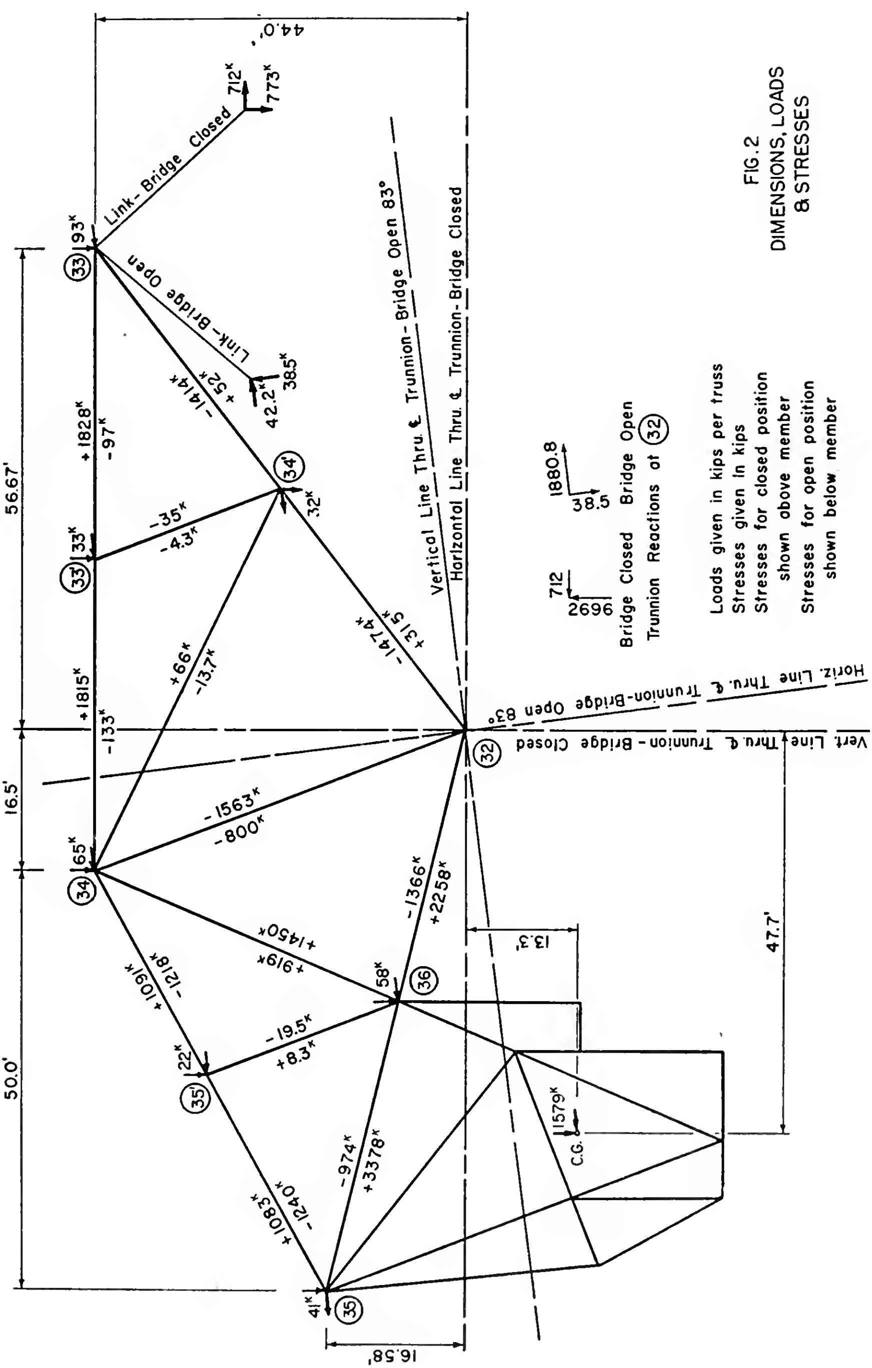


FIG. 2
DIMENSIONS, LOADS & STRESSES

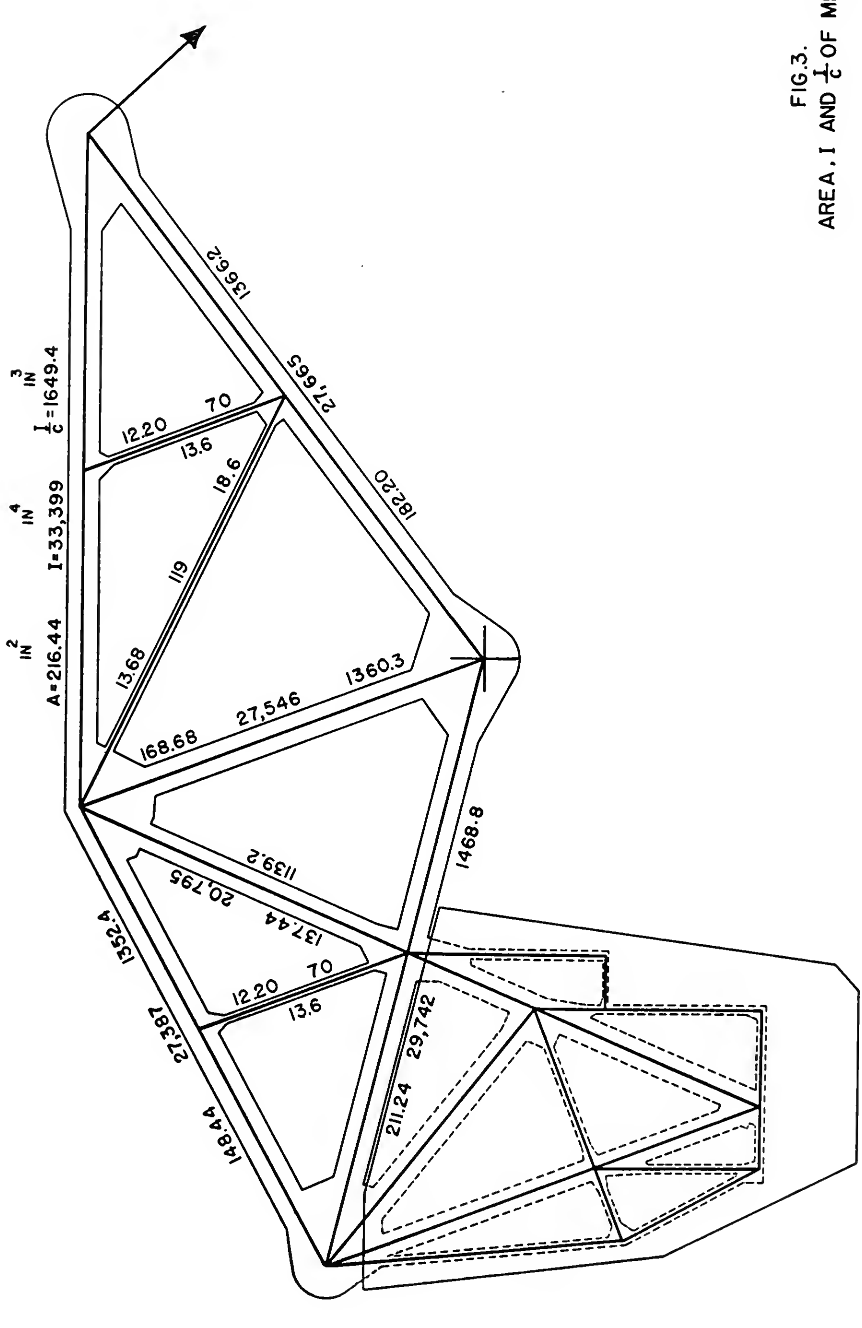


FIG. 3.
AREA, I AND $\frac{I}{c}$ OF MEMBERS

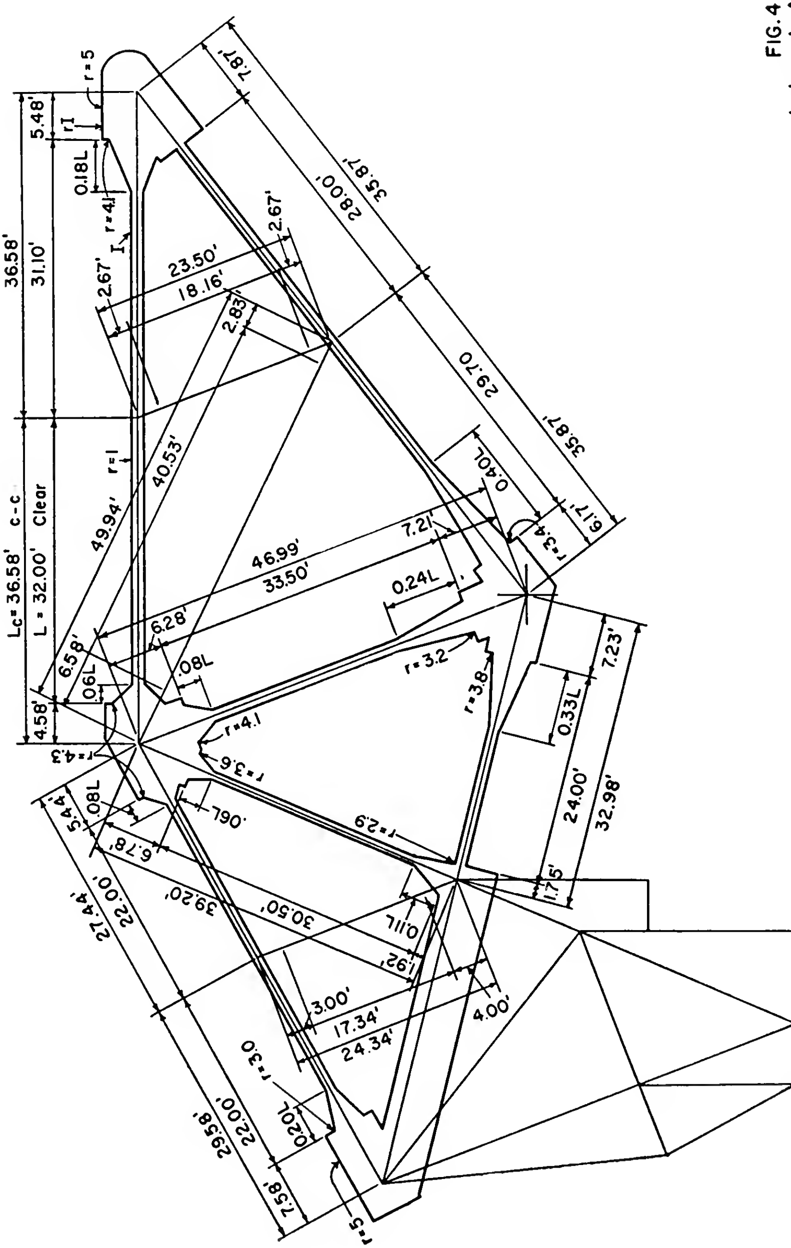
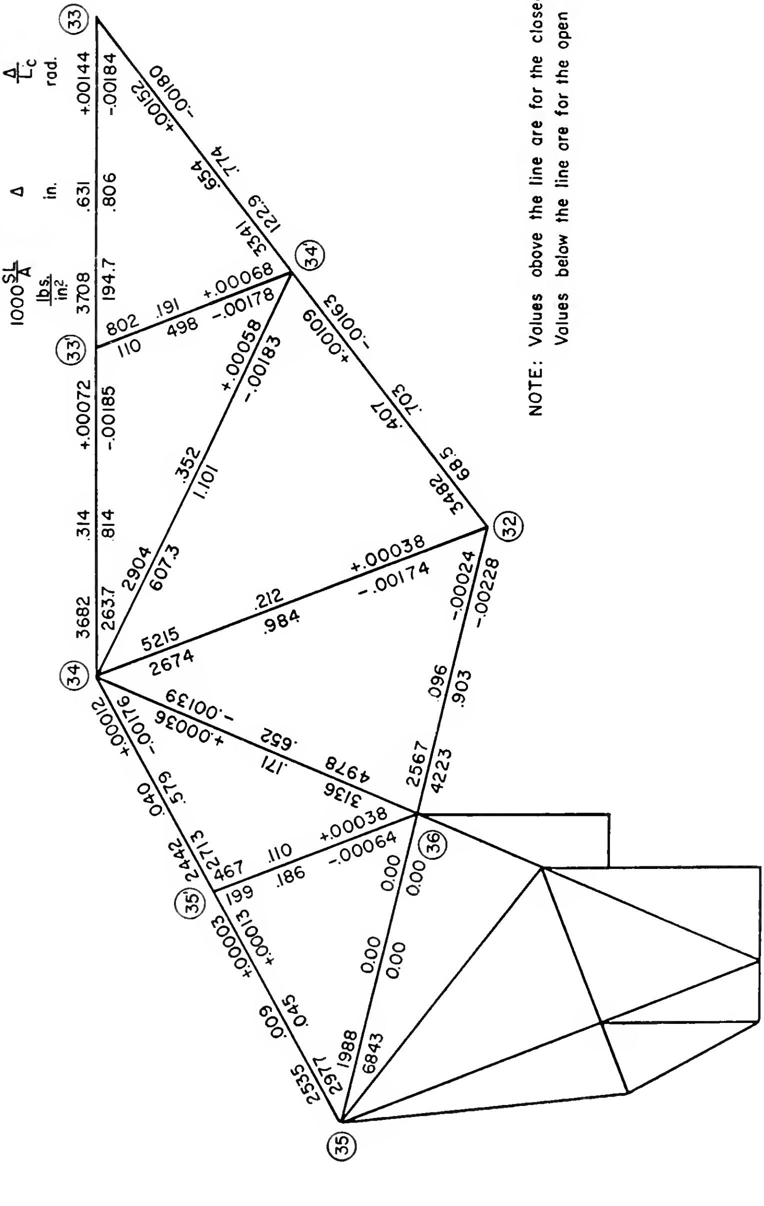


FIG. 4
L, Lc, aL AND r
WITH EQUIVALENT GUSSETS



NOTE: Values above the line are for the closed position.
Values below the line are for the open position.

FIG. 5.
$\frac{SL}{A}$, Δ AND $\frac{\Delta}{L_c}$
CLOSED AND OPEN POSITIONS

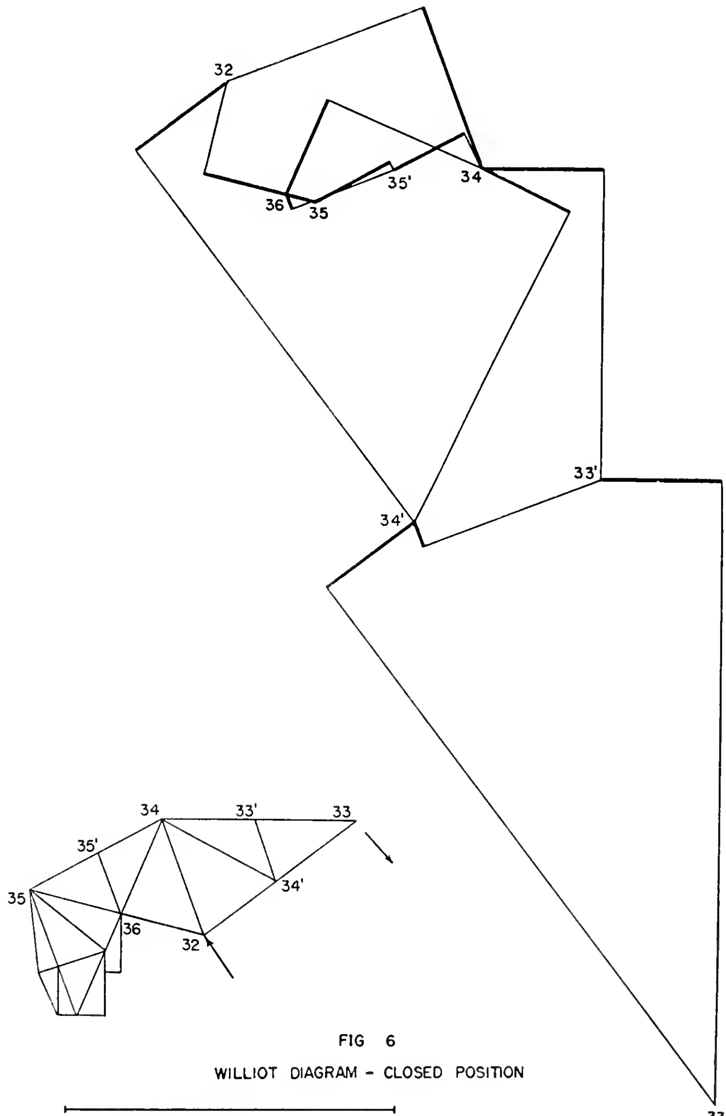


FIG 6

WILLIOT DIAGRAM - CLOSED POSITION

SCALE: 10,000 $\frac{SL}{A}$

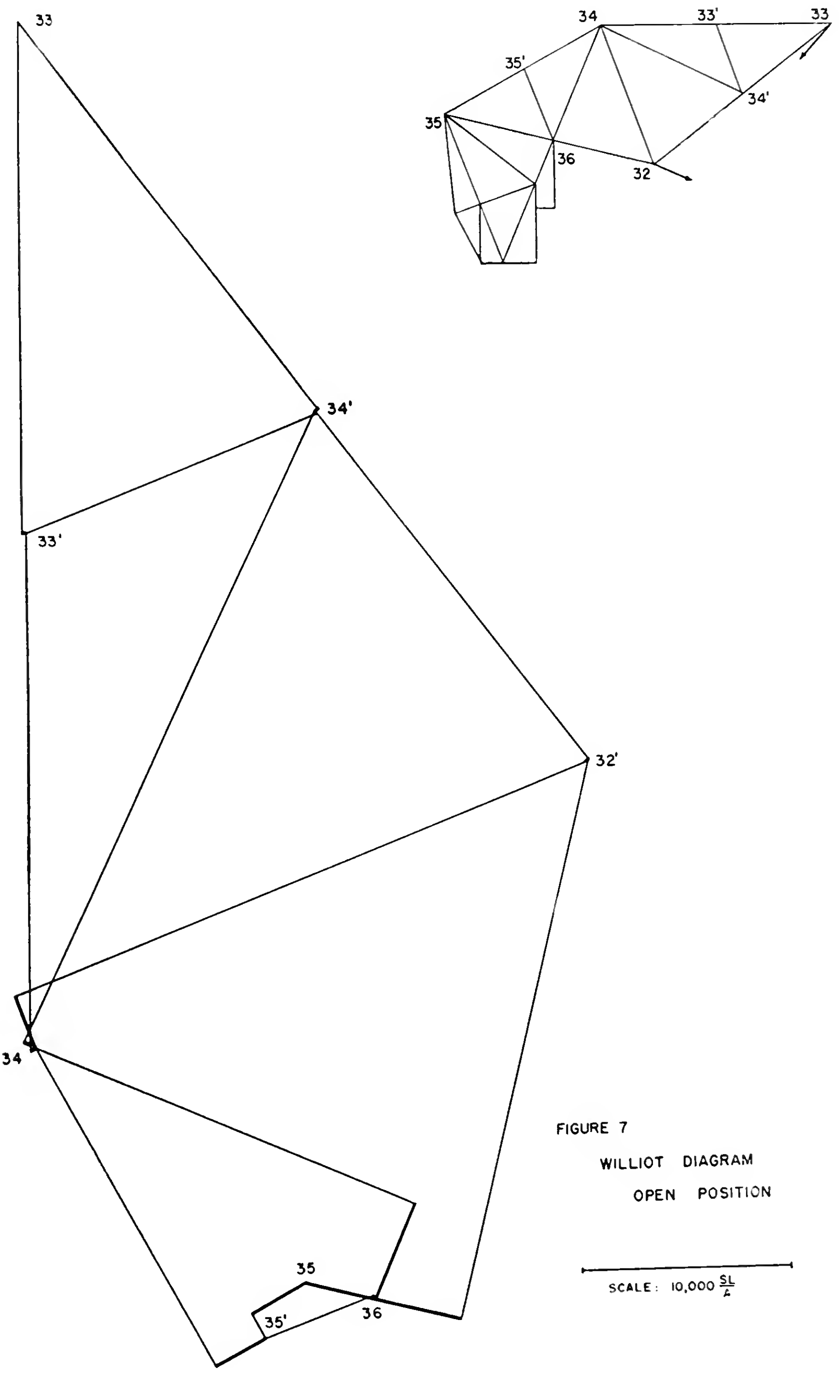


FIGURE 7

WILLIOT DIAGRAM

OPEN POSITION

SCALE: 10,000 $\frac{SL}{A}$

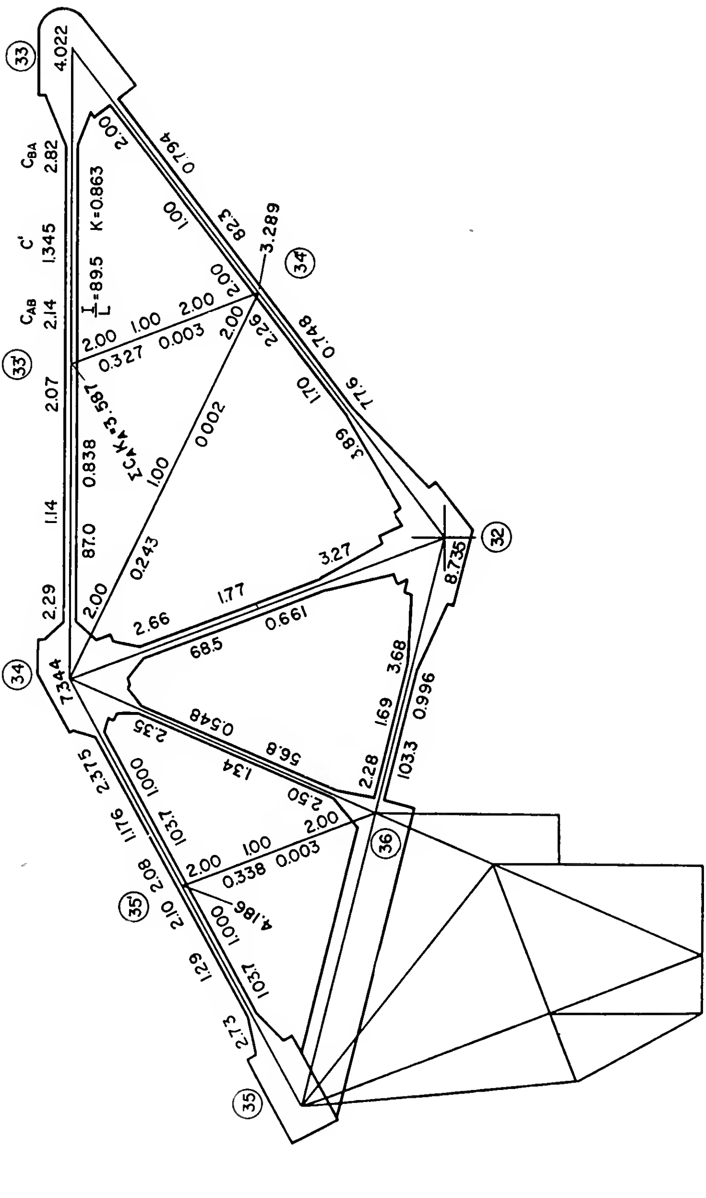


FIG. 8
$\frac{I}{L}$, K AND SLOPE DEFLECTION CONSTANTS

TABLE: I EQUATIONS AND SOLUTIONS BY SUCCESSIVE APPROXIMATIONS

Joint	Variables $\theta_{35'}$	θ_{34}	θ_{32}	$\theta_{34'}$	$\theta_{33'}$	θ_{33}	= Constant: Joint Unbalance $\Sigma M_1 \frac{\Delta}{L} = \Sigma K(C+C')\frac{\Delta}{L_c}$ Closed	Open
Equations	1.0	.2809					.0001185	−.0012652
	.1601	1.0	.1593	.00003	.1300		.0005909	−.0026531
		.1339	1.0	.1456			.0005197	−.0028400
		.0006	.3869	1.0	.0009	.2415	.0020861	−.0027807
		.2662		.0008	1.0	.3237	.0017491	−.0029345
				.1974	.2887	1.0	.0021872	−.0027103
Trial	Bridge Closed							
1	.0000050	.0004039	.0002290	.0016251	.0011439	.0015362		
2	.0000004	.0004058	.0002264	.00016262	.0011378	.0015377		
3	.0000045	.0004048	.0002286	.0016250	.0011420	.0015367		
4	.0000048	.0004046	.0002289	.0016252	.0011426	.0015365		
Trial	Bridge Open							
1	−.0005748	−.0019456	−.0023972	−.0013812	−.0017914	−.0019205		
2	−.0007186	−.0019256	−.0023784	−.0013939	−.0017938	−.0019173		
3	−.0007243	−.0019237	−.0023792	−.0013944	−.0018001	−.0019154		
4	−.0007248	−.0019234	−.0023794	−.0013948	−.0018013	−.0019149		

FIG. 9: STEP I, θ VALUES

EQUATIONS

$M_{IAB} = 2E$

$\theta_{IA} = \frac{\Sigma K_{A}}{}$

NOTE: E tal

M_1 {35-35'=207.4; 35'-35=207.; 35'-34=20; 34-35'=2

M_1 {36-34=1; 34-36=1

EQUATIONS (See Fig 8 Part I)

$$M_{1AB} = 2E\frac{I}{L}_{AB}\left[(C_{AB}+C')\frac{\Delta}{L_C}_{AB} - C_{AB}\theta_{1A} - C'\theta_{1B}\right]$$

$$\theta_{1A} = \frac{\Sigma K_A (C_{AB}+C')\frac{\Delta}{L_C}_{AB}}{\Sigma K_A C_A} - \frac{\Sigma K_{A_1} C' \theta_{1C'}}{\Sigma K_A C_A}$$

NOTE E taken as 30,000,000 psi

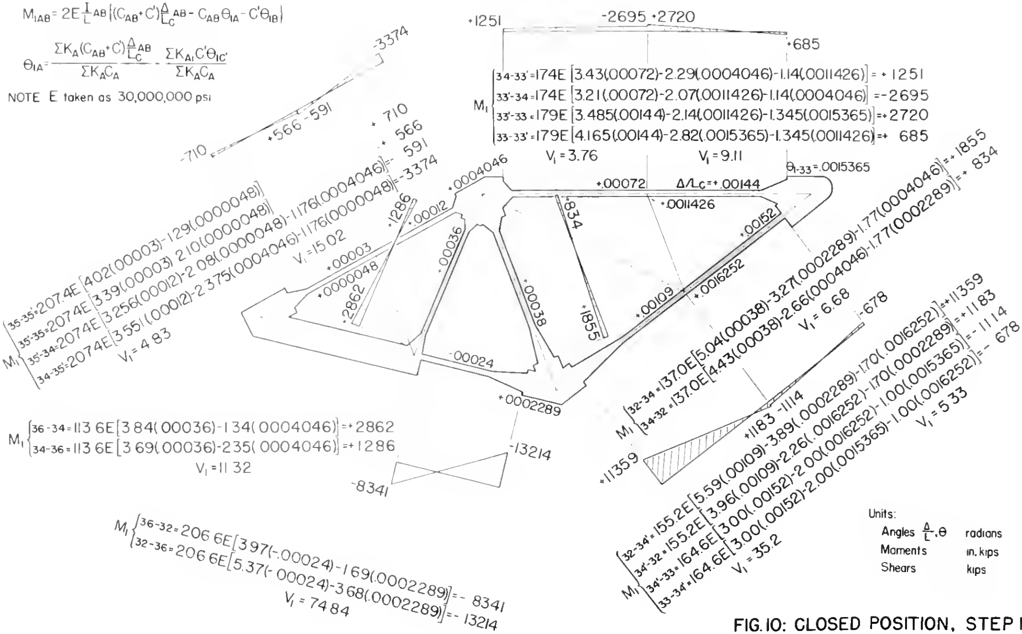


FIG. 10: CLOSED POSITION, STEP 1

UNB

I

3

5

7

M

M

M

M

2

4
6
8

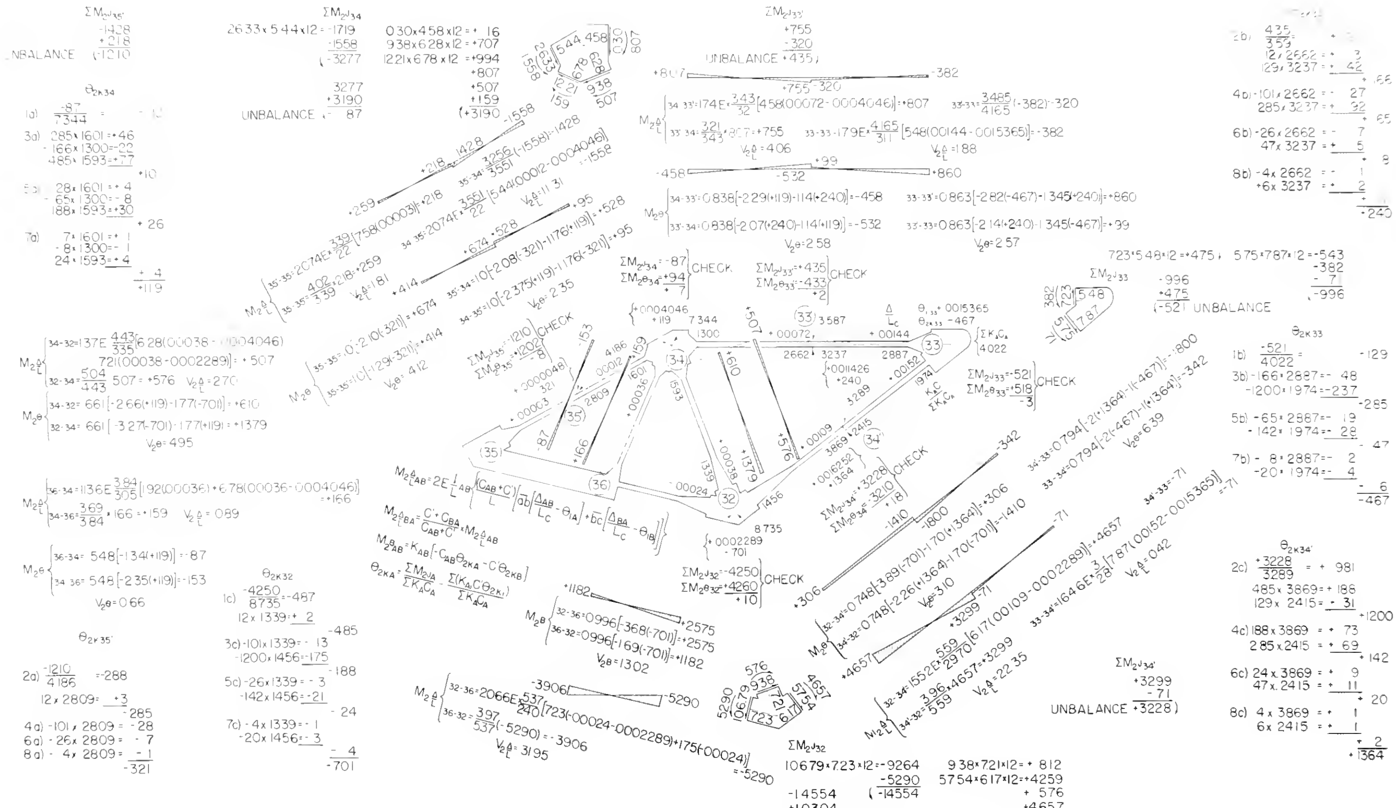


FIGURE 11 CLOSED POSITION STEP 2

UNB

la)

3a)

5a)

M₂

M

M

M

2

4
6

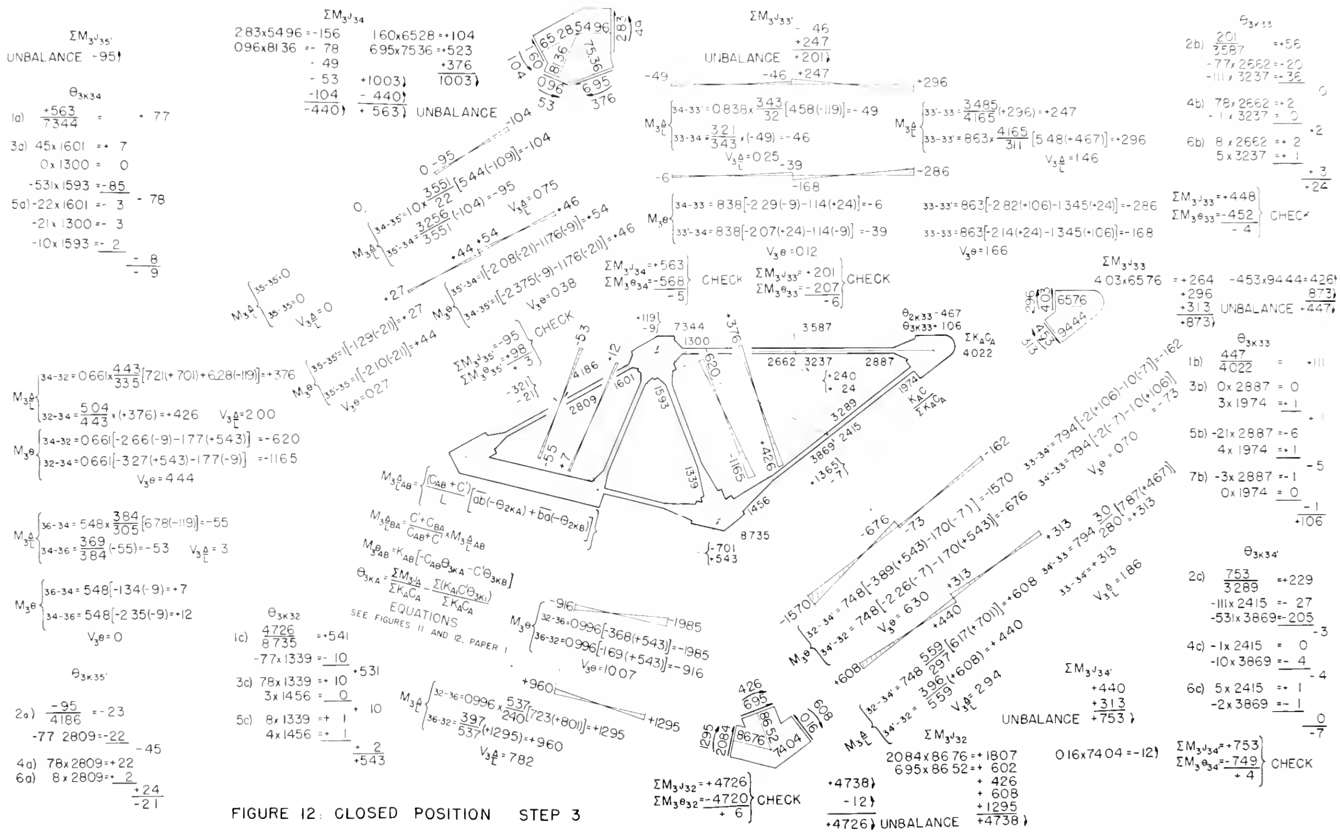


FIGURE 12: CLOSED POSITION STEP 3

EQUA

M_{1A}

Θ_{1A}

NOTE

$M_1 \begin{cases} 35-35' \\ 35'-3 \\ 35' \end{cases}$

$M_1 \begin{cases} 3 \\ 3 \end{cases}$

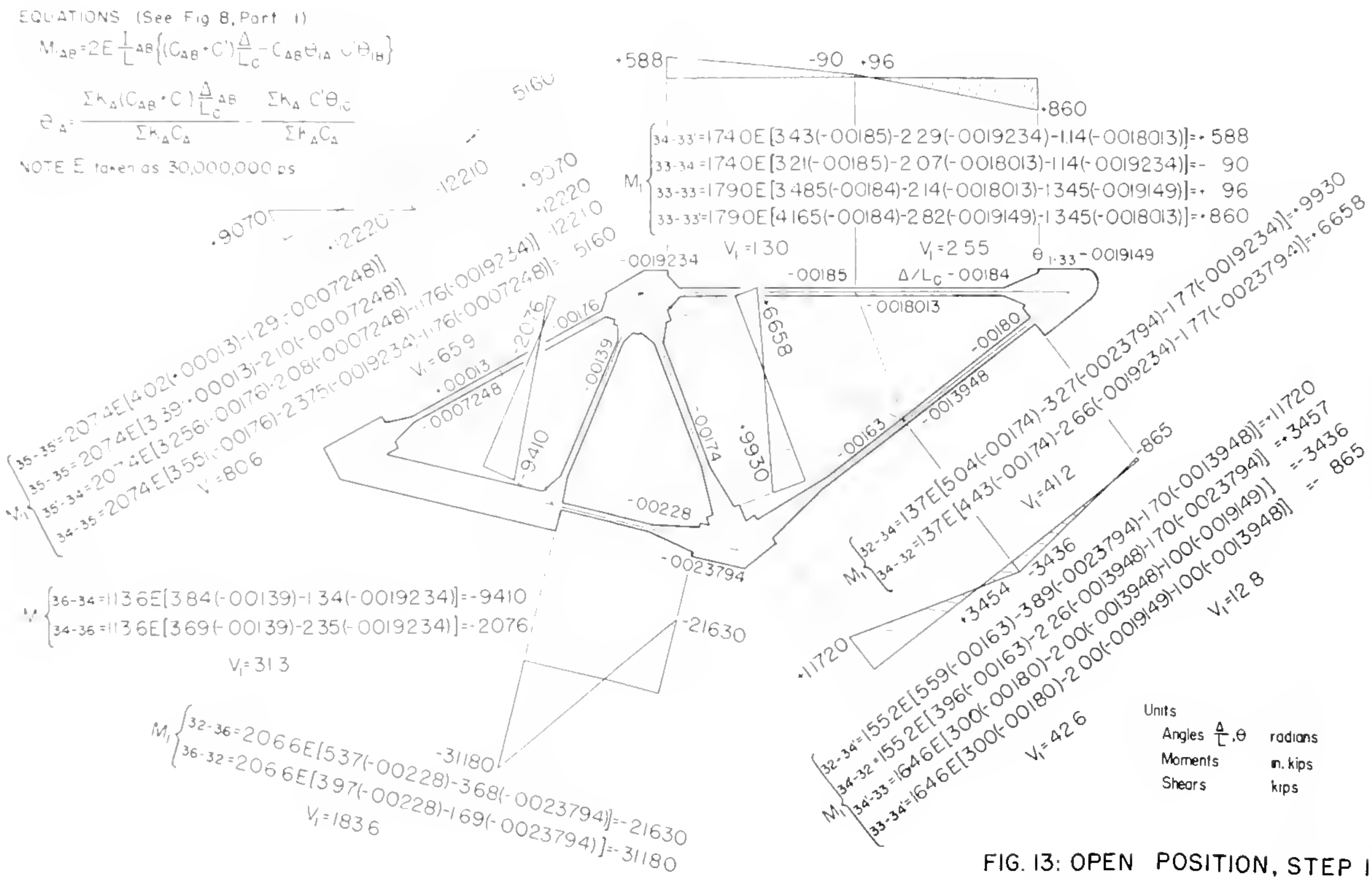


FIG. 13: OPEN POSITION, STEP 1

TABLE: I EQUATIONS AND SOLUTIONS BY SUCCESSIVE APPROXIMATIONS

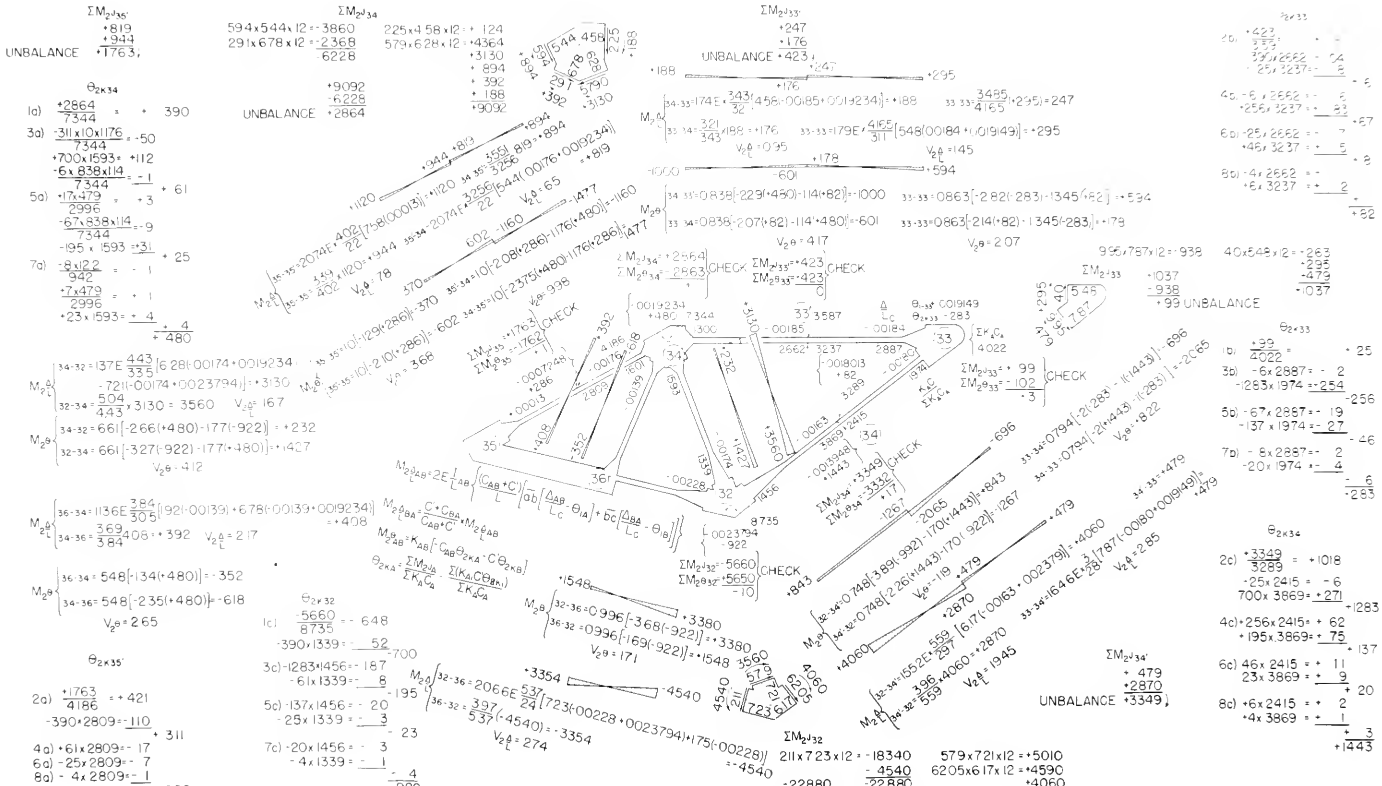


FIGURE 14 OPEN POSITION STEP 2

UNE

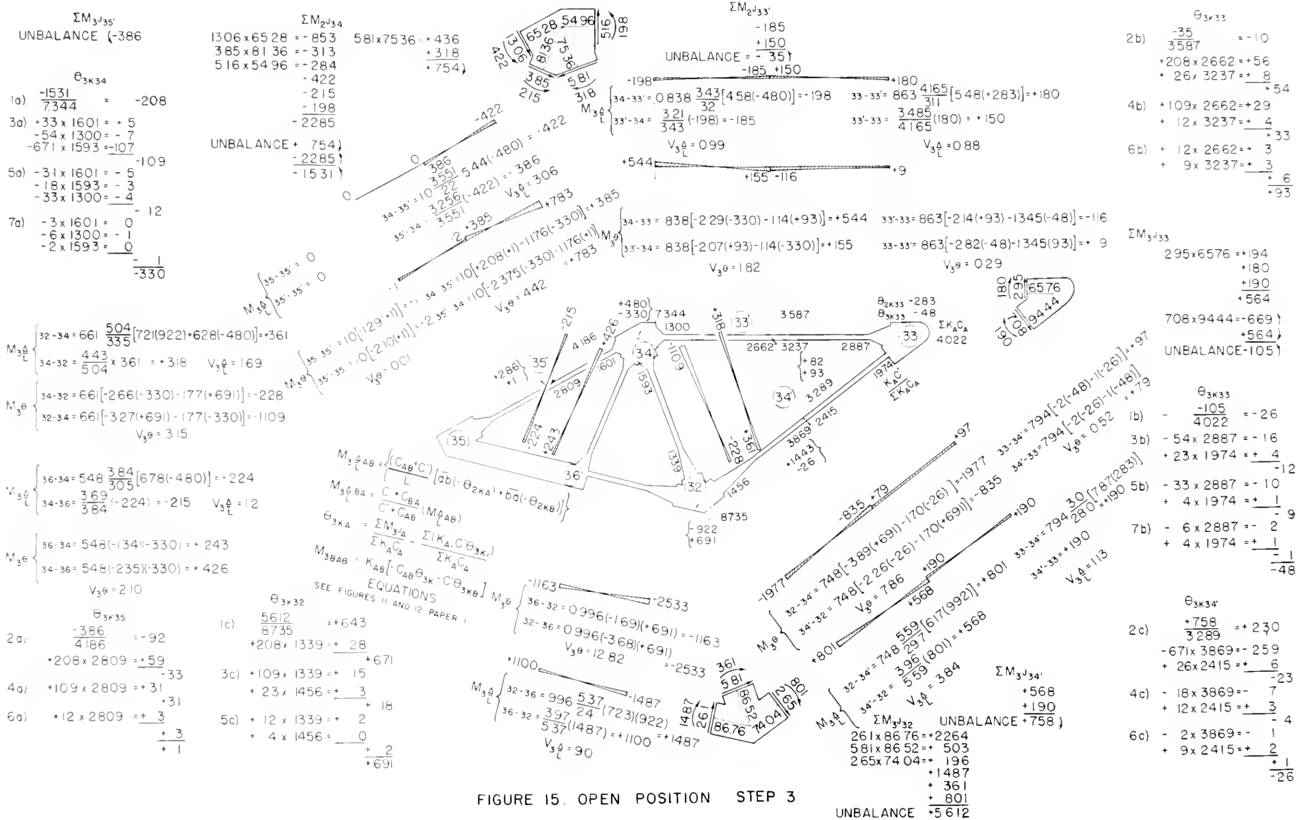


FIGURE 15. OPEN POSITION STEP 3

UNBALAN

1a) $\frac{-1531}{7.344}$

3a) +33 x.1
-54 x.1
-671 x.1

5a) -31 x.1
-18 x.1
-33 x.1

7a) -3 x.1
-6 x.1
-2 x.1

$M_3\frac{\Delta}{L}$ { 32-34 / 34-32

$M_3\theta$ { 34-32 / 32-34

$M_3\frac{\Delta}{L}$ { 36-34 / 34-36

$M_3\theta$ { 36-34 / 34-36

2a)
+20

4a) +10

6a) +12

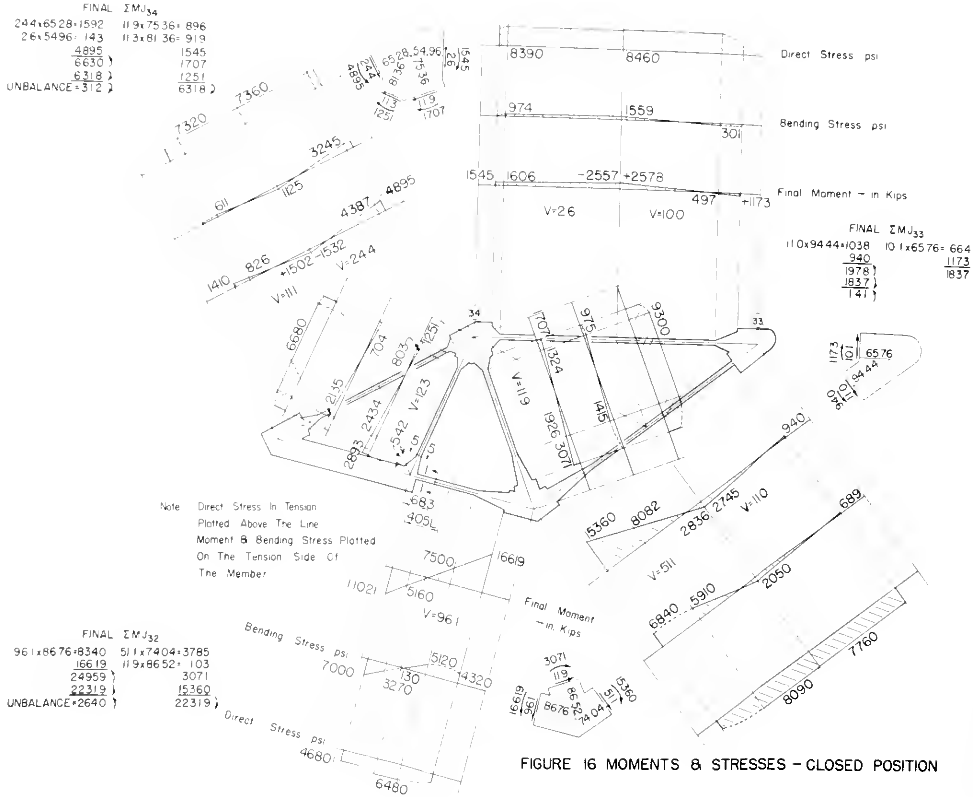


FIGURE 16 MOMENTS & STRESSES – CLOSED POSITION

24.4x6
2.6x5

UNBAL/

96.1

UNBA

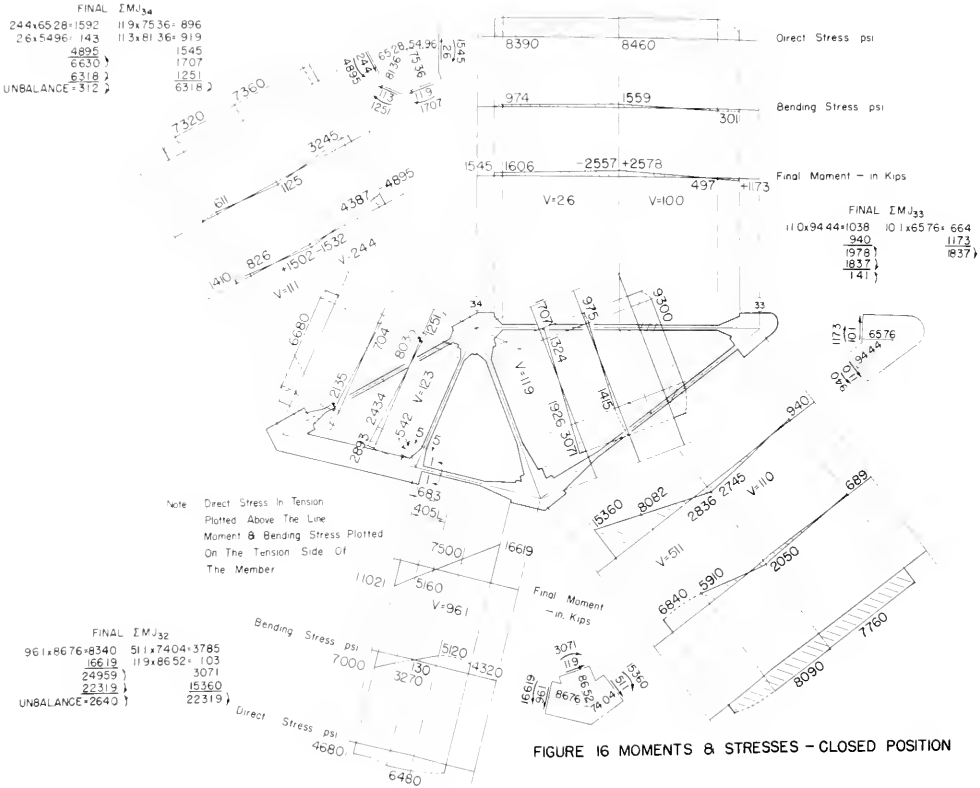


FIGURE 16 MOMENTS & STRESSES – CLOSED POSITION

67.9x
31.2x
1.1 x

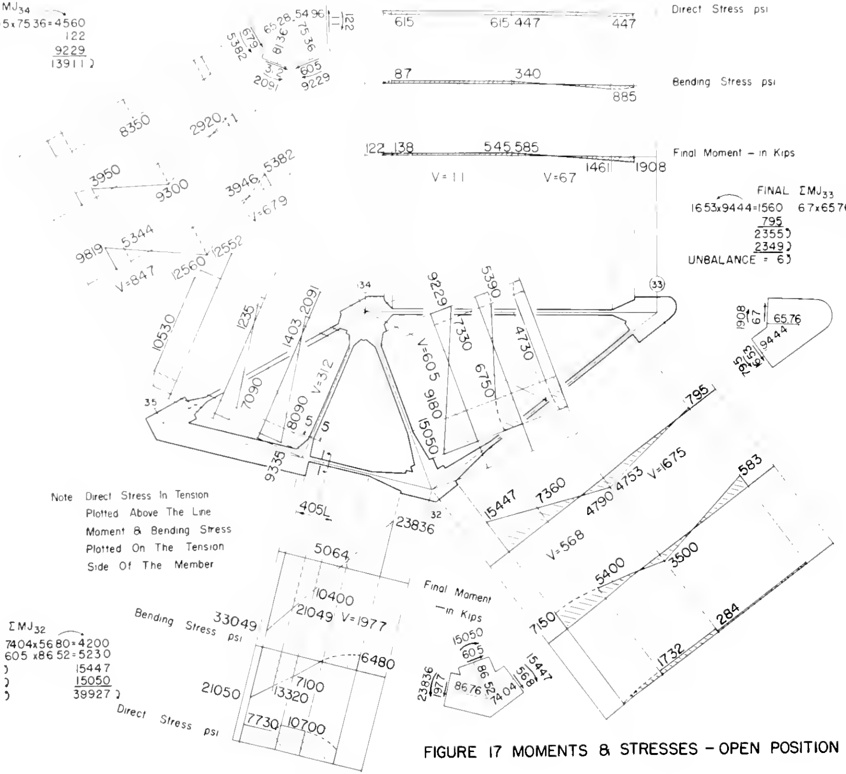
UNBA

197

UNE

FINAL ΣMJ_{34}

679x65 28=4430 605x75 36=4560
312x81 36=2540 122
11x5496= 60 9229
5382 13911)
2091
14503)
13911)
UNBALANCE = 592)



FINAL ΣMJ_{33}

1653x9444=1560 67x6576=441
795 1908
2355) 2349)
2349)
UNBALANCE = 6)

Note Direct Stress In Tension
Plotted Above The Line
Moment & Bending Stress
Plotted On The Tension
Side Of The Member

FINAL ΣMJ_{32}

1977x8676=17140 7404x5680=4200
23836 605 x8652=5230
40976) 15447
39927) 15050
UNBALANCE = 1049) 39927)

FIGURE 17 MOMENTS & STRESSES – OPEN POSITION

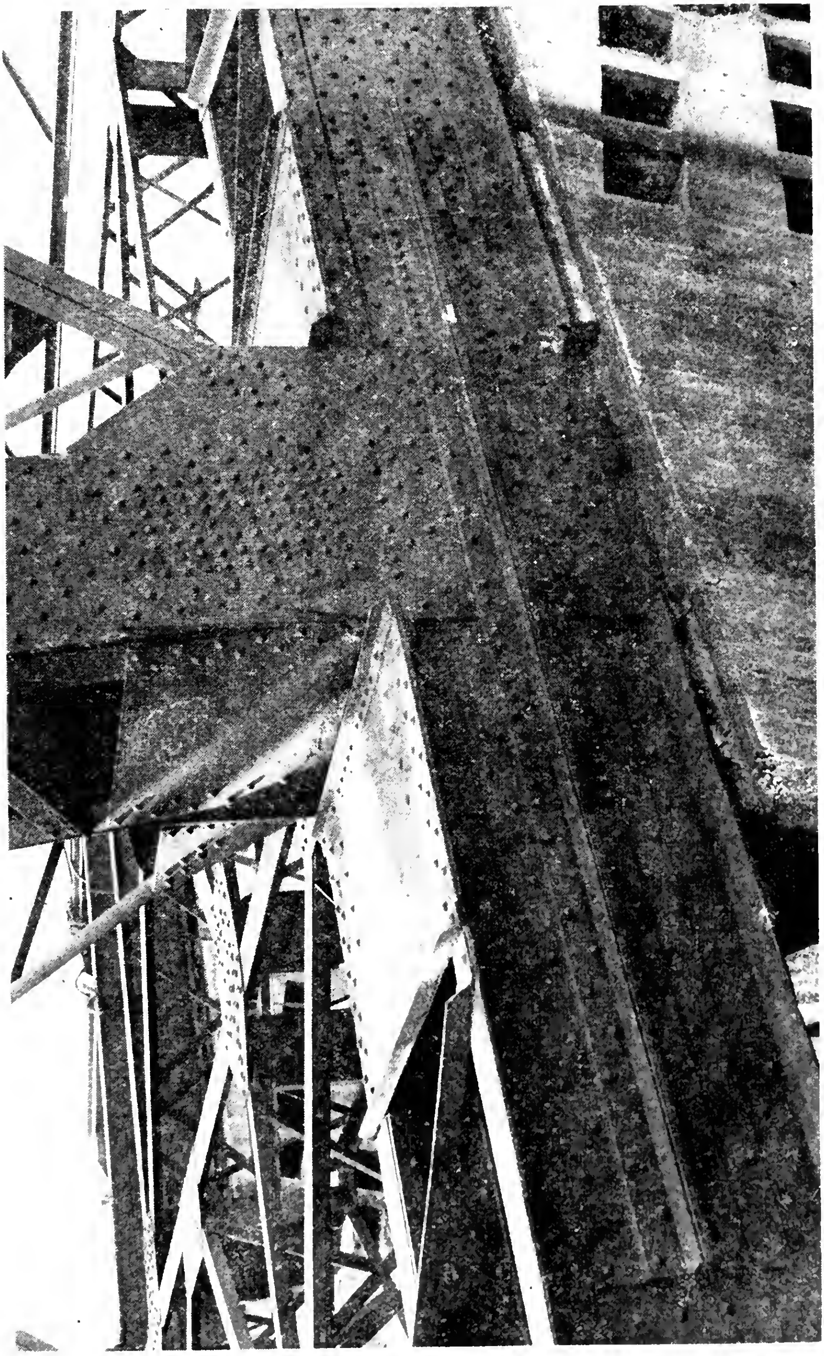
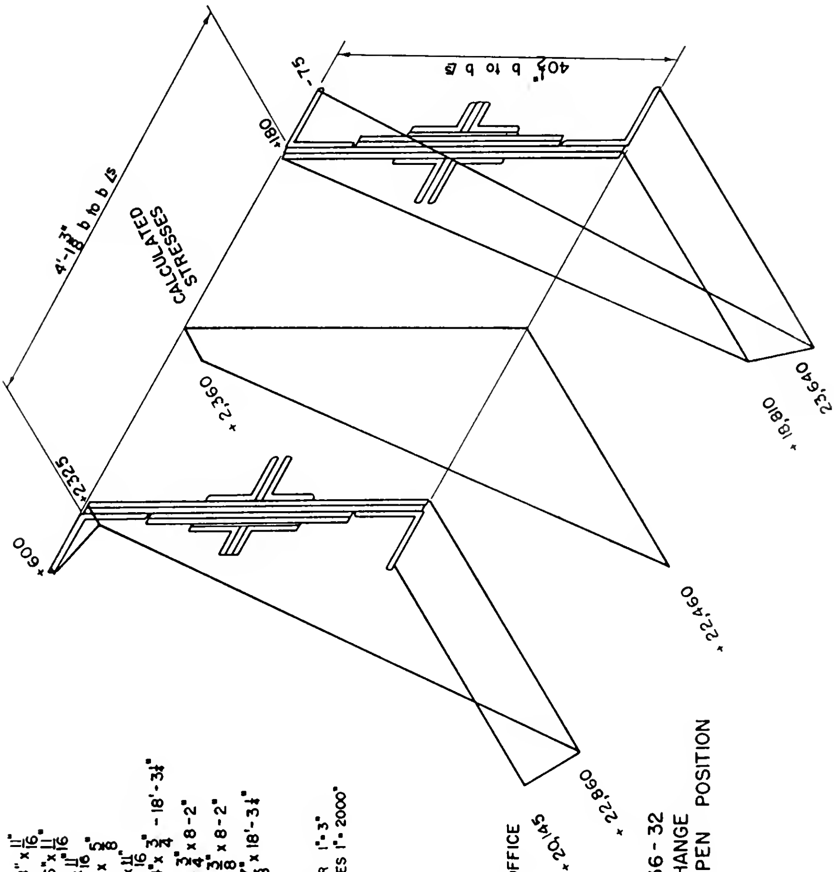


Fig. 18—Photograph of joint 36.



SECTION	
4 ∠s	8"x 8" x 11/16"
4 ∠s	6"x 6" x 11/16"
2 PLS.	40" x 11/16"
2 PLS.	40" x 5/8"
2 PLS.	24" x 11/16"
4 ∠s	6"x 4" x 3/4" - 18'-3¼"
2-FILLS	24" x 3/4" x 8-2"
2-FILLS	13" x 3/8" x 8-2"
2-FILLS	4" x 7/8" x 18'-3¼"

SCALE OF
MEMBER 1" = 3"
STRESSES 1" = 2000"

STRESSES COMPUTED
L.T. WYLY
K.H. LENZEN
MEASURED STRESSES
A.A.R. RESEARCH OFFICE

FIG. 19
MEMBER 36-32
STRESS CHANGE
CLOSED TO FULLY OPEN POSITION

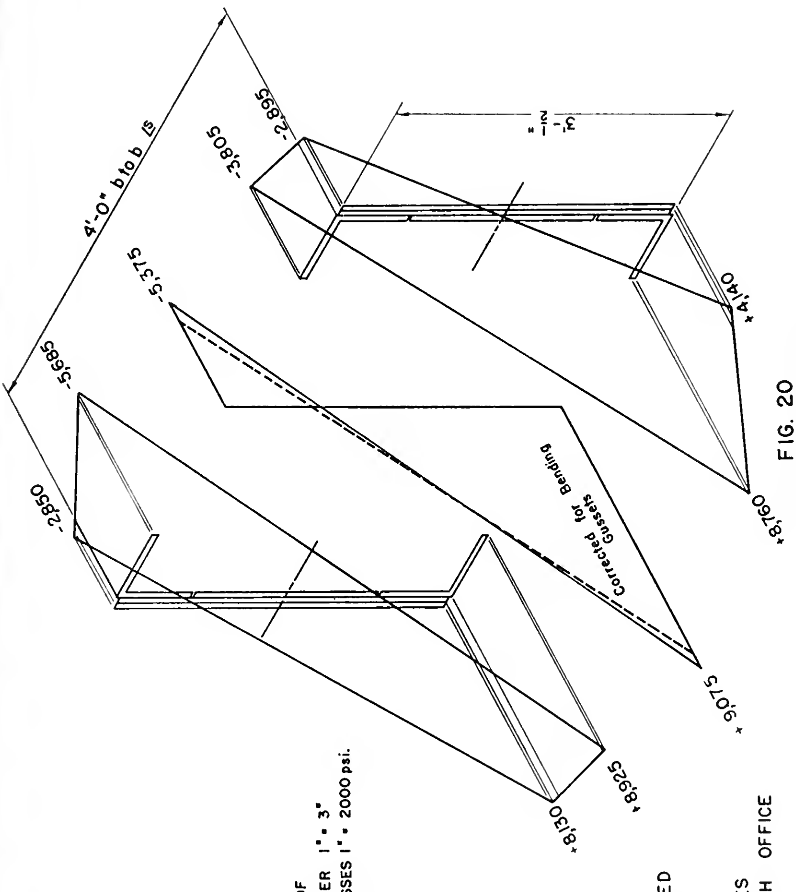
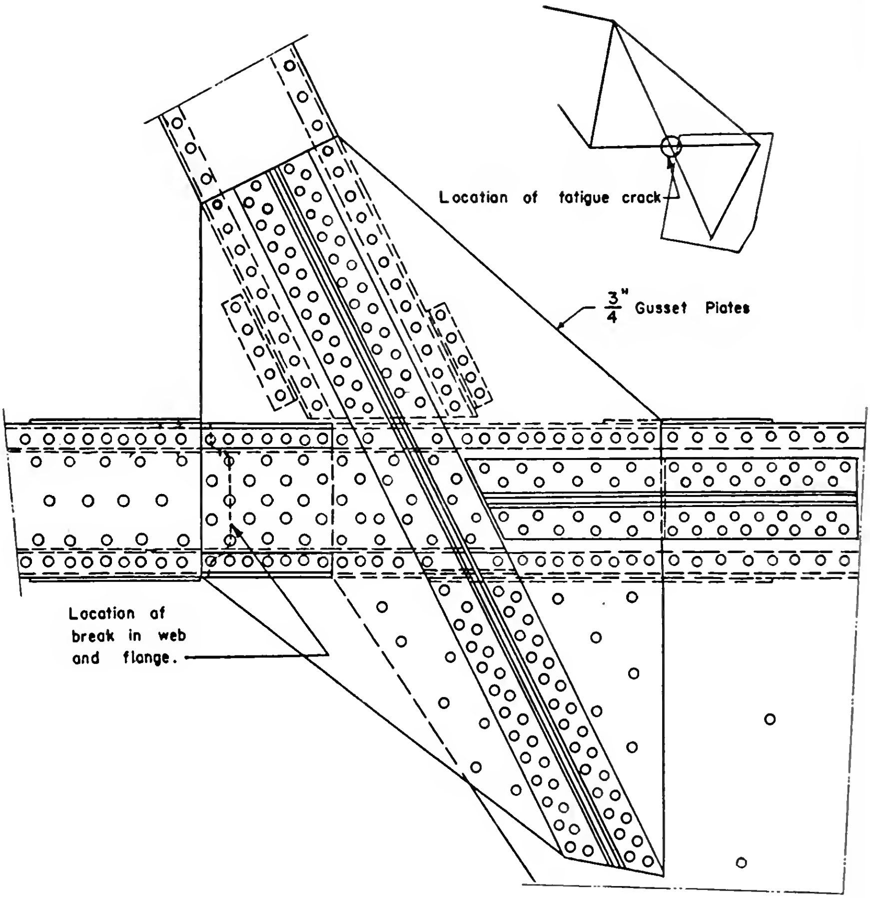


FIG. 20
MEMBER 36-34
STRESS CHANGE
CLOSED TO FULLY OPEN POSITION

SECTION
4 ∠s 8 x 8 x 5/8
4 PLS. 36 x 11/16
2 PLS. 33½ x 11/16

SCALE OF
MEMBER 1" = 3"
STRESSES 1" = 2000 psi.

STRESSES COMPUTED
L.T. WYLY
K.H. LENZEN
MEASURED STRESSES
A.A.R. RESEARCH OFFICE



LOCATION OF FATIGUE CRACK IN COUNTERWEIGHT TRUSS MEMBER

FIGURE 21

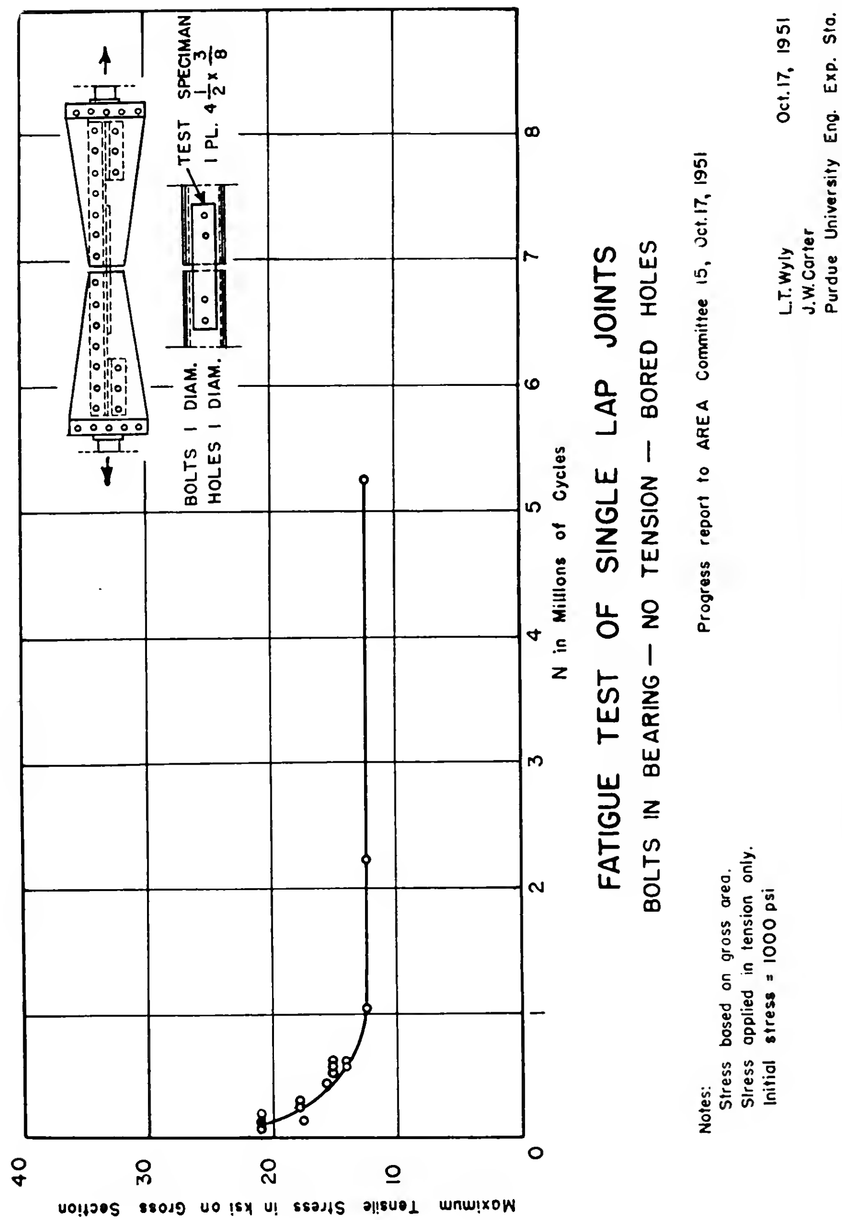
TABLE 2 TEST RESULTS L. T. Wyly

FATIGUE STRENGTH OF SINGLE LAP BOLTED JOINTS J. .W Carter

Failure Date	*Specimen Mark*	*Tensile Stress*			*Tensile Stress*			*N*
		Ksi Min	*Gross Area*		*Ksi Min*	*Net Area*		
			Max	*Range*		*Max*	*Range*	
11- 1-48	W3	1.17	17.5	16.3	1.5	22.5	21	132
12-27-48	W5	1.56	21	19.4	2	27	25	75
29	W6	1.56	17.9	16.3	2	23	21	251
5- 3-50	WB2- 5	1.40	17.9	16.5	1.8	23	21.2	245
26	- 7	1.56	15.6	14	2	20	18	463
7-13-51	- 8	1.56	12.4	10.8	2	16	14	2235
20	- 9	1.56	12.4	10.8	2	16	14	5233
21	-10	1.56	15.2	13.6	2	19.5	17.5	610
23	-11	1.56	15.2	13.6	2	19.5	17.5	501
25	-12	1.56	15.2	13.6	2	19.5	17.5	578
26	-13	1.56	14	12.4	2	18	16	604
28	-14	1.56	12.4	10.8	2	16	14	1035
31	-15	1.56	14	12.4	2	18	16	589
31	-16	1.56	21	19.4	2	27	25	93
8- 1-51	-17	1.56	21	19.4	2	27	25	138

Notes:
1. See Fig. 1 of Progress report of Oct. 17, 1951, to AREA Committee 15, by Wyly and Carter.
2. Gross area of specimen = 1.68 sq. in.
   Net area of specimen = 1.31 sq. in.
3. All loads in tension N in 1,000 cycles
   Speed of loading: 1,000 cps
4. Single lap joints used, 2 bolts each end
   Bolts in full bearing, no clamping
5. Bored holes, push fit with bolts
6. Tests run by L. T. Wyly and J. W. Carter.
7. For sketch of specimens and loading methods, see Fig. 24, p. 493, text p. 499, Proc. AREA Vol. 51, 1950

Figure 22



Maximum Tensile Stress in ksi on Gross Section
40
30
20
10
0
1
2
3
4
5
6
7
8
N in Millions of Cycles
BOLTS 1 DIAM.
HOLES 1 DIAM.
TEST SPECIMAN
1 PL. 4 1/2 x 3/8
FATIGUE TEST OF SINGLE LAP JOINTS
BOLTS IN BEARING — NO TENSION — BORED HOLES
Progress report to AREA Committee 15, Oct.17, 1951
Notes:
Stress based on gross area.
Stress applied in tension only.
Initial stress = 1000 psi
L.T.Wyly
J.W.Carter
Purdue University Eng. Exp. Sta.
Oct.17, 1951

FIGURE 23

Part 3

Experimental and Analytical Studies of Stress Distribution in Laboratory Models of Floorbeam Hanger Frames

By J. W. Cox*

Introduction

During July and August of 1948, a static load test was performed on a 200-ft through Warren truss on the Missouri–Kansas–Texas Railroad near Erie, Kan. This test was a part of an overall investigation of floorbeam hanger stresses being conducted at Purdue University, sponsored by the AAR. One fact immediately evident from analysis of the Erie bridge test was that measured hanger bending stress was 35 percent greater than the most carefully computed values.

To study the behavior of floorbeam and hanger frames independent of the effect of adjoining bridge members, it was necessary to construct model frames to be tested under controlled laboratory conditions. The frames tested were composed of floorbeam and hangers similar in section and details to the prototype frames. In addition to testing the model frames, three supplementary specimens were made and tested. Each of these supplementary specimens was designed to isolate one of the factors observed to be contributing to measured hanger bending stresses.

The main body of this paper will be divided as follows:

1. Description of the frames and supplementary specimens, including a discussion of test procedure.
2. Presentation and discussion of test results.
3. Developing a shear slope theory and applying it to the tested models in order to explain measured stresses.

Figs. 1 and 1a give a complete program of the model frames and supplementary specimens tested.

Test Frames and Supplementary Specimens

The Model Frames

The assembly drawing of frames HF11, HF22, HF32, and the testing fixtures are shown in Fig. 2. Frame HF512 fits these same fixtures. Details of joint connections for all frames are given in Fig. 3. Sketches of the assembled frames showing the particular hanger and floorbeam combination used for each test are shown in Fig. 1.

These models are designed to provide a means for studying the bending stress occurring in railroad bridge floorbeam hangers of a wide-flange, thin-web section. To reproduce as closely as possible the conditions encountered in actual bridge frames, it was necessary to:

1. Make the model hangers of a wide-flange, thin-web section.
2. Fasten the floorbeam to the inside flange of the hanger, leaving the outside flange unrestrained below the top of the floorbeam connection.

---

* Instructor in Civil Engineering, Purdue University.

A

3. Provide a restrained condition at the upper end of the hanger, such as that normally provided by the sway bracing.
4. Make the floorbeam stiffness a reasonable value relative to the stiffness of the hanger.
5. Detail floorbeam connection both with and without knee braces.

These objectives were accomplished by the design shown in Figs. 2 and 3. Aluminum rather than steel was chosen for the model frames for two reasons:

1. Aluminum is extruded in small, wide-flange, thin-web shapes ideal for making model hangers of a convenient size. To construct steel models of a comparable size would have required expensive machining operations on the hangers.
2. For a given size specimen and load, aluminum will yield about three times more strain than will steel. Since testing the models was to involve measurements of strain, the use of aluminum would help minimize the percent of error in these measurements.

The hanger section chosen was a 2-in by 0.804-lb special I-beam of 61S–T Alcoa aluminum. For the floorbeam a 7-in by 6.23-lb I-Beam of 24S–T Alcoa aluminum was altered as shown in Fig. 3. Section and material properties are given in Fig. 40

The upper end of the hangers is framed into gussets of a heavier gage than the hanger flange thickness. This detail is in keeping with conventional railroad design.

All fastening was done using SAE ¼–28 hexagon-head bolts of 1035 steel. Holes were drilled with a ¼-in drill to provide a close fit for the bolts. Brass washers were used under the nuts to prevent scoring the aluminum. Bolts were tightened with an 8-in box wrench so that the bolt material was just under its yield strength. The amount of pull necessary to develop this bolt stress was found by trial.

All machining and fabrication were done in the Central Machine Shop at Purdue University.

With the exception of HF11, testing of all frames was performed in the Structural Engineering Laboratory at Purdue University, using the 120,000-lb Baldwin hydraulic machine of that laboratory. HF11 was tested in the 300,000-lb Riehle mechanical machine of the Materials Testing Laboratory, also at Purdue. Figs. 4 and 5 show frames HF11 and HF32 being tested.

To adapt the models for testing, the fixtures shown in Fig. 2 were designed. In detailing and fabricating the upper testing fixture, care was taken to insure that, as nearly as possible, the frame would be supported along the center line of the hangers. The lower testing fixture was designed to divide the testing machine load into two equal loads applied symmetrically to the floorbeam. These two symmetrical loads simulate the action of the stringers in an actual bridge structure. In both upper and lower testing fixtures spherical seating was used for self-alinement of frame and load.

Specimen T–6

Details of the plate connection for specimen T–6 are given in Fig. 15. A photograph of this specimen under test is shown in Fig. 16. Specimen T–6 consists of a length of the same I-beam section used for the model hangers.

This specimen was designed to study the action occurring at the intermediate floorbeam connection on frame HF512. The short length of plate fastened to one flange of T–6 simulates this action and allows investigation of such a connection independent of other effects.

This specimen was held in the tension grips of the 120,000-lb hydraulic testing machine and was subjected to a straight pull. Lateral movement of the joint was prevented by a heavy bar fastened across the columns of the testing machine.

Specimen T–18

Fig. 20 shows joint details for specimen T–18.

Specimen T–18, like specimen T–6, consists of a length of the I-beam section used for model frame hangers. T–18 was designed to show the effect of connecting the model frame floorbeams to one flange of the model hangers, leaving the other flange unrestrained. The heavy 5-in I-beam fastened to one flange of the model hanger represents the floorbeam connection and allows investigation of the effect of this connection independent of floorbeam rotation.

T–18 was held and tested in the manner described for T–6 above.

Specimen C

Details for specimen C are the same as shown in Fig. 20 for specimen T–18. Fig. 29 is a photograph showing specimen C in the testing machine.

Specimen C, like specimen T–18, was tested in order to study the effect of connecting the model floorbeams to one hanger flange only. As for T–18, the heavy 5-in I-beam represents the floorbeam connection, but eliminates floorbeam bending. Here, however, moment load applied to specimen C brings out the behavior of the connected length of member independent of axial load.

Specimen C was clamped rigidly to the table of the testing machine and the moment load was applied by cantilever action.

Test Procedure

Tests on all model frames and supplementary specimens involved measurement of strains and slopes. SR–4 gages of types A–8 (⅛-in gage length), A–7 (¼ in), AX–7 (¼ in rosette), and A–5 (½ in) were used, and their measurements were read from a Baldwin Type K strain indicator. The procedure for placing and wiring gages has been covered in previous papers*. It is worthy of note, however, that aluminum requires little preparation before applying SR–4 gages, and the problem of rust under the gages is non-existent.

The model frames and supplementary specimens were placed in the testing machine and loaded as described above under the description of these frames and specimens. A load of 4000 lb in each hanger was found to be sufficient to bring out the action of the floorbeam hanger frames. A total applied load of 8000 lb was used in testing frames HF11, 22, 32, and 512. (See Figs. 7, 9, 11, and 13). Test D of frame HF42 was a special case where the load was applied to the inside hanger flange only, and for this test it was necessary to reduce the hanger load to 2000 lb per hanger. (See Fig. 12). Specimens T–6 and T–18 were loaded axially to 8000 lb in order to bring out clearly the action of these specimens. (See Fig. 17 and Fig. 22). Specimen C was loaded to produce a cantilever moment at the end of the joint. A load of 800 lb applied to an arm of 6 in was found to produce enough flange stress to develop the action of the specimen. (See Figs. 29 and 31).

* See, for instance, "A Further Study of the Behavior of Floorbeam Hangers," by M. B. Scott and J. W. Cox, AREA Proceedings, Vol. 53, 1952, p. 37.

In all cases, strain readings were taken first for an initial load, then for the applied load, and finally for the initial load again. The two initial load readings were necessary to check the electric drift of the strain measuring circuit. In no case did the two initial load readings differ by more than a negligible amount.

Slope readings were made using the mirror and reflected image method commonly used in galvanometry. This procedure for measuring slopes is described completely in Fig. 42. Typical data and plotted results are also given in this figure. Use of a line of sight rather than a reflected light beam was suggested by Prof. J. E. Goldberg. The writer found that a surveyor's level of 28 power would allow readings to 0.01 in for a distance of about 25 ft from scale to mirror. This corresponds to an accuracy of about 0.00002 radians—much more than the accuracy required for the testing described herein.

Shear stress measurements on specimens C and T–18 were facilitated by the use of "Stresscoat" brittle lacquer. The brittle lacquer cracks along the planes of maximum tension, exhibiting the same action under load as do the Lüder lines occurring in the mill scale on hot-rolled steel. After establishing the direction of these principal planes, AX–7 gages were placed so as to measure the principal strains. These strains were then converted into principal stresses, from which the shear stress on any plane through the point of measurement could be determined.

All tests were performed under laboratory conditions, eliminating errors in strain measurements due to changes in temperature and humidity.

Presentation and Discussion of Test Results

Test of Model Frames

The results of tests on the model frames are given graphically in Figs. 7–14. The information obtained from each test is listed in Fig. 1. The location of gages inside the frame joints and the position of slope mirrors for each frame and test are shown in Fig. 6. A discussion of the test performed on each frame follows.

(a) Frame HF11

Stresses determined at the various sections of the hanger above the floorbeam of this frame are shown in Fig. 7. The strains used, in micro-inches per inch, measured at the hanger flange corners and center, at the six sections, are shown by isometric drawings. Values shown by solid lines were measured in the left hanger, while those shown by the dotted lines were measured in the right hanger. It can be seen from these strains that the stress distribution on a cross section of the hanger is planar, except near the connections at sections 11 and 6. At these sections, the fasteners and holes produce unequal distribution of flange stress.

The average strain in the inside and outside flange at each section of both hangers is shown in the upper left table on Fig. 7, cols. 2 and 3. The bending stresses shown in Col. 6 of this table were then determined from these values for each section. The average bending stresses in the left and right hangers are given in Col. 7. This average measured bending stress in the hangers is plotted graphically in Fig. 7, showing that hanger bending stress varies as a straight line throughout its length above the floorbeam. Bending stresses as computed by the standard slope-deflection method and by the modified slope-deflection method are shown for comparison, and it is seen that these computed values are considerably smaller than the measured values. Bending stresses calculated by modified slope–deflection including shear slope agree very well with the measured values, as is shown.

Measured hanger load at each section was determined from the average stress on the section and section area. These values are given in the lower left table of Fig. 7, which shows that by neglecting the top and bottom sections, the measured hanger load agrees very well with the applied load of 4.0 kips.

The stresses determined in the inner and outer flanges of the hanger at various sections throughout its entire length are shown in Fig. 8. This figure shows that the hanger flange stress is quite small at sections E and g near the bottom, and that the floorbeam reaction is transferred to the hanger for the full length of the connection. A rapid increase in load carried to the inside flange occurs near the top of the floorbeam connection. The rotation of the floorbeam connection angles at mid-height of the floorbeam was found to be 0.00113 radians, while the slope of the hanger at the top of the floorbeam connection was found to be 0.00179 radians, or about 60 percent greater than the rotation of the end of the floorbeam.

(b) Frame HF22

Fig. 9 gives the results of tests on this frame. Average measured bending stress in the hangers is plotted to the right of the frame diagram. The manner in which the plotted values of average bending stress were obtained is shown in the upper left hand table of Fig. 7. This is discussed above under frame HF11. Bending stress as computed by the standard and modified methods of slope-deflection are plotted for comparison. Notice that measured bending stress is about twice the value computed by modified slope-deflection and about three times greater than the value computed by standard slope-deflection. Hanger bending stress computed by modified slope-deflection including shear slope agrees with the measured values.

Stresses determined in the inner and outer flanges of the hanger at various sections throughout its entire length are shown to the left of the frame diagram. It is seen that hanger flange stress is quite small at sections C and c near the bottom, and that the floorbeam load is transferred to the hanger throughout the connected length. The behavior of the joint is similar to that observed for frame HF11 above. Here, however, the shorter length of floorbeam connection makes it necessary to transfer the floorbeam load to the hangers within a shorter length of hanger. Inside hanger flange stress increases very rapidly near the top of the floorbeam connection.

Slope of the hangers at the top of the floorbeam connection is seen to be about 90 percent greater than the measured rotation of the end of the floorbeam. Also, there is a rotation of the hanger at the upper gussets, showing that this upper connection does not provide a fixed support.

Fig. 10 gives the results of a test of frame HF22 where the floorbeam load was applied adjacent to the hangers. This test was performed to show the significant effect on hanger bending of the larger slope angle of the hanger at the top of the floorbeam connection. Note that while the floorbeam rotation has been reduced, there still remains a large slope angle of the hanger at the top of the joint. Here, the hanger slope is about six times as great as the floorbeam rotation. Measured hanger bending stress and measured stress in the outside hanger flange are shown as in Fig. 9. No analysis was made of HF22 for this floorbeam loading.

Note in Fig. 9 that only one flange gage opposite the web was used to measure the bending stress at a section. Fig. 7, giving results of tests on HF11, shows that only one gage is necessary, since stress distribution across a hanger section is planar.

(c) Frame HF32 —Test C
Frame HF512—Test E1

Frame HF32 and frame HF512 for test E1 (see Fig. 1) are identical except that for frame HF512 the hanger extends below the bottom of the floorbeam connection.

Test C on frame HF22 was performed to verify further the behavior to the model frames HF11 and HF22. Results of testing HF32 are shown in Fig. 11. Average measured bending stress in the hangers is plotted between the frame diagrams. These plotted values were obtained as described above under frame HF22. Results of analysis of this frame by standard and modified slope–deflection are plotted for comparison. As was observed for HF11 and HF22, the hanger bending stress computed by these procedures is much less than the measured values. Bending stresses computed by modified slope–deflection including shear slope agree very well with those measured.

Floorbeam rotation measured at mid-height of the connection angles is the same as that measured for frame HF22.

To show the effect of continuing the hanger past the floorbeam connection, frame HF512 was first tested with floorbeam F1 removed. This frame would then be similar in detail to HF32, except for the extra length of hanger below the joint. Bending stresses measured for this frame are plotted with those measured for frame HF32. A comparison of the plotted bending stresses shows that extending a length of hanger below the floorbeam connection has no appreciable effect on hanger bending stress. This is further verified by examination of the stress in the outside hanger flange of HF512. The manner in which the floorbeam load is delivered to the outside hanger flange is similar to that observed in HF11 and HF22 where no extra hanger length exists.

(d) Frame HF42

Fig. 12 shows the results of tests on frame HF42. Loading the hanger through one flange only made it necessary to reduce the load applied to the floorbeam, and 2.0 kips were used as the floorbeam reaction for this frame. Average measured hanger bending stress is plotted to the right of the frame diagram. These plotted values show that bending stress in the hanger is given by a straight line throughout its length, even though the hanger is slotted to the inside flange at the top of the floorbeam connection. Since hangers of both HF32 and HF42 are the same length, a comparison of the hanger bending for HF32, given in Fig. 11, with the bending for HF42 given in Fig. 12, shows directly the effect of removing the hanger web and outside flange below the top of the floorbeam connection.

Measured hanger flange stress is shown in Fig. 12 to the left of the frame diagram. Floorbeam load is all transferred to the inside hanger flange in this frame, and it is seen that the full connected length of flange is utilized for load transfer. Measured stress in the outside hanger flange below the slot is practically negligible.

The slope of the hanger above the slot is very great since no rigid frame action exists and the hanger is essentially a tension member with a load applied to one flange. A comparison of the slope of the hanger below the slot with the slope of the floorbeam shows that, relative to the floorbeam, negative slope has been caused at the top of the hanger block opposite the floorbeam connection.

(e) Frame HF512—Test E3

Measured hanger bending stress and stresses measured in the outer and inner hanger flanges throughout their length are shown in Fig. 13. Slopes measured at the end of both floorbeam connections are given, as well as hanger slope at the top of the F1 connection and at the top and bottom of the F2 connection.

Values of bending stress computed by standard and modified methods of slope deflection are shown for the lower bay. As was observed in all preceding frame tests, the measured values of bending stress at the top of the floorbeam connection are far in excess of those computed by these procedures. Analysis of the frame by modified slope-deflection, including the effect of shear slope and the effect due to the intermediate floorbeam connection, agrees very well with measured values.

Notice that bending in the hangers of the upper bay is completely opposite from what would be expected from a slope-deflection analysis. Examination of the measured hanger slope at the top of the intermediate floorbeam connection makes clear that bending tension must be in the inside hanger flange at this point.

Measured stresses in the hanger flange opposite the intermediate floorbeam connection show that the connection angles here greatly restrain the inner hanger flange and increase the stress in the outer flange. Rotation of the end of the intermediate floorbeam is practically zero, while the slope of the hanger above and below this floorbeam connection is quite considerable. The behavior of the intermediate joint would not be expected to be the same as that for the lower floorbeam connection, since no load is removed from the hanger at F2.

(f) Frame HF512—Test E2

Fig. 14 gives the stress and slope values measured for this test. The information obtained here was the same as that obtained in test E3 of HF512, described above, and is presented in a similar manner (see Fig. 13).

Applying the test load to the intermediate floorbeam completely changes the action of HF512 observed in test E2. With the middle floorbeam loaded, frame HF512 exhibits the same behavior as might be expected of frame HF32 with a restraining moment applied to the bottom of the hanger. Comparing the floorbeam rotation measured for HF32 with that measured for HF512 shows the effect of this restraining moment on joint rotation.

Comparison of slope measured on the hanger at the top of the F2 connection with end rotation of F2 further illustrates the shear slope phenomenon.

Test of Specimen T–6

Results of tests on specimen T–6 are given graphically in Figs. 17–19. Information obtained from these tests is listed in Fig. 1a. The location of gages opposite the plate connection is given in Fig. 15.

Specimen T–6 was used to study the effect on hanger bending of the intermediate floorbeam connection of frame HF512. The short length of plate attached to one flange of the through hanger member reproduces the reinforcing action of the connection angles encountered at the intermediate joint of HF512. To simulate further the condition occurring in HF512 it was necessary to restrain lateral movement of the T–6 joint.

The connection angles used in frame HF512 were ⅛-in thick. Specimen T–6 was tested using ⅛-in, ¼-in, and ½-in plates. All tests exhibit the same general behavior of the specimen and discussion will be confined to Fig. 17 showing results using the ⅛-in plate.

Measured bending stress and measured stress in the outer and inner flanges are plotted in a manner similar to that used to show the model frame test results. It is seen that the short length of plate reinforcing one flange only sets up bending in this tension member. Within the plate length, inner flange stress drops off sharply to the center of the connection, while outside flange stress increases considerably toward the center of the connection. The reinforcing plate restrains the inside flange and allows the outside flange to elongate, thus causing the slope angle at the ends of the plate connection. It is these angles which cause the observed bending stress.

It is now clear how the intermediate floorbeam connection of frame HF512 affected the stresses observed in test E3. (See Fig. 13)

Slopes of the member at the machine grips were measured to use in analysis of the specimen.

The lack of symmetry in the measured stresses above and below the center line of the plate can be accounted for by considering the equilibrium of the connected length of member.

Test of Specimen T–18

Measured values of the bending stress and stress in the inner and outer flanges of the test piece throughout its entire length are plotted in Figs. 21 to 27, incl. Values of the measured shear slope at the top of the I-beam connection for the several tests on T–18 are also given in these figures.

From the results of tests on the model frames (Figs. 7–14) it is seen that in all cases the slope of the hangers at the top of the floorbeam is greater than the slope of the end of the floorbeam. This greater hanger slope must occur because the floorbeam load is delivered to the inside hanger flange, leaving the outside flange unrestrained below the top of the floorbeam connection. Specimen T–18 eliminates floorbeam rotation and allows an independent study of the effect of connection details on hanger bending.

Tests on specimen T–18 were also arranged to show the effect of length of connection on hanger bending stress. A complete test was performed for each of six connection lengths, the results being summarized in Fig. 28 where a curve of shear slope vs length of hanger connection is given.

Test T–18C, results of which are shown in Fig. 21, was performed before the test piece was cut to represent the model frame floorbeam connections. Since the piece is continuous through the I-beam connection, this test is similar to the tests performed on specimen T–6. (See Fig. 17). Slopes at the ends of the I-beam of T–18 were caused by the same action that induced the slopes at the ends of the plate connection of T–6. These slopes on T–18 are much larger than those on T–6 because the I-beam connection provides a heavier reinforcement over a greater length of flange.

Stress in the inside flange of the test piece drops off rapidly below the top of the I-beam connection and becomes constant after a connected length of about 5 in. Comparison of the stress in the flanges at the center line of the I-beam with the flange stresses at the top of its connection shows that a considerable amount of the applied load has been transferred to this I-beam reinforcement. Evidently, about 5 in of connected length are necessary to make the inside flange of the test piece act integrally with the attached I-beam.

After completing test T–18C the test piece was cut at the center line of the I-beam connection. This freedom of the outside flange now represents the condition existing at the floorbeam connection in the model hanger frames, and tests T–188 through T–183 were each performed for a different length of hanger connection. Results of these tests are shown in Figs. 22–27.

The effect of breaking the continuity of the test piece by cutting through it at the center line of the I-beam connection is seen from a comparison of the measured slopes shown in Figs. 21 and 22. This slope jumps from 0.00192 radians to 0.00251 radians immediately the continuity is broken. Further reduction of the connected length of the test piece leads to further increase in the slope at the top of the I-beam connection.

In all cases the full connected length of the inside flange is used to pick up the load in the test piece. Inside flange stress is quite small at the lower end of this piece and increases rapidly to a maximum value at the top of the I-beam connection. Tests T–188 through T–185 verify the conclusion from test T–18C that a connected length of 5 in is necessary to develop the inside flange. The erratic behavior of stresses in the connected length of the inside flange observed in tests T–184 and T–183 (connected lengths of 4 in and 3 in, respectively) demonstrates that joint slip is occurring.

While inside flange stress decreases sharply where the test piece enters the I-beam connection, stress in the outside flange takes a sudden increase at this point. This seems logical, since at the top of the I-beam connection bending suddenly is retarded, thereby reducing the value of bending stress at this section (compression in the outside flange) and causing the outside flange stress to tend more toward the P/A value (tension).

A graphic study of the behavior of the web within the connected length of hanger was made possible by use of Stresscoat brittle lacquer. Fig. 25a shows the results of this study. Examination of the cracks occurring in the brittle lacquer show the principal planes in the web to be well inclined to the axis of the hanger. This inclination of the principal planes to the direction of the loading indicates the presence of an appreciable amount of shear. Fig. 25b shows how the shearing stress was measured using AX–7 strain rosettes. This figure also shows that a large shearing effect does exist. This effect is discussed further under Specimen C, following.

For all tests on specimen T–18, the slope of the test piece at the machine grips and lateral movement of the ends of the test piece were measured to facilitate analysis of test results.

Test of Specimen C

Figs. 30, 31, 32, 32a, and 33 show results of tests on specimen C. Information obtained from these tests is listed in Fig. 1a. The location and type of all gages used is given in Fig. 31. A study of the model hanger frame tests and the tests performed on specimen T–18 shows clearly that delivering floorbeam load to the inside hanger flange, leaving the outside flange unrestrained, causes additional hanger slope at the top of the floorbeam connection. Since no bending can occur within the joint length, the additional hanger slope must have been caused by a shearing deformation in the hanger web opposite the floorbeam connection. This theory seems all the more likely when it is recognized that load in the outside hanger flange at the top of the floorbeam is carried there primarily by shear in the hanger web. In addition, the hanger web is relatively thin and easily subjected to a shearing deformation. Specimen C was tested in order to study the manner by which load in the outside hanger flange is carried over to the floorbeam connection through the hanger web. Load in the outside flange is induced by cantilever action, making the test independent of axial load effects.

Stresscoat brittle lacquer was used to show direction of principal planes in the web of the test piece. After determining these directions, AX–7 strain gages were used to measure the principal strains. Using these strains the web shear on longitudinal and transverse planes could be computed.

Examination of the Stresscoat cracks pictured in Fig. 32a indicates that the principal planes in the web within the connected length are at very nearly a 45-deg angle with the axis of the specimen. This shows that maximum shear occurs on planes nearly parallel and transverse to the axis of the test piece. Shear on these planes contributes directly to slope at the end of the joint connection.

Placing AX–7 gages as shown in part (c) of Fig. 32 yields the magnitude of shear stress on parallel and transverse planes. As shown in Figs. 30 and 32 this measured shear stress is constant across the web at a given section.

Reducing principal stresses to shear stress on transverse and parallel planes was greatly facilitated by the use of Mohr's circle of stress. This use of Mohr's circle is given in Fig. 33.

Stress in the connected flange goes from compression to tension about half way through the joint length. This is seen clearly in Figs. 31 and 33. The value for the inside flange stresses plotted in these figures was obtained by measuring flange strain in an axial direction only. The writer believes that the plotted values are not the true values for the inside flange stress. A study of part (c) of Figs. 30 and 32 shows that throughout all but about the first inch of connection, the connected flange is being pulled down in order to resist the applied moment load. The writer feels that this "pull" on the inside flange by the bolts causes transverse compression of the flange between the bolt gage lines. Such a transverse compression might well cause the tension strain measured in the axial direction.

The small amount of compression measured in the outer flange of specimen C near the very end of the test piece is not representative of the average flange stress at this section. The plotted values for flange stress were obtained from strain measurements at the center of the flange opposite the web. Stresscoat studies of the behavior of this outer flange of specimen C disclose that near the rear end of the connected length the edges of the flange begin to slide up relative to the center, which is restrained by the web. In test C–8, three gages were used to obtain the average outer flange stress near the end of the connected length. Measurements from these three gages showed that even though there is compression in the flange opposite the web, the average flange stress is still tension.

While the measured compression stress at the rear of the connected length is not appreciable, it seems well to understand its cause since this behavior of the outer flange was observed in the frame tests and in tests of specimen T–18.

Shear Slope Theory and Application to Tested Models

Derivation of Fundamental Relations

Tests on specimen C demonstrate completely how transfer of outside hanger flange load into the floorbeam connection causes shearing deformation in the web of the hanger.

Figs. 34 and 34a develop a shear stress theory based on the observed action of specimen C. The assumptions made and the procedure followed in arriving at expressions for the shear slope and flange stress are clearly explained in these figures. To arrive at the expression for shear slope derived in Fig. 34 it is necessary to make some simplifying assumptions. These are:

1. The connected length of inside flange may be represented by a uniform area throughout. The outside flange opposite connection is already a uniform area throughout. These outside and inside areas are called A_1 and A_2, respectively, in Fig. 34.
2. Web material may be considered as being effective in shear only, i.e. carrying no direct stress. To account for the fact that the web does carry a direct stress, a portion of the web area may be included with A_1 and A_2.

3. The applied moment, M, may be replaced by a couple whose forces are applied at the centroid of the flanges.
4. Shearing deformation of the web occurs as a straight line across the width of the web, i.e. shearing stress is constant across any section of the web.
5. Axial and shearing deformations take place elastically.

Eq. 1 of Fig. 34 is based on the relationship between elastic deformation of the flanges and shearing deformation of the web. The geometry of these relations is shown in a sketch. Eq. 2 of this figure is based on the internal equilibrium existing over any element of length, dx. Both equations 1 and 2 involve the three variables, which are the axial stress in the two flanges and the shearing stress in the web.

Solution of Eq. 1 and 2 leads to the differential equation shown. Out of the solution to this differential equation comes the expression for shear slope, given in Fig. 34.

The equations for flange stress shown in Fig. 34a follow directly from the expression developed in Fig. 34.

Analysis of Specimen C and Specimen T–18

Computations for the analysis of specimens C and T–18 are given in Figs. 43 and 44, respectively.

The general equations derived in Figs. 34 and 34a are directly applicable to specimen C. It is necessary to compute an equivalent hanger section to account for the shift of the neutral axis toward the connected flange. This shift of the neutral axis was clearly shown in the tests of specimen C. (See Figs. 30 and 32). The procedure is to assume a shift of the neutral axis equal to one-tenth the section depth and then compute the necessary increase of the inside flange area to cause this shift. Using this new section, the properties necessary for a shear slope analysis may be computed. Fig. 35 shows a complete shear slope analysis for the model frame hanger section. When applied to specimen C this analysis gives the computed values for shear slope, web shear stress and flange stress shown in Figs. 31 and 33. The close comparison between measured and computed values for specimen C justifies the above approach to the shear slope phenomenon.

Fig. 36 shows how the shear slope may be introduced into an analysis of specimen T–18 by slope deflection. The condition that must exist is that the slope of the hanger block fastened to the I-beam must equal the slope at the end of the hanger. The expression for shear slope developed in Fig. 35 may be used here. The computed curve of Fig. 28 is based on the shear slope analysis for specimen T–18 outlined in Fig. 36.

Analysis of the Model Frames

Fig. 37 shows clearly the procedure for including shear slope with an analysis of the model frames by modified slope–deflection.

The equivalent hanger section is computed on the basis of a shift in the neutral axis equal to one-tenth the section depth. This is the same assumption that was made for specimens C and T–18, and Fig. 35 will show the properties of the equivalent hanger section used for the frame analysis.

However, a modification must be made in the basic derivation for the shear slope expression shown in Fig. 34. In the analysis of specimen T–18 it is assumed that only the closing moment, M (see Fig. 36), affects the shear slope. For T–18 this assumption is about right since the heavy I-beam restrains elongation of the inside flange. But in the model frames, the inside hanger flange is fastened to floorbeam connection angles of the same thickness as the hanger flange itself. When the floorbeam load is applied to the inside flange for purposes of analysis, the relatively light connection allows the connected flange to elongate. This elongation causes a slope at the top of the joint opposite in direction to the shear slope caused by the closing moment, M (see Fig. 37). This effect is clearly shown by test D on frame 42. Note here that the slope at the end of the floorbeam is greater than the slope on the hanger block below the slot. This difference is due to elongation of the connected flange relative to the outside flange below the slot. (See Fig. 12)

To account for the above effect, it is only necessary to assume the compression flange is fixed against axial elongation when deriving the expression for shear slope in Fig. 34. The negative slope, due to elongation of the connected flange, is offset by neglecting this positive effect of the closing moment, M. A modified expression for shear slope is derived in the analysis of frame HF22 in Fig. 46.

Note that analysis of the frames depends upon an accurate value for the eccentric moment, Pe (see Fig. 37). Frame HF42 affords a means for determining the eccentricity. The measured bending stress at the end of the hangers of frame HF42 must be caused only by the moment, Pe, and careful determination of the elastic modulus for hanger material and of hanger section properties leads to the evaluation of the eccentricity, e.

Analysis of frames HF11, HF22, HF32 and HF512 are offered in Figs. 46–50. The computed results are plotted in Figs. 7, 9, 11 and 13. Computations are based on the exact solution outlined in Fig. 37. The shear slope procedure used here can easily be included with an analysis by modified slope-deflection using the method of approximations. This method is described in Part 1 of this symposium and Fig. 39 shows how shear slope is included by addition of a final step.

Analysis of Specimen T–6

Fig. 38 shows the procedure used in the analysis of specimen T–6. This analysis is not based on web shear since no load is removed at the plate connection. The analysis shown in Fig. 38 is based on the following observations from tests T68–T62 (Figs 17–19):

1. At the center line of the plate connection, stresses can be computed by the flexure formula using a fully developed plate.
2. At the end of the plate connection, stresses can be computed by the flexure formula, assuming a partially developed plate.
3. Stress variation inside the plate connection may be closely approximated by a straight line.

An analysis of T–6 with the ⅛-in plate is offered in Fig. 45. The computed slope at the end of the plate connection agrees almost exactly with the average measured slope (see Fig. 17). Assuming that one-half the plate is effective at the end of the joint accounts for values measured in tests T–168 and T–164. However, to compute the slope measured at the end of the ½-in plate, it is necessary to assume that less than one-half the plate thickness is effective at the end of the connection.

The procedure outlined in Fig. 38 is included with an analysis of frame HF512. This analysis accounts completely for the slopes measured at the intermediate floorbeam connection.

Conclusions

Significant conclusions from the tests of the model frames and supplementary specimens are:

1. Floorbeam hanger bending depends upon two major factors:
   (a) Rigid frame action between floorbeam and hangers. See Fig. 39, steps I, II, IIa.
   (b) Additional rotation of the lower end of the hanger due to shear deformation in the hanger web opposite the floorbeam connection. This effect from shear slope is shown in Fig. 28.
2. Shear slope occurs in a thin web structural member when its load is delivered through a connection to one flange only. The length of this connection has a direct bearing on the magnitude of the shear slope. See Fig. 28.
3. Shear slope can be computed and included with a rigid frame analysis. Fig. 37 gives the general procedure for frame analysis and measured hanger bending stresses can be accounted for using this procedure.
4. In all the frames tested, measured hanger bending stress greatly exceeded the computed value based on rigid frame action alone. Two frames showed measured stress 100 percent greater than the computed value, this excess being caused by shear slope. See Figs. 9 and 13.
5. Bending will be induced in a tension member when a short length of one flange is restrained by a gusset or reinforcement, such as occurs when connecting a transverse member. Such bending is shown in Fig. 13 where the intermediate floorbeam connection upsets the hanger stress. The effect is shown independent of frame action in Fig. 17.
6. Shear slope in hanger frames will be lessened by restraining movement of the outside hanger flange below the top of the floorbeam connection. This is demonstrated by comparing results of tests T–18C and T–188. (See Figs. 21 and 22). In bridge frames, such restraint might be offered by tieing the outside hanger flange into the lower chord.
7. Shear slope in hanger frames will be increased by reinforcing the hanger flange to which the floorbeam is connected. The effect of adding restraint to the connected hanger flange is fully discussed under Analysis of Model Frames above. Such reinforcement in an actual bridge structure would take the form of fill plates and gussets, as well as floorbeam connection angles.
8. Maximum total stress in the clear-length of the model hangers occurs in the inside flange at the top of the floorbeam connection. This fact is evident from all the frame tests.
9. Stress distribution on a cross section of the hanger is planar, except near the connections where the bolt holes upset the flange stress. This is evident from test A of HF11, as seen in Fig. 7.
10. Hanger bending stress varies as a straight line throughout the hanger length. This conclusion is evident from all frame test—Figs. 7–14.
11. The hanger load is acquired in a gradual manner, the full connected length of the hanger being utilized in picking up the floorbeam load. Evidence of this occurs in tests A, B, and E2. See Figs. 8, 9 and 14.
12. Slope of the hanger at the top of the floorbeam is *not* equal to the slope at the end of the floorbeam, but is much greater, the difference being due to shear slope in the web of the connected hanger length. This is seen in tests A, B, BS, E2, Figs. 8, 9, 10, 14, and 13, respectively.
13. Increasing the length of the floorbeam connection by use of knee braces increases hanger bending stress. This conclusion is seen from a comparison of the tests on frames HF11 and HF22. See Figs. 7 and 9.

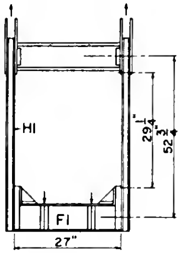
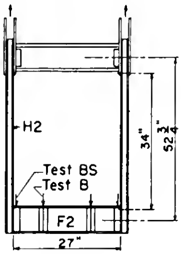
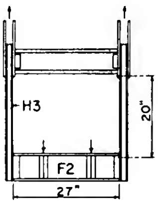
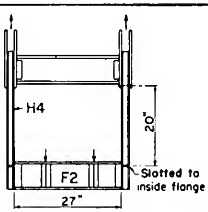
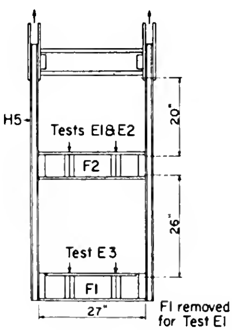
<table>
<tr><th>FRAME</th><th>SKETCH</th><th>TEST</th><th>LOAD POSITION</th><th>INFORMATION OBTAINED</th></tr>
<tr><td>HF11</td><td>
</td><td>A</td><td>Stringer</td><td>1. Stress distribution across hanger section
2. Bending stress in hangers.
3. Stress in outside and inside flange of hangers below top of floorbeam connection.
4. Slope of floorbeam at face of hanger.
5. Slope of hanger at top of floorbeam connection.</td></tr>
<tr><td rowspan="2">HF22</td><td rowspan="2">
</td><td>B</td><td>Stringer</td><td>1. Bending stress in hangers.
2. Stress in outside and inside flange of hangers below top of floorbeam connection
3. Slope of floorbeam at face of hanger.
4. Slope of hangers at top of floorbeam connection.
5. Slope of hangers at gusset connection.</td></tr>
<tr><td>BS</td><td>Adjacent to Hanger</td><td>Same as Test B except no stress obtained in inside flange of hanger below top of floorbeam connection & no slope at gusset connection.</td></tr>
<tr><td>HF32</td><td>
</td><td>C</td><td>Stringer</td><td>1. Bending stress in hangers.
2. Slope of floorbeam at face of hanger.</td></tr>
<tr><td>HF42</td><td>
</td><td>D</td><td>Stringer</td><td>1. Bending stress in hangers
2. Stress in outside and inside flange of hanger block below top of floorbeam connection.
3. Slope of floorbeam at face of hanger.
4. Slope of hanger at slot.</td></tr>
<tr><td rowspan="3">HF512</td><td rowspan="3">
</td><td>E1</td><td>Stringer</td><td>1. Bending stress in hangers.
2. Stress in outside and inside flange of hangers below top of F2 connection.</td></tr>
<tr><td>E2</td><td>Stringer</td><td>1. Bending stress in hangers
2. Stress in outside and inside flange of hanger opposite F2 and F1 connections.
3. Slope of F2 and F1 at face of hanger.
4. Slope of hangers at top and bottom of F2 connection and at top of F1 connection.</td></tr>
<tr><td>E3</td><td>Stringer</td><td>Same as test E2</td></tr>
</table>

FIG. 1 TEST PROGRAM OF ALUMINUM MODEL FLOORBEAM & HANGER FRAMES

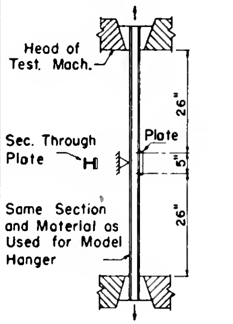
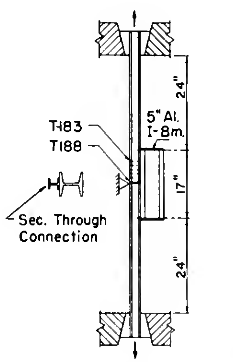
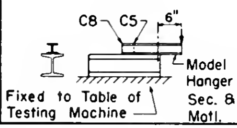
SPECI-MEN	SKETCH	TEST	INFORMATION OBTAINED
T6		T68 Plate $\frac{1}{8}$" Thick T64 Plate $\frac{1}{4}$" Thick T62 Plate $\frac{1}{2}$" Thick	FOR EACH TEST 1 Bending stress in clear length. 2. Stress in inside and outside flange of member opposite plate connections 3. Slope at top and bottom of plate connections 4. Slope at upper and lower head of testing machine
T18		T18C Continuous Through Connection T188 8" Conn. Lgth. T187 7" Conn. Lgth. T186 6" Conn. Lgth. T185 5" Conn. Lgth. T184 4" Conn. Lgth. T183 3" Conn. Lgth.	FOR EACH TEST 1 Bending stress in clear length. 2 Stress in inside and outside flange of member through the connected length (on upper member connection only). 3. Slope at the beginning of the I-beam connection for upper and lower members. 4. Slope at upper and lower head of testing machine. 5. Transverse movement of testing machine head relative to the I-beam connection FOR TESTS T18C & T185 1. Shear stress in web of connected length of the member.
C		C8 8" Conn. Lgth. C5 5" Conn. Lgth.	FOR EACH TEST 1. Stress in flanges of test piece throughout its length. 2. Shear stress in web of connected length of test piece. 3 Slope at ℄ of first hole in connection FOR TEST C5 1. Slope of test piece at end of connection

FIG. 1a PROGRAM OF SUPPLEMENTARY TESTS

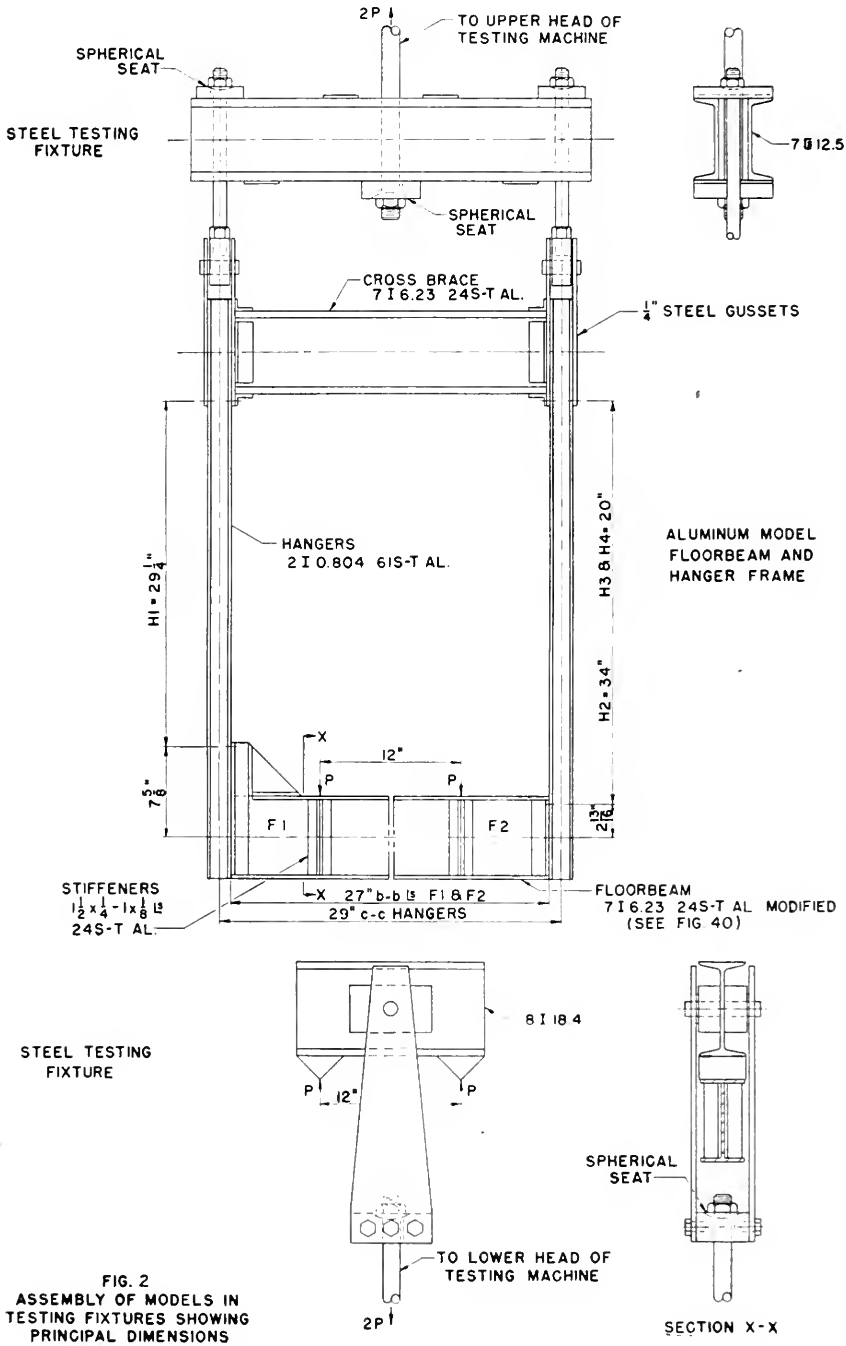


FIG. 2
ASSEMBLY OF MODELS IN TESTING FIXTURES SHOWING PRINCIPAL DIMENSIONS

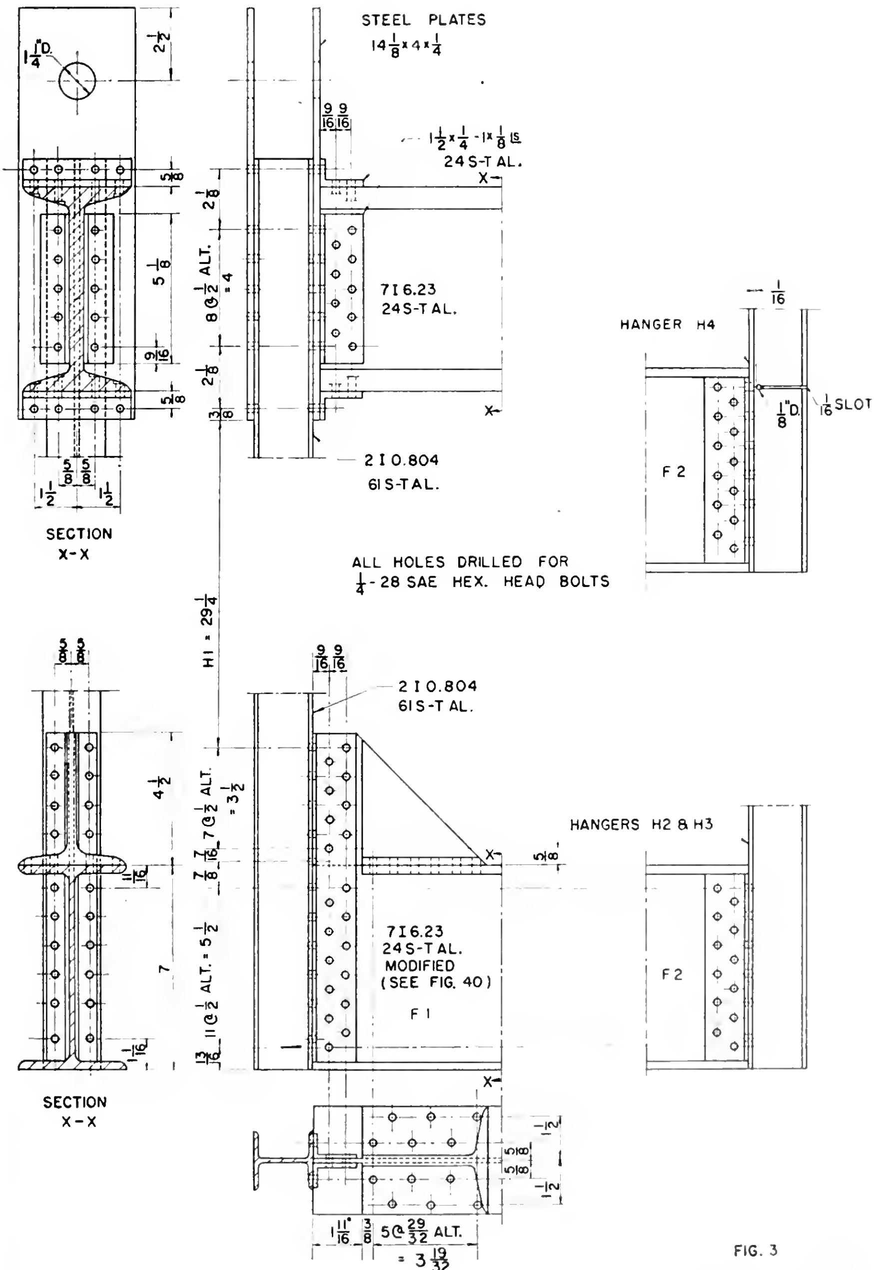


FIG. 3

DETAILS OF ALUMINUM MODEL FLOORBEAM AND HANGER FRAMES

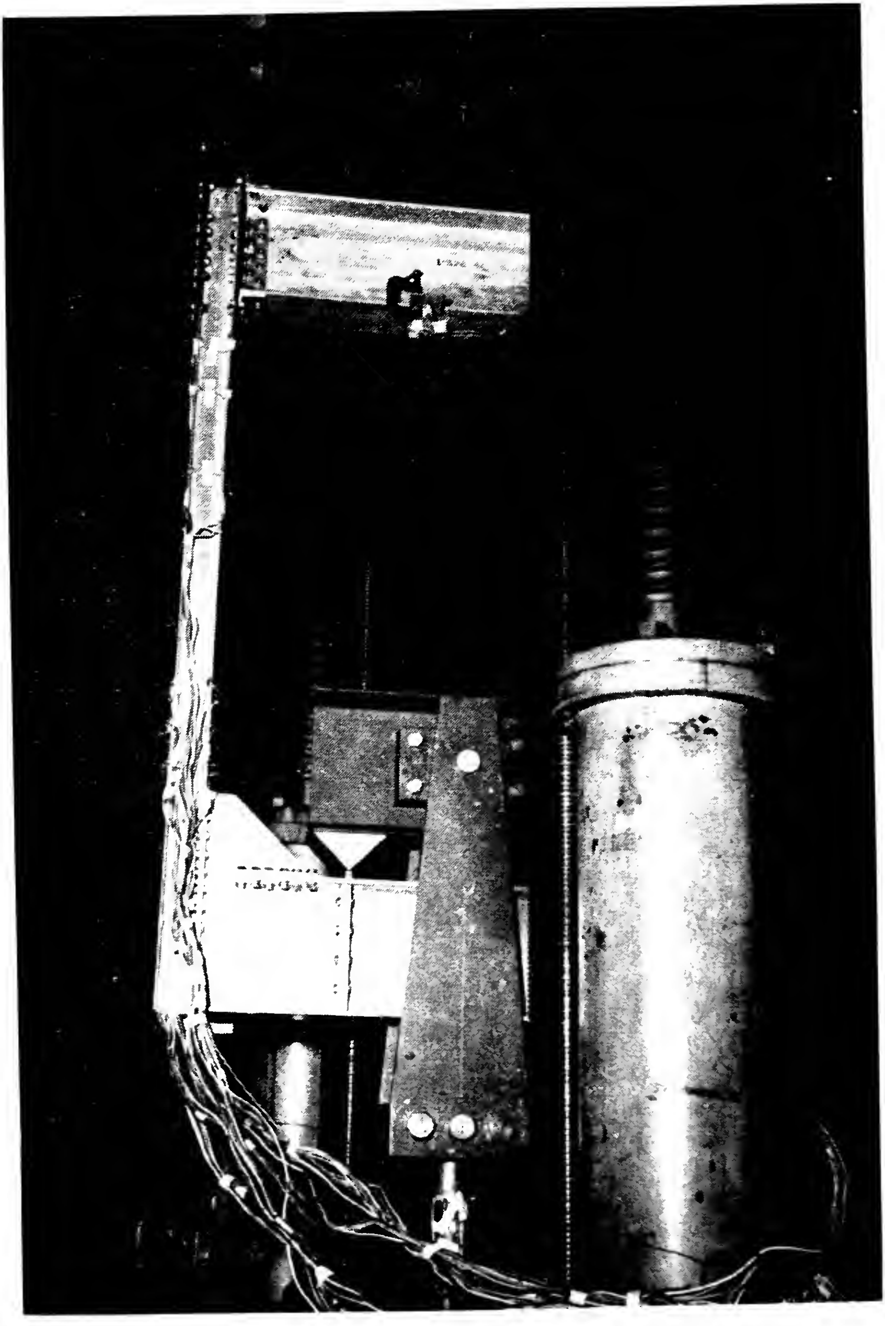


Fig. 4—Frame HF11 in testing machine.

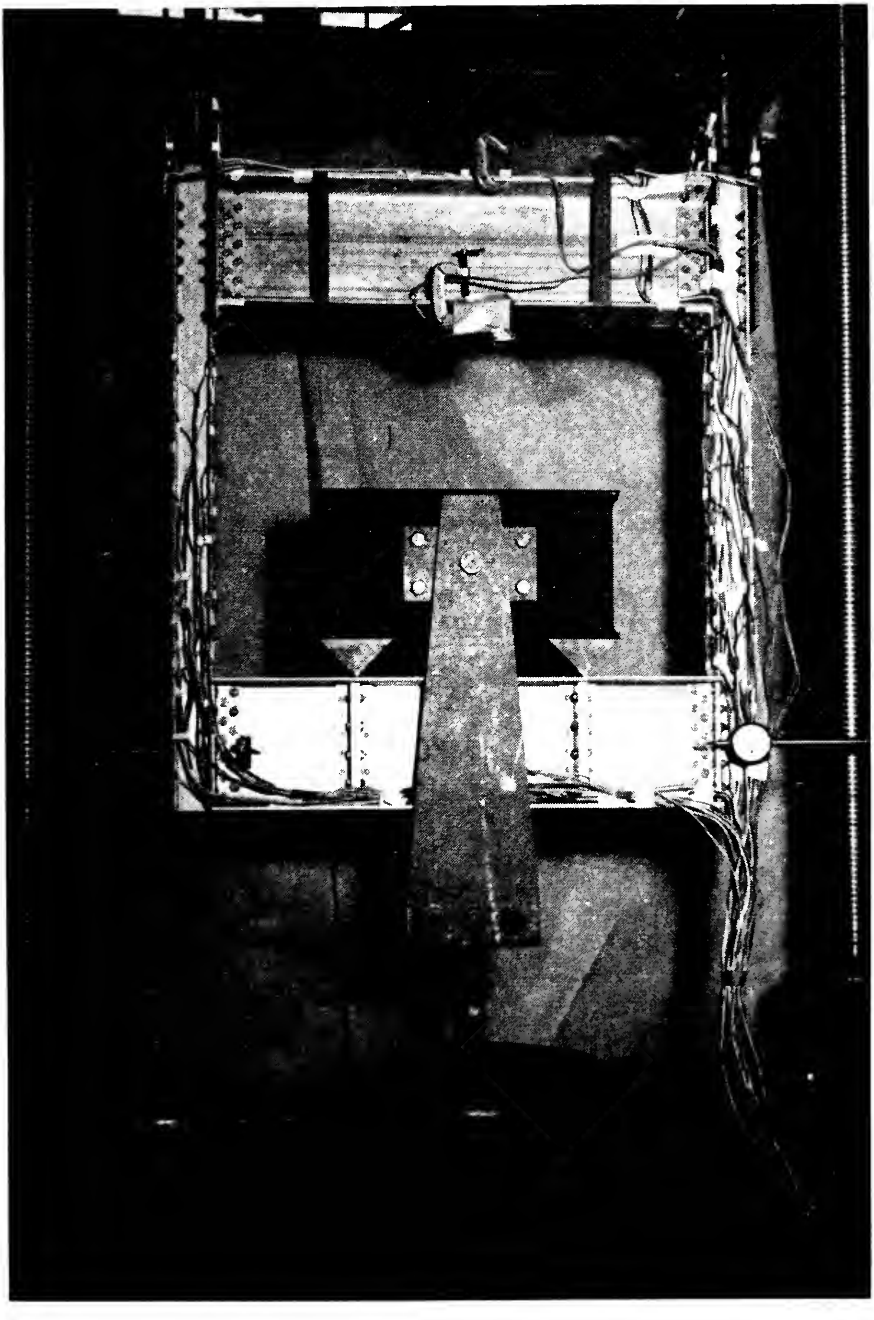


Fig. 5—Frame HF32 in testing machine.

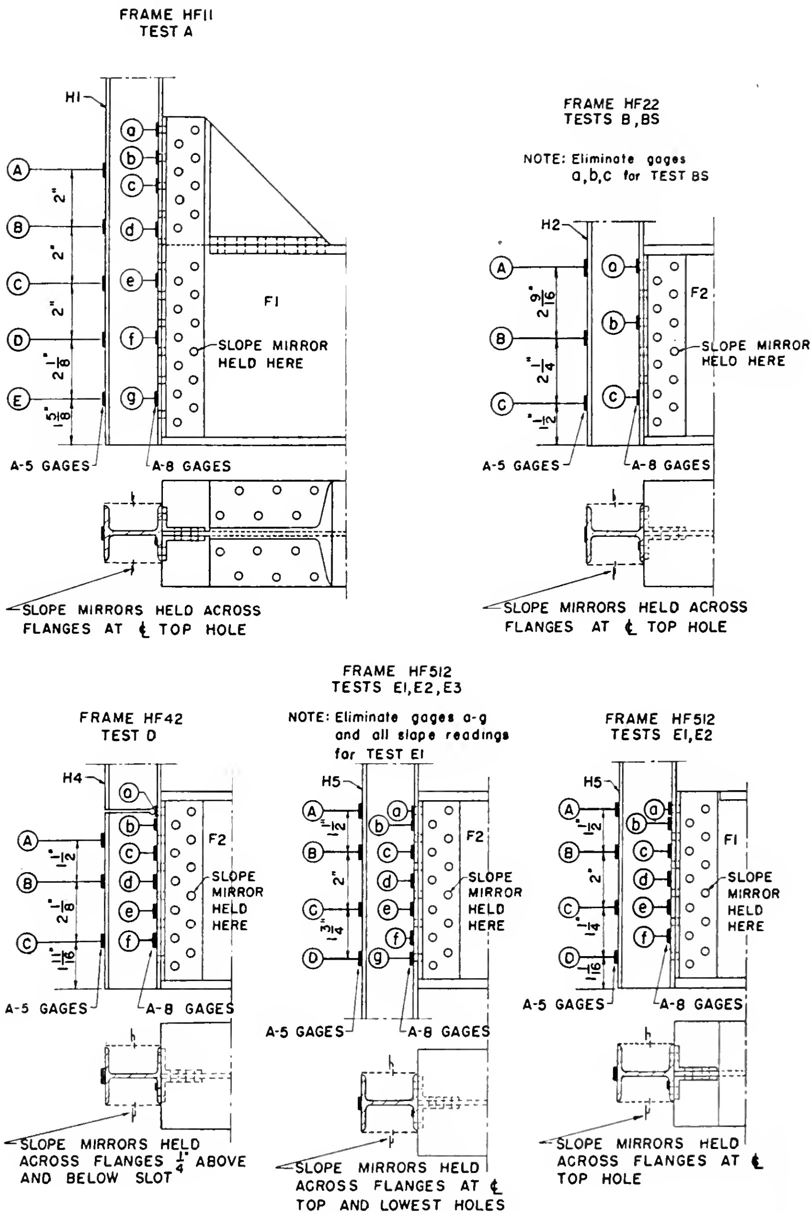


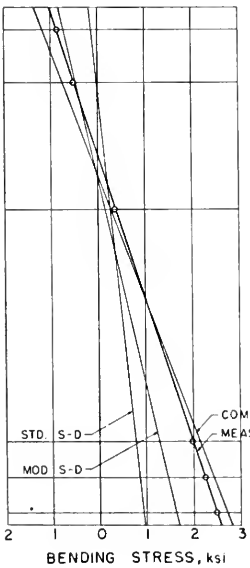
FIG. 6

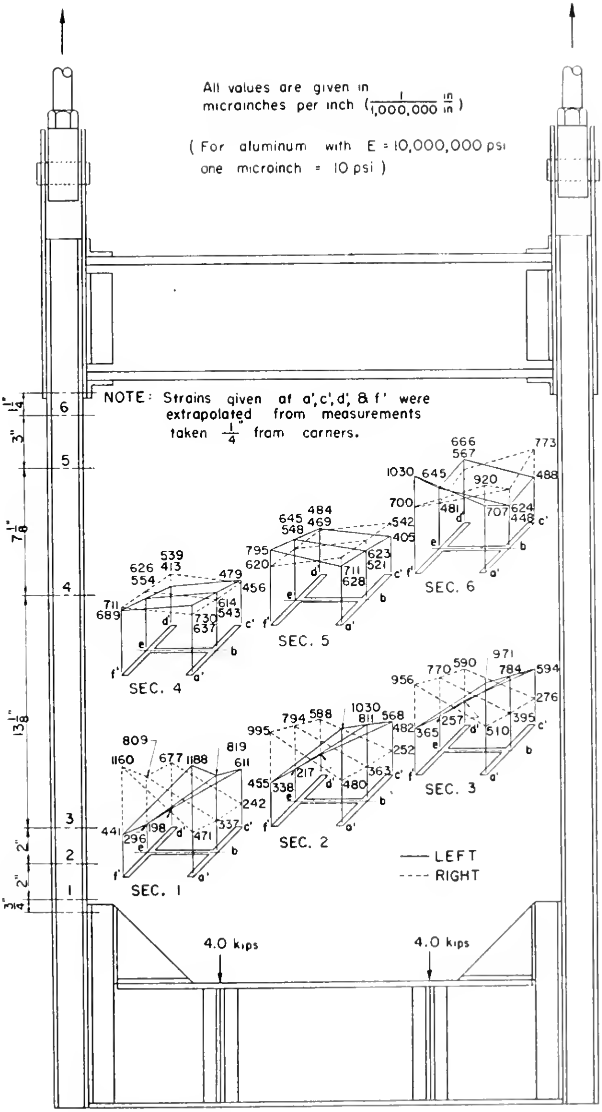
LOCATION OF JOINT GAGES AND POSITION OF SLOPE MIRRORS

BENDING STRESS FROM MEASURED STRAINS

Sec	Avg. of a',b,c'	Avg. of d',e,f'	Avg. Strain micro in.per in	Bend Strain micro in per in	Bend Stress ksi	Avg L&R ksi
1L	819*	296*	558	262	2.60	2.48
1R	337*	809*	573	236	2.35	
2L	803	337	570	233	2.32	2.23
2R	365	792	579	214	2.13	
3L	783	368	576	208	2.07	1.98
3R	394	772	583	189	1.88	
4L	608	552	580	28	.28	34
4R	545	625	585	40	.40	
5L	518	641	580	62	.62	.51
5R	625	546	586	40	.40	
6L	448*	645*	547	99	.98	.85
6R	624*	481*	553	72	.72	

*b only *e only





MEASURED HANGER LOAD

Sec	Avg Strain micro in.per in	Avg Stress ksi	Meas Load kips	Avg Load kips
1L	558	5.55	3.80*	3.93
2L	570	5.67	3.87	
3L	576	5.73	3.93	
4L	580	5.77	3.95	
5L	580	5.77	3.95	
6L	547	5.44	3.73*	
1R	573	5.70	3.91	3.97
2R	579	5.76	3.95	
3R	583	5.80	3.98	
4R	585	5.81	4.00	
5R	586	5.82	4.00	
6R	553	5.50	3.77*	

*Not included in Avg Load

HANGER PROPERTIES: Area = 0.686 sq in
E = 9,940,000 psi

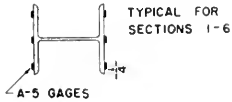


FIG. 7
RESULTS OF TEST A

MEASURED STRAINS AND HANGER BENDING STRESS

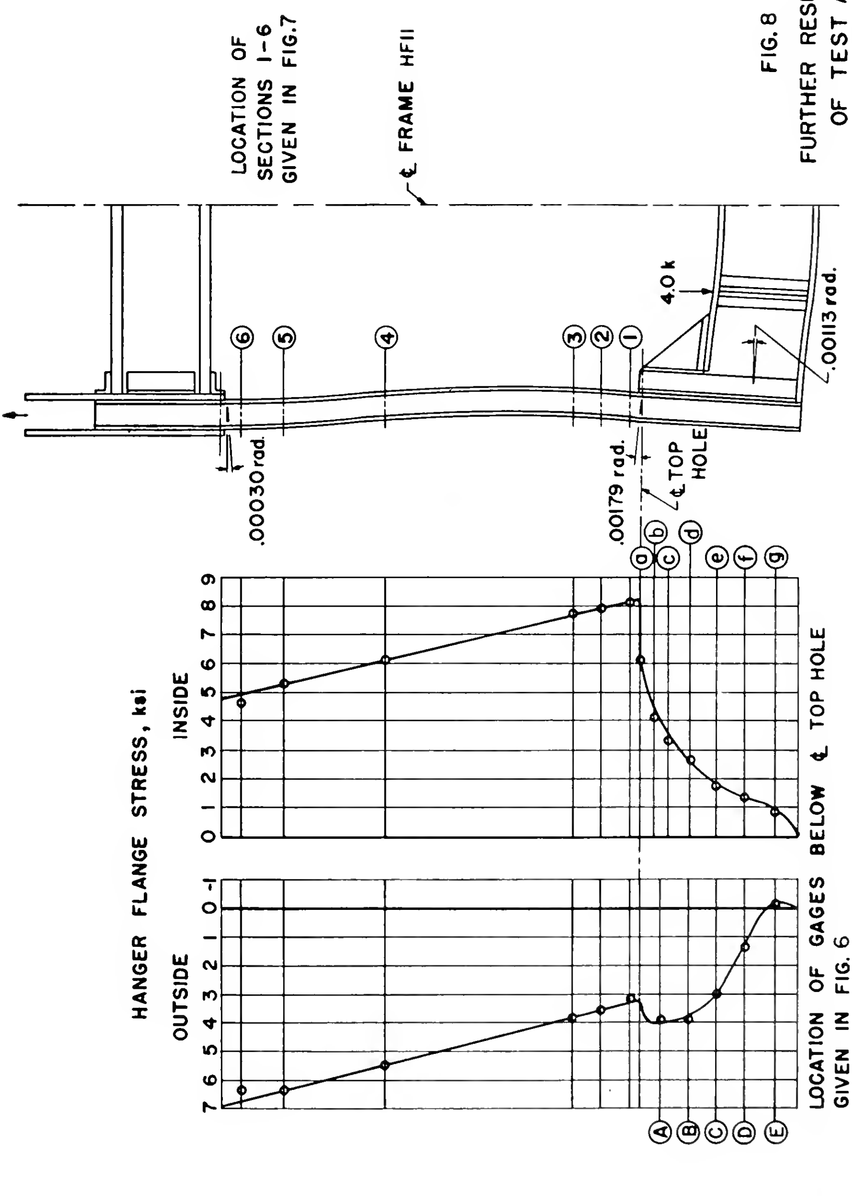


FIG. 8
FURTHER RESULTS OF TEST A

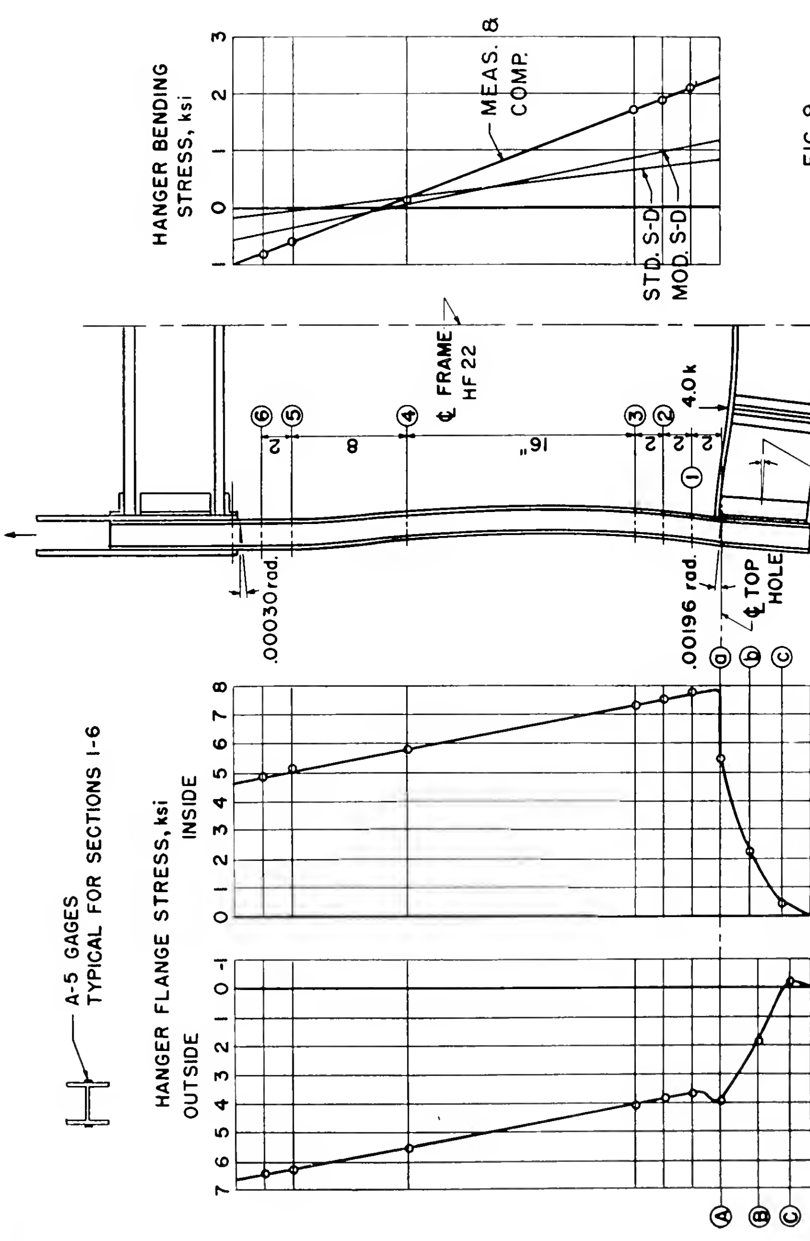


FIG. 9
RESULTS OF TEST B

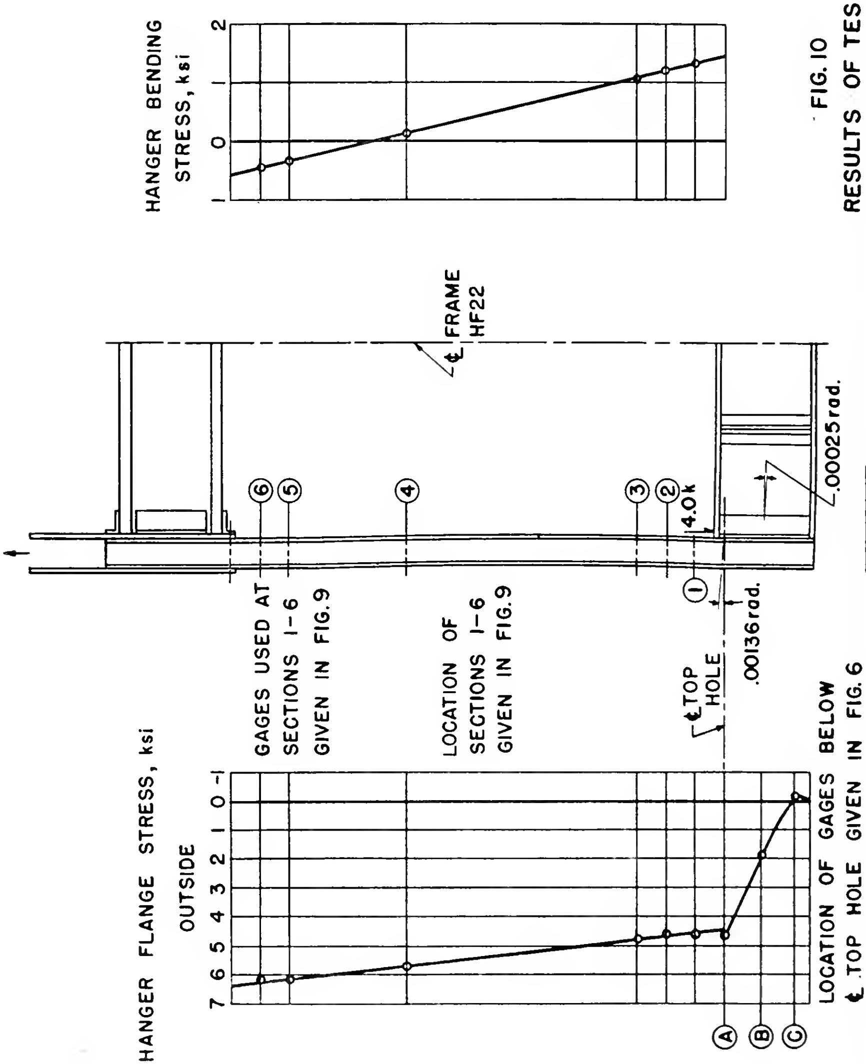


FIG. 10
RESULTS OF TEST BS

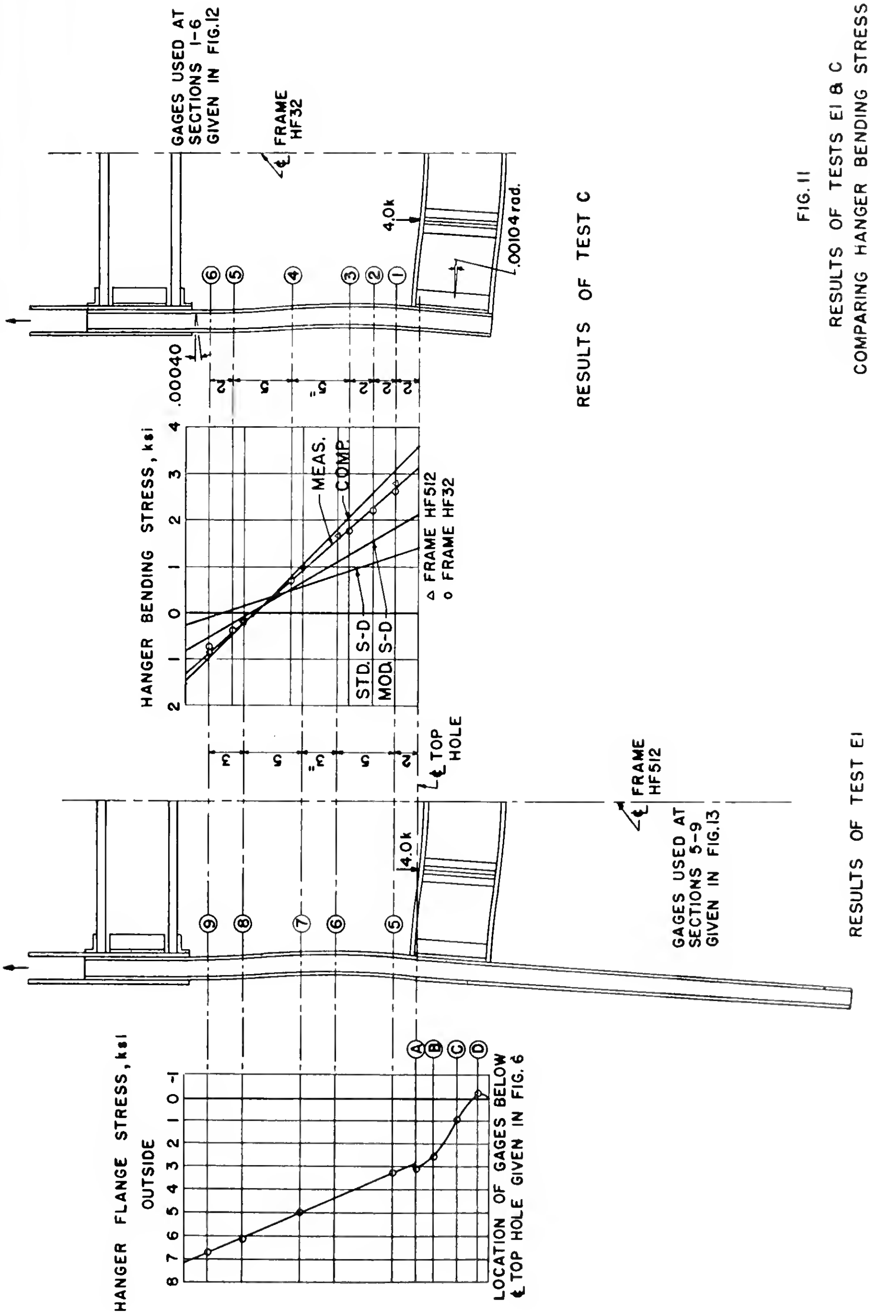


FIG. 11
RESULTS OF TESTS E1 & C
COMPARING HANGER BENDING STRESS

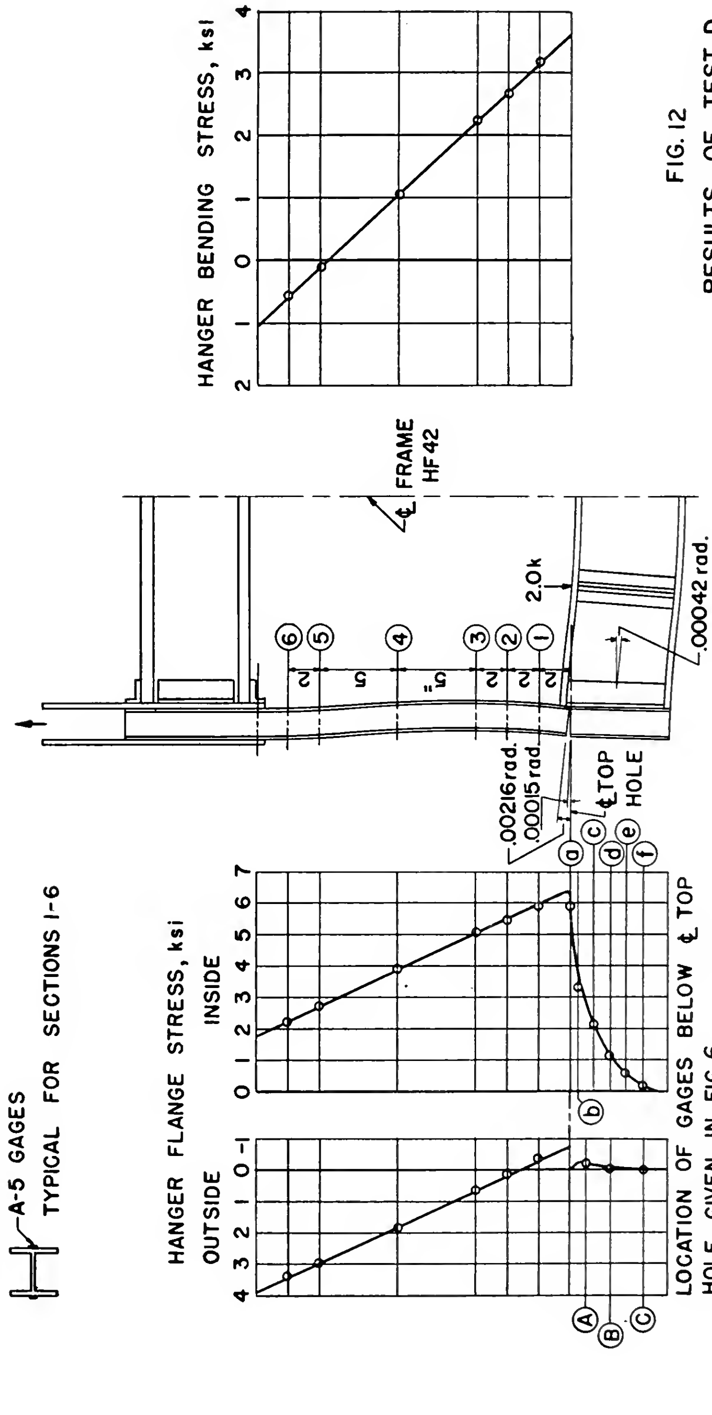


FIG. 12
RESULTS OF TEST D

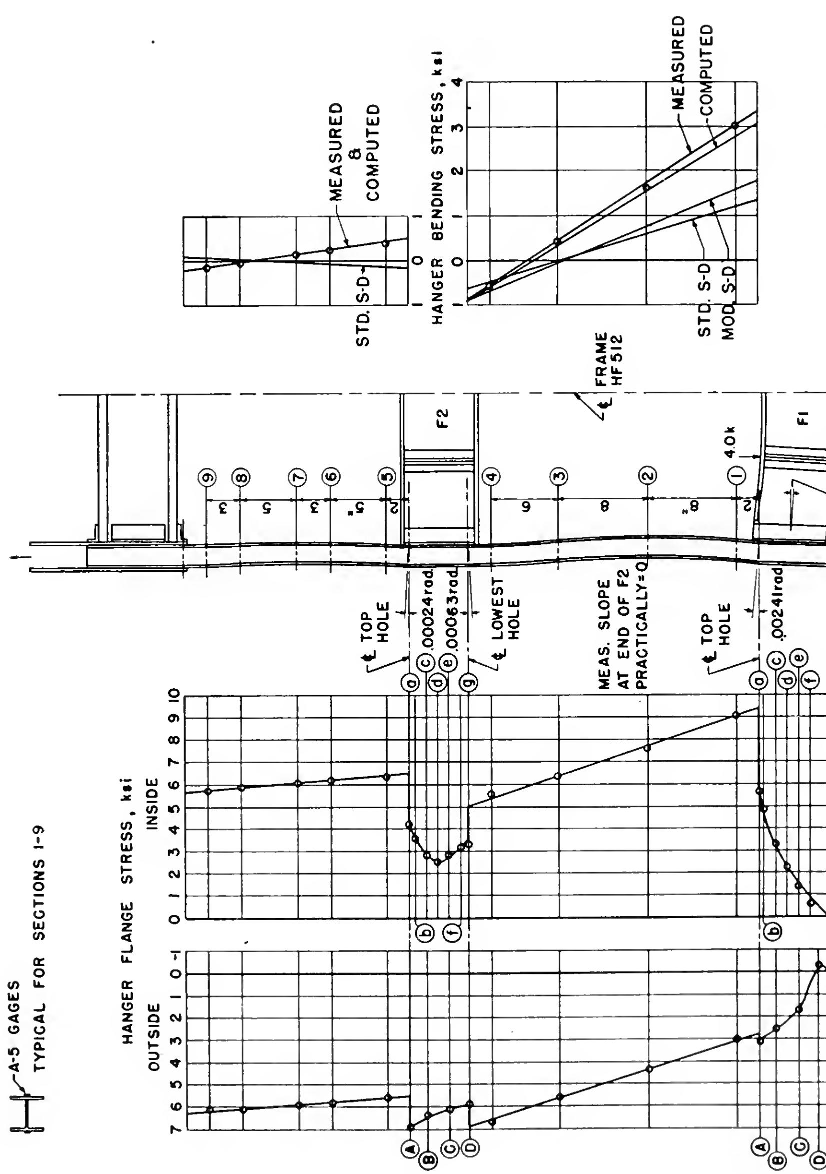


FIG. 13
RESULTS OF TEST E3

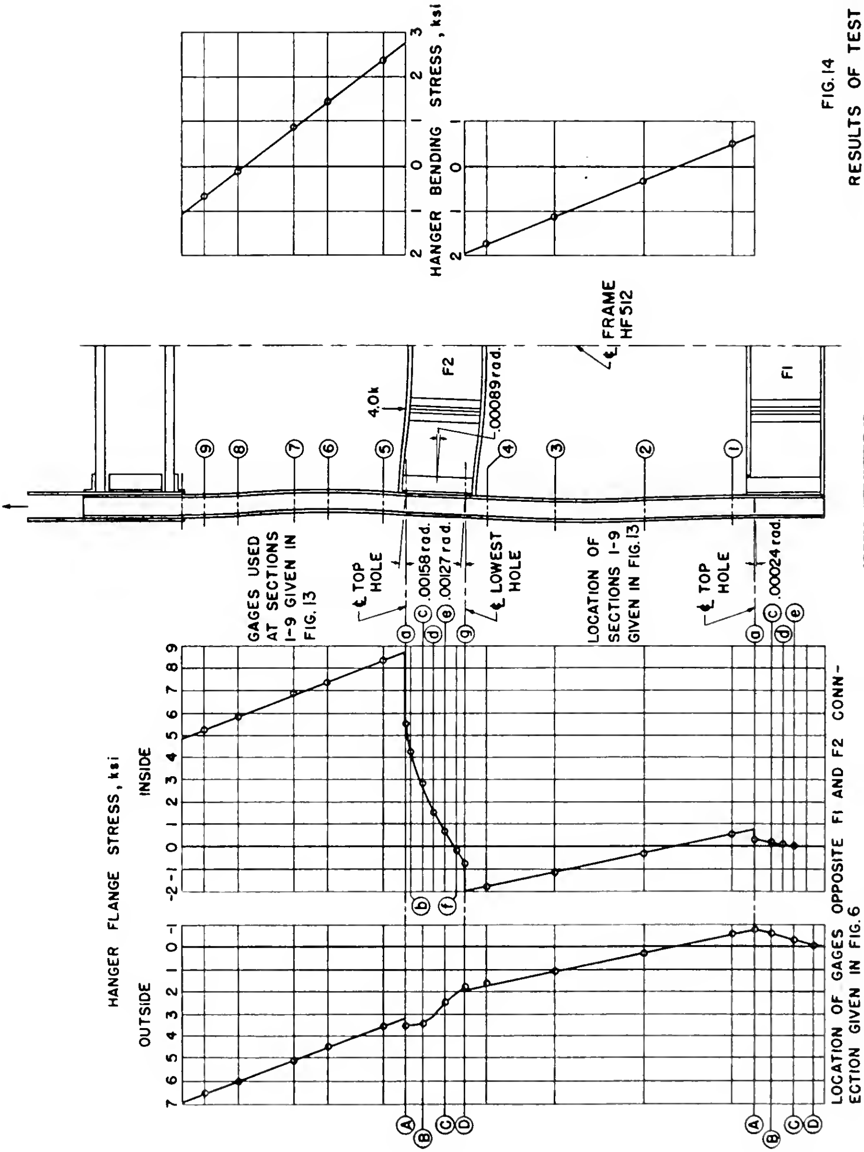


FIG. 14
RESULTS OF TEST E2

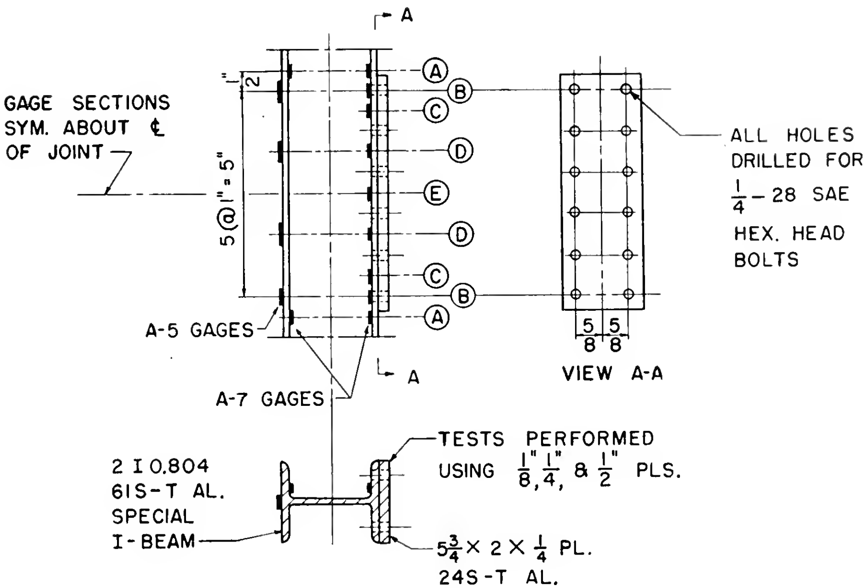


FIG. 15

SPECIMEN T-6

JOINT DETAILS & GAGE LOCATIONS

Fig. 16—Specimen T-6 under test.

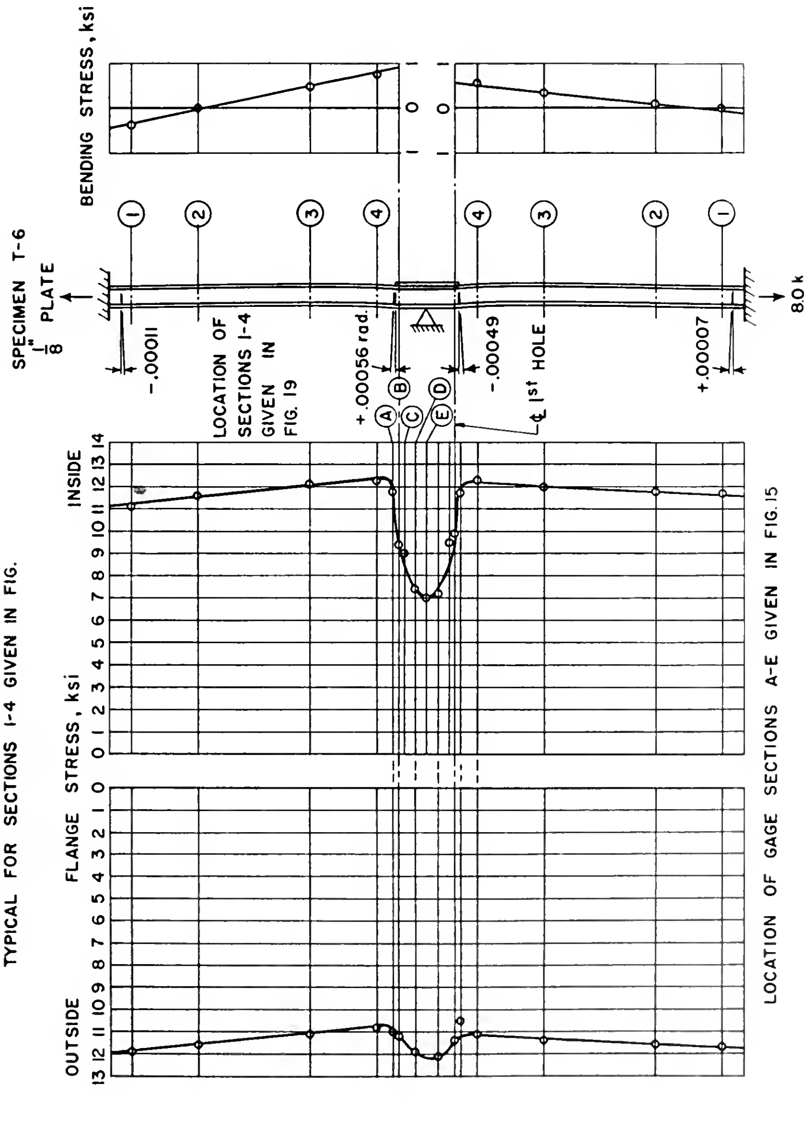


FIG. 17
RESULTS OF TEST T68

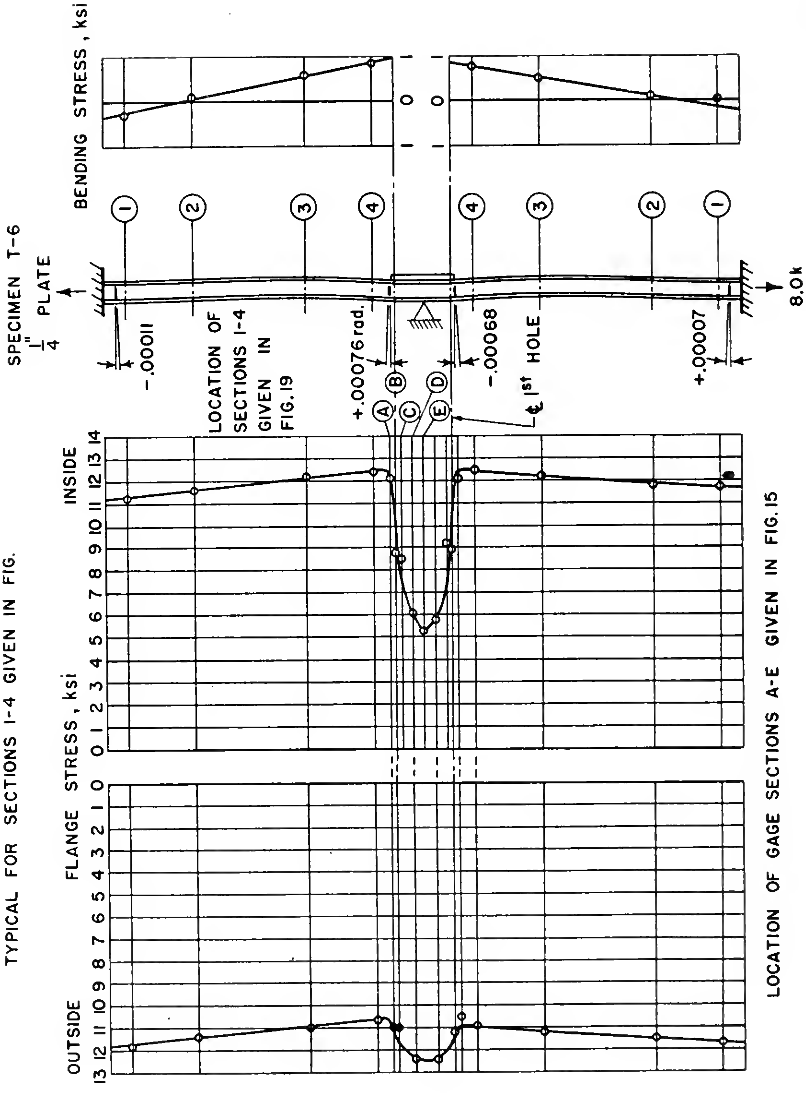


FIG. 18
RESULTS OF TEST T64

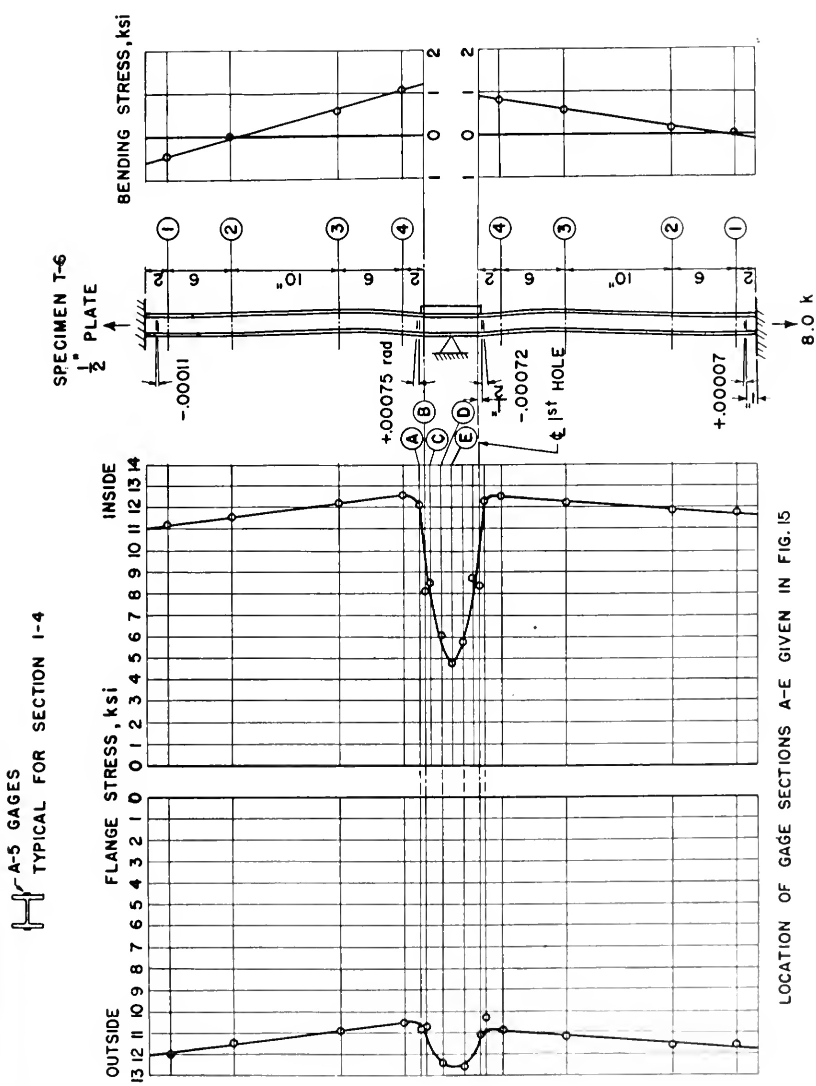


FIG. 19
RESULTS OF TEST T62

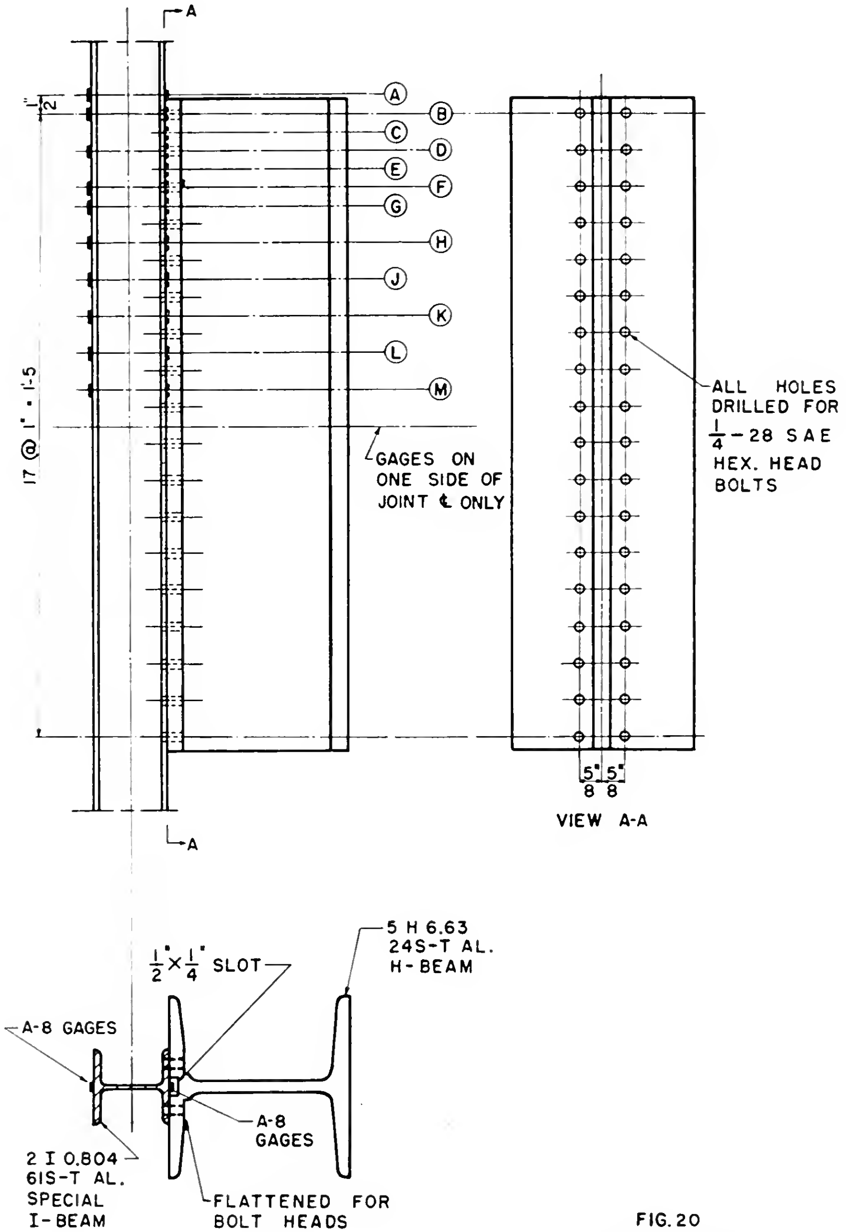


FIG. 20

SPECIMEN T-18

JOINT DETAILS & GAGE LOCATIONS

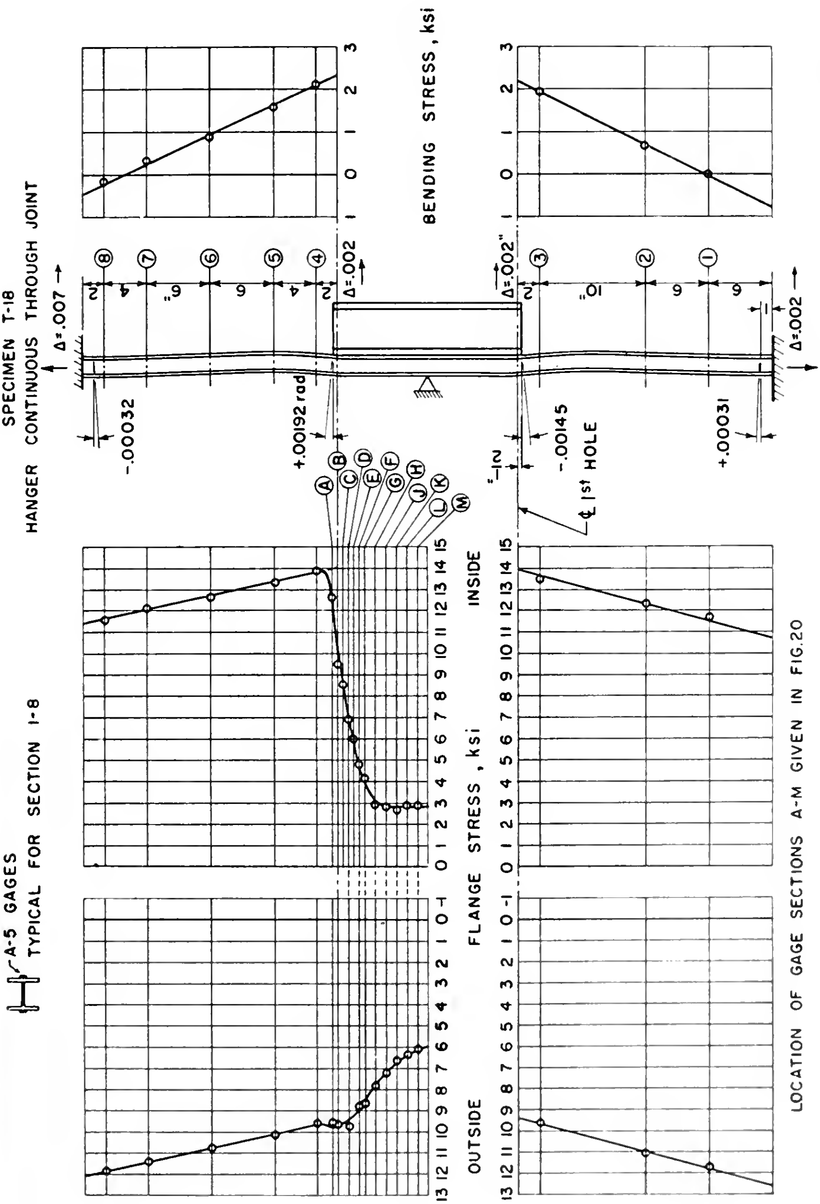


FIG. 21
RESULTS OF TEST T18C

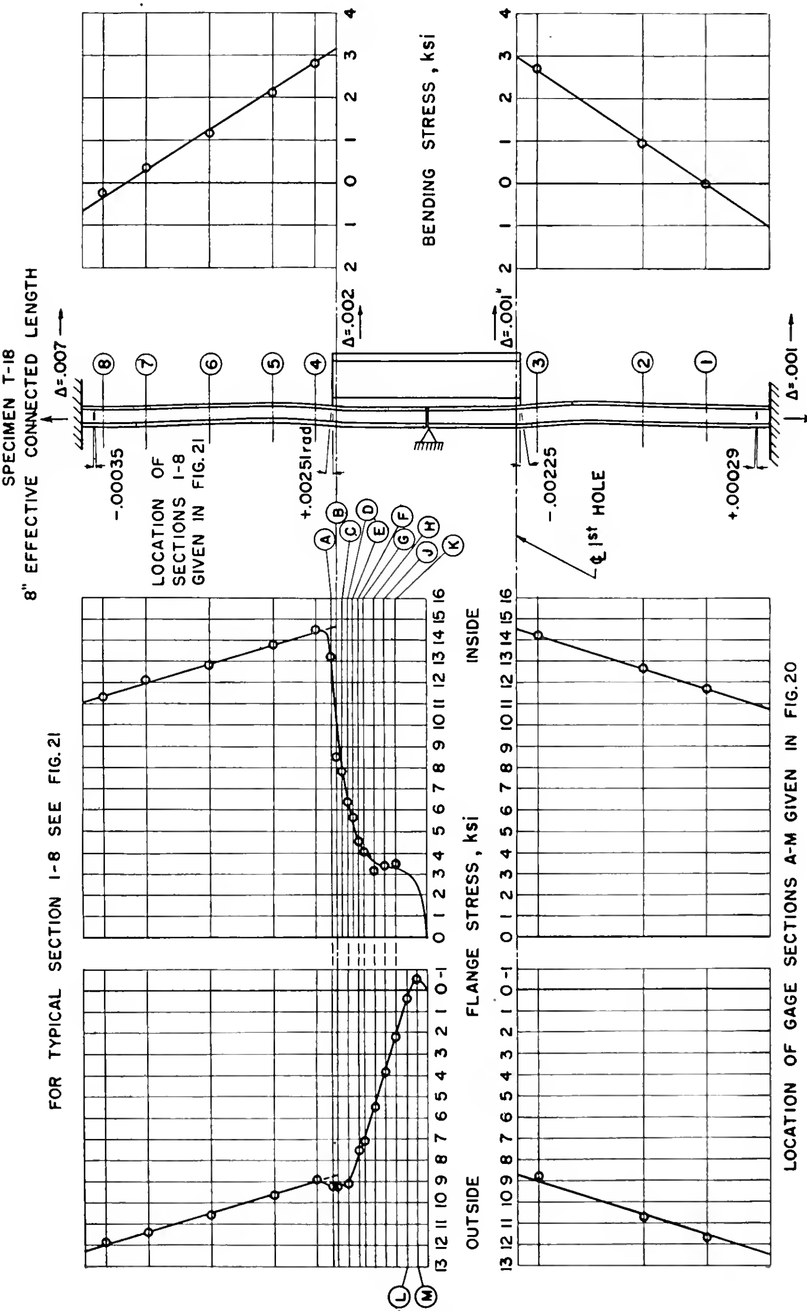


FIG. 22
RESULTS OF TEST T188

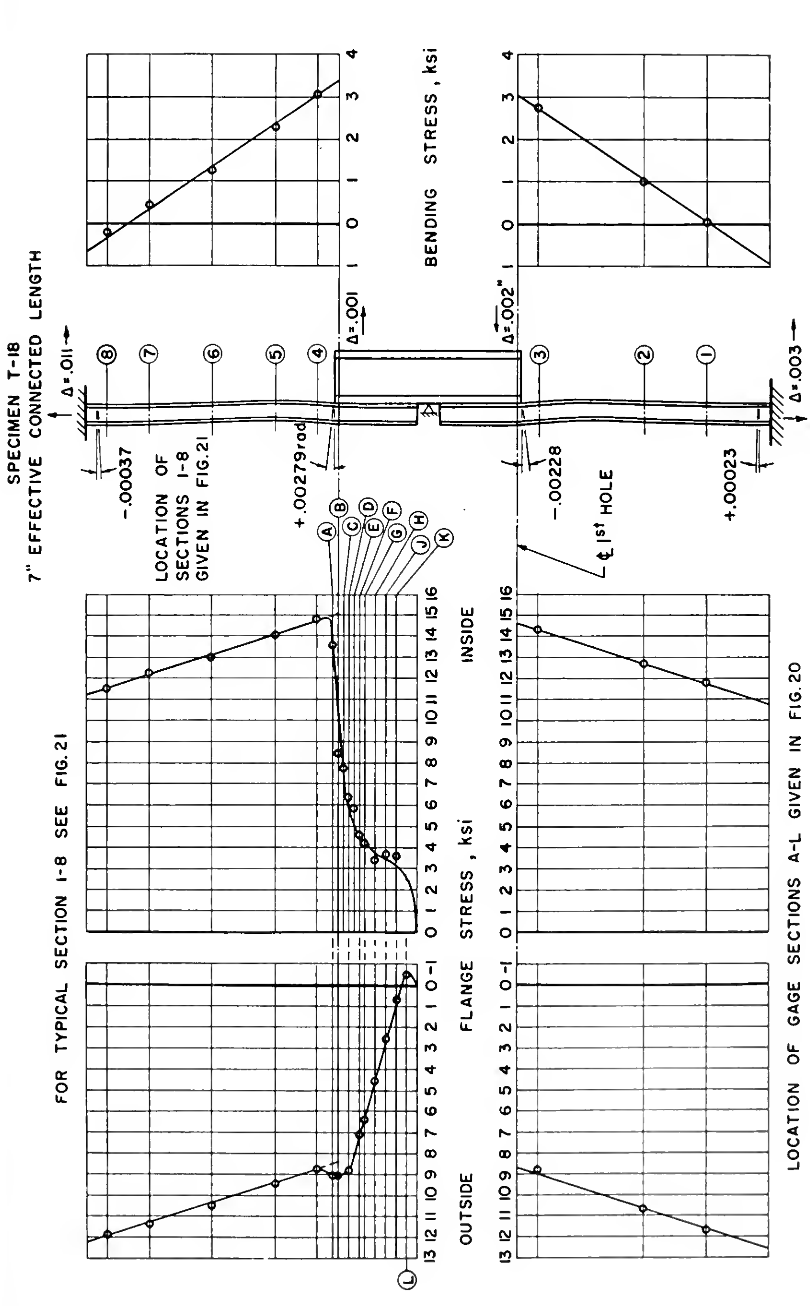


FIG. 23
RESULTS OF TEST T187

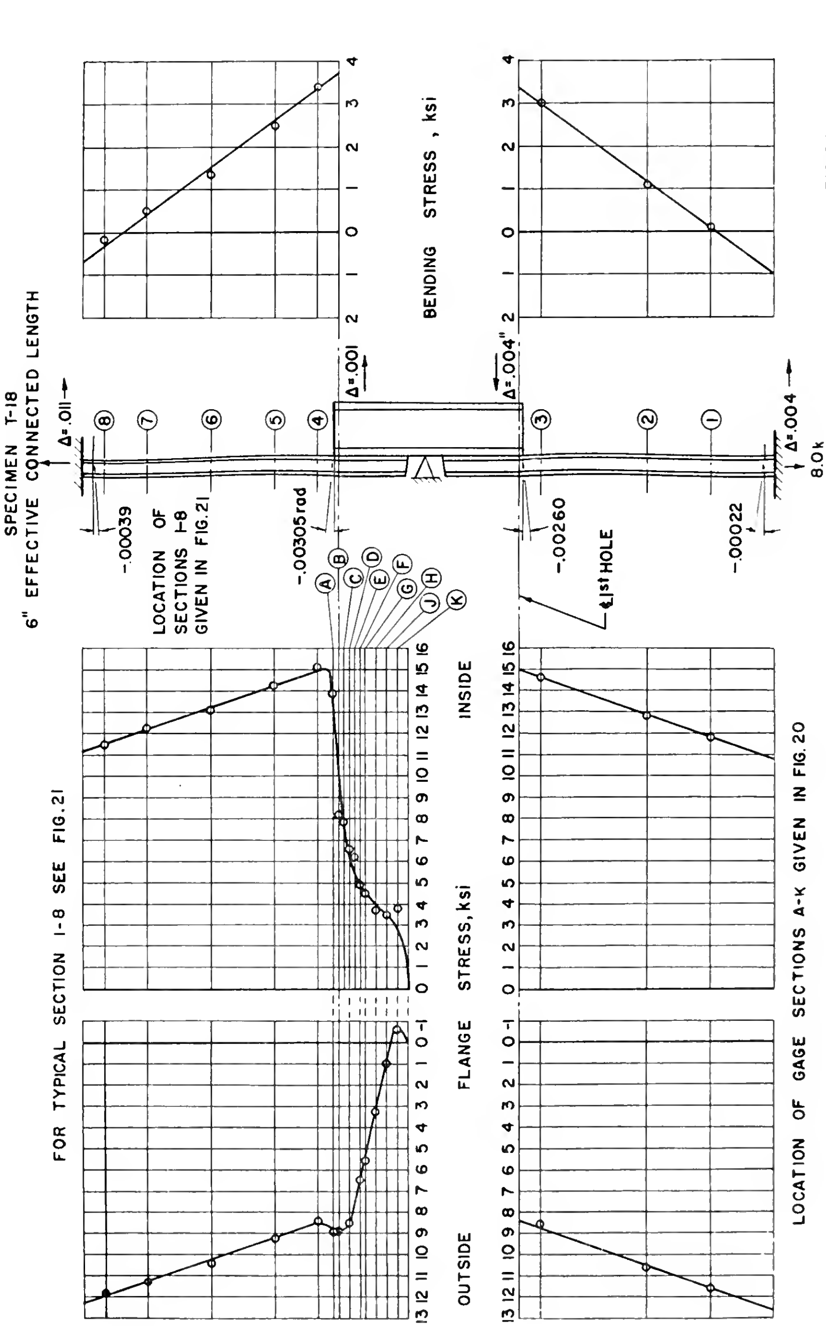


FIG. 24
RESULTS OF TEST T186

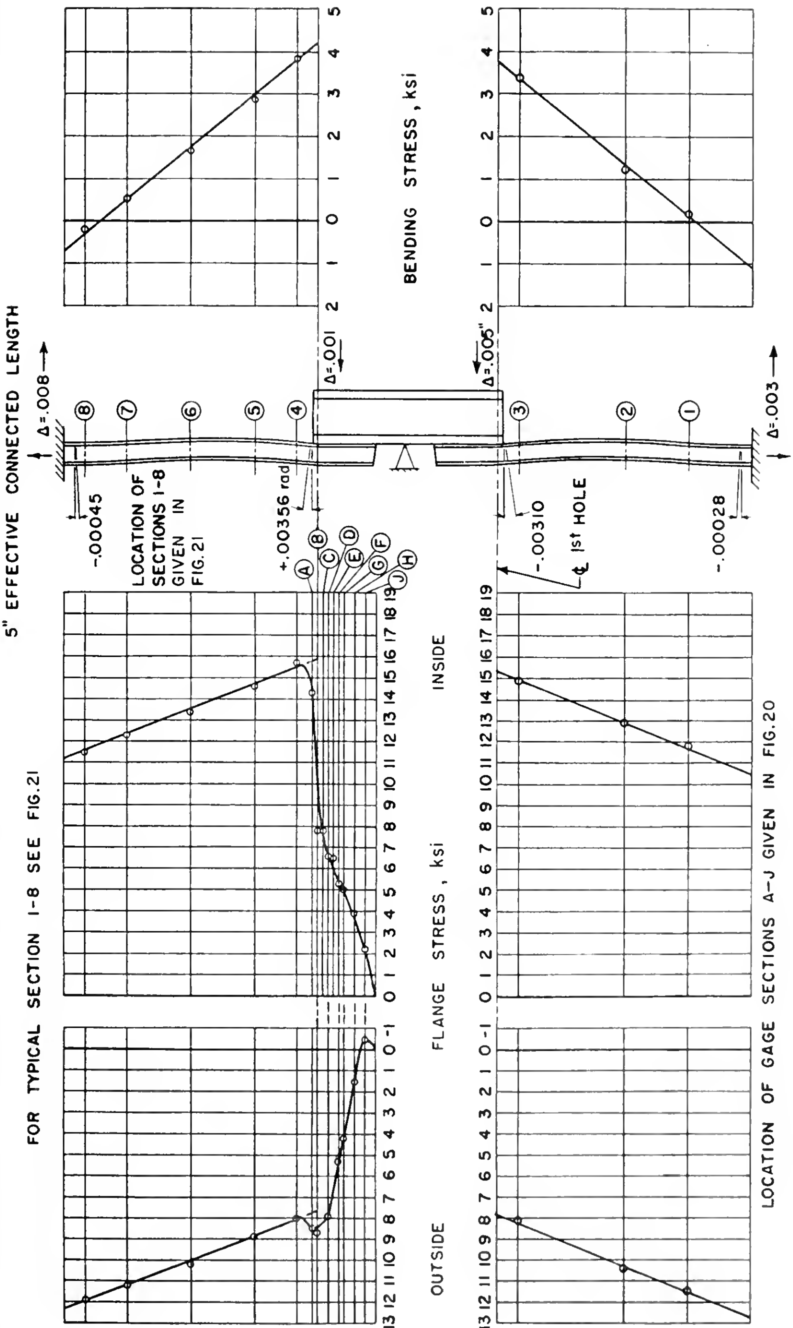


FIG. 25
RESULTS OF TEST T185

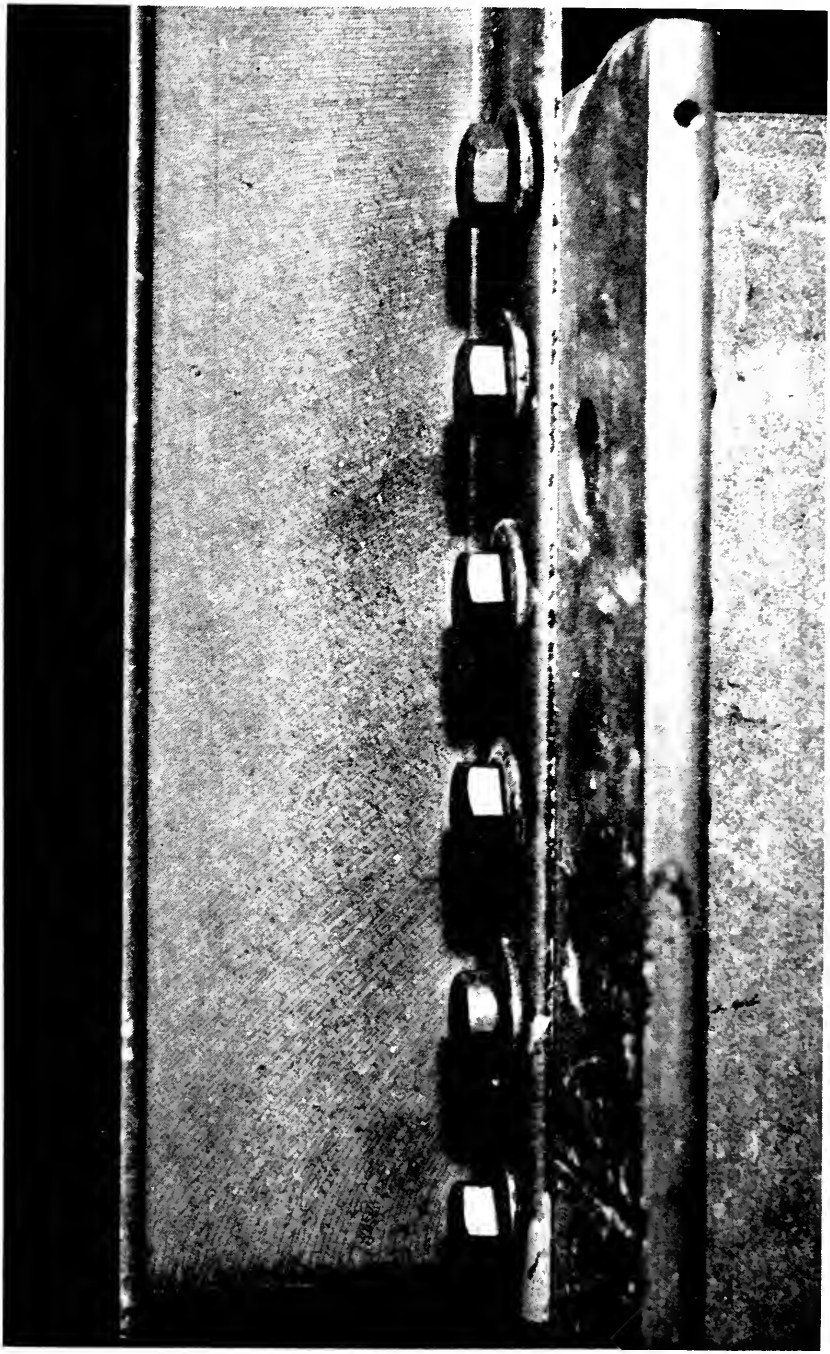
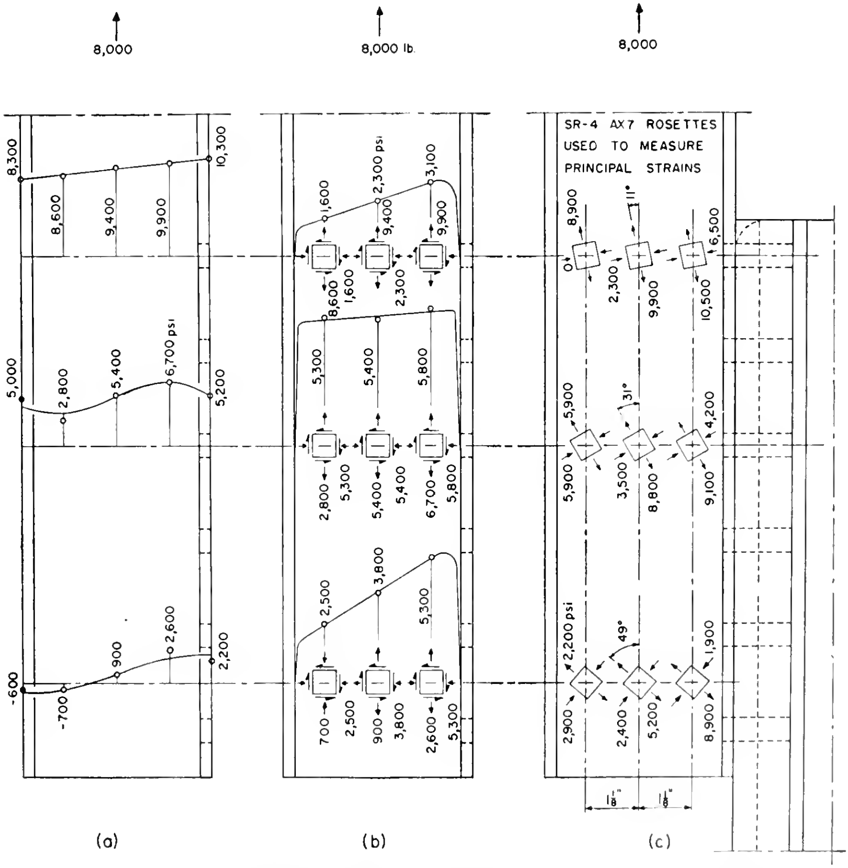


Fig. 25a—Principal plane directions disclosed by Stresscoat. Specimen T-18, test T185.



STRESS PARALLEL TO AXIS

STRESS ON LONGITUDINAL & TRANSVERSE PLANES SHOWING MEASURED SHEAR STRESS

STRESS ON PRINCIPAL PLANES COMPUTED FROM THE MEASURED STRAINS

FIG. 25b FURTHER RESULTS OF TEST T185 ON SPECIMEN T-18

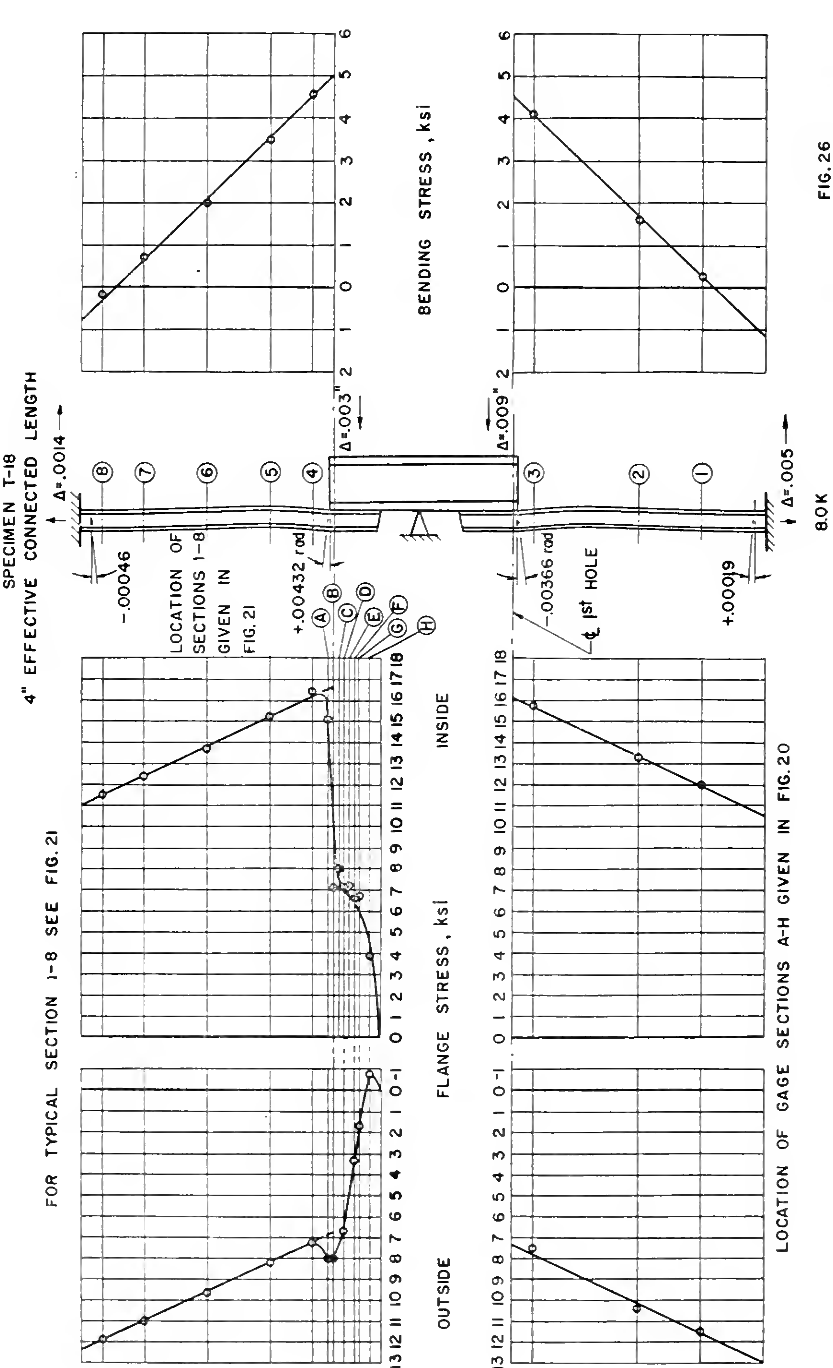


FIG. 26
RESULTS OF TEST T184

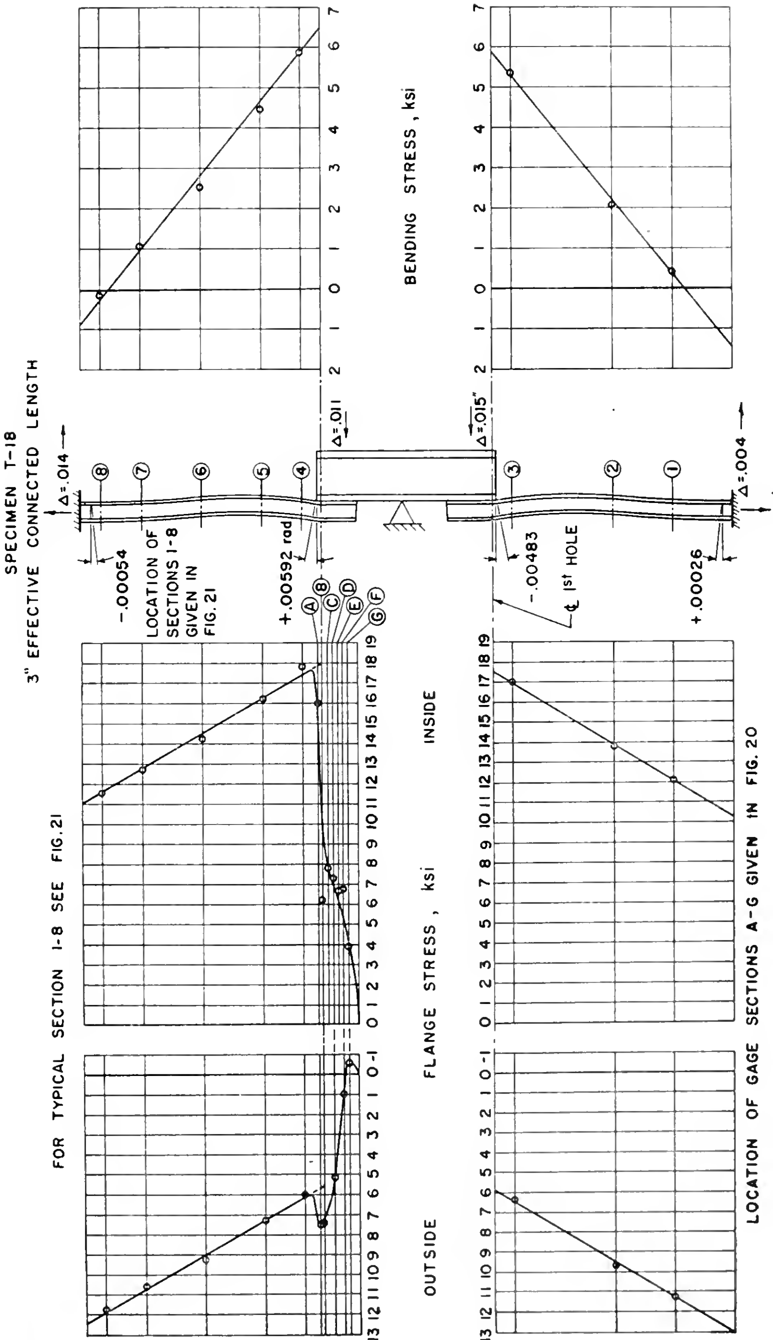


FIG. 27
RESULTS OF TEST T183

NOTE: Φ_S GIVEN AS MEASURED IN TESTS T183 - T188 AND CORRECTED TO A FIXED CONDITION AT B.

FOR ANALYSIS PROCEDURE SEE FIG. 36

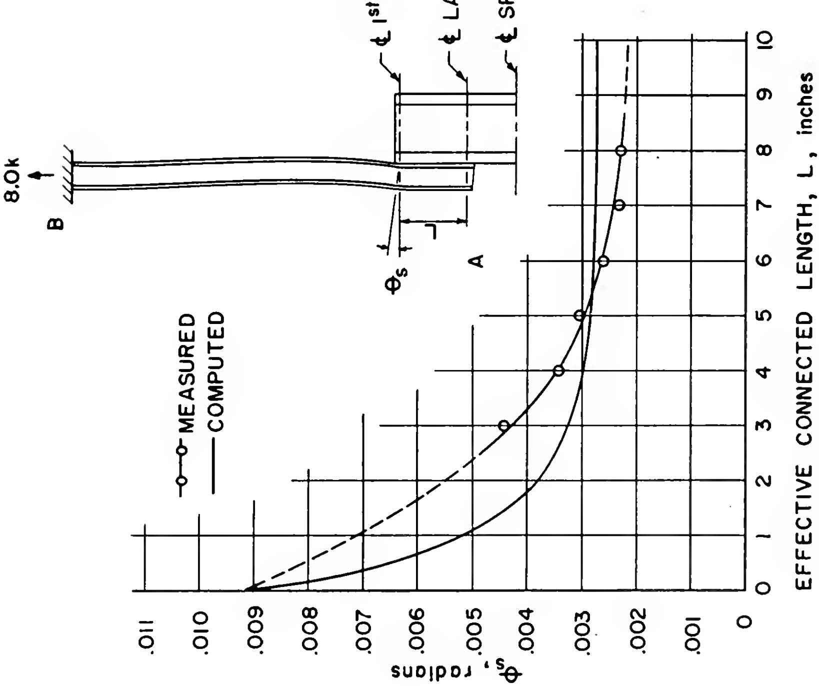


FIG. 28
SHEAR SLOPE
vs
LENGTH OF JOINT CONNECTION

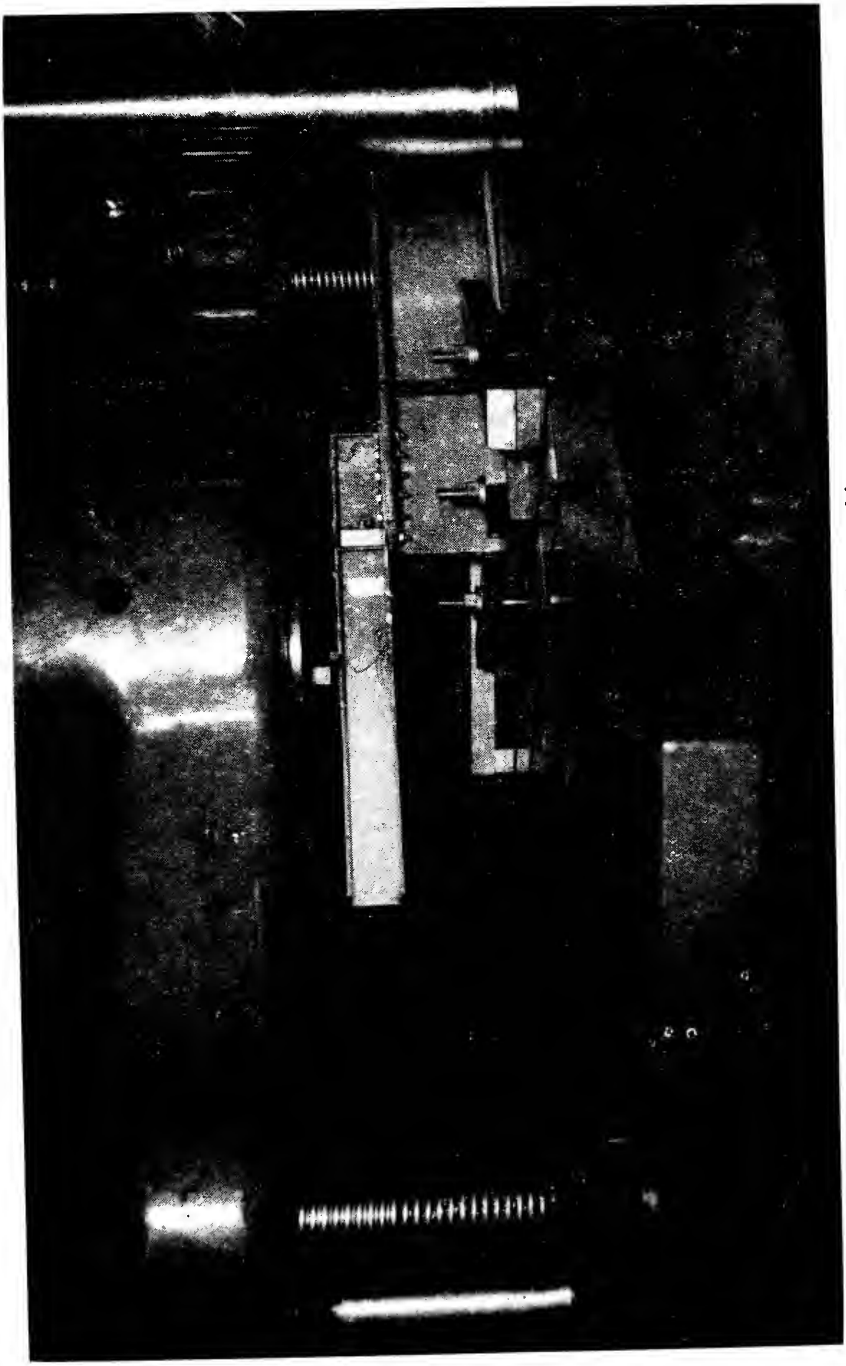


Fig. 29—Specimen C in testing machine.

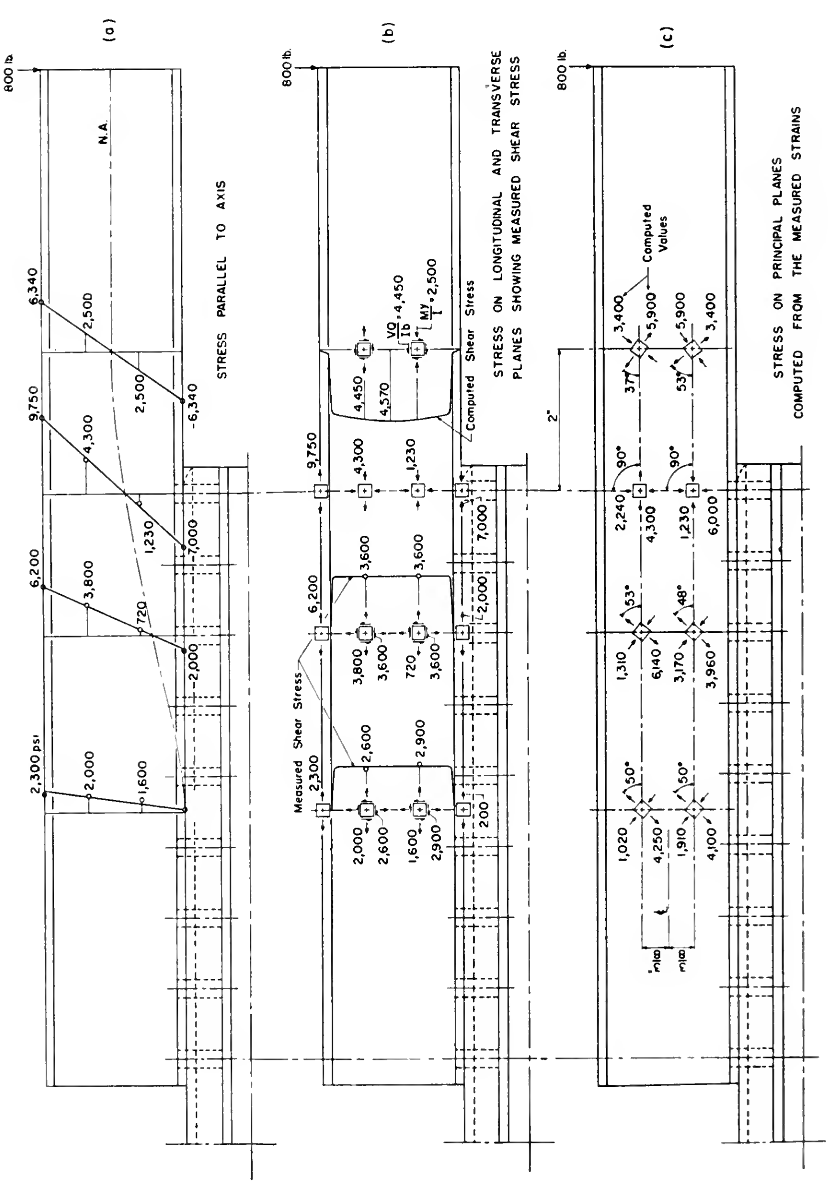


FIG. 30 RESULTS OF TEST C8 ON SPECIMEN C

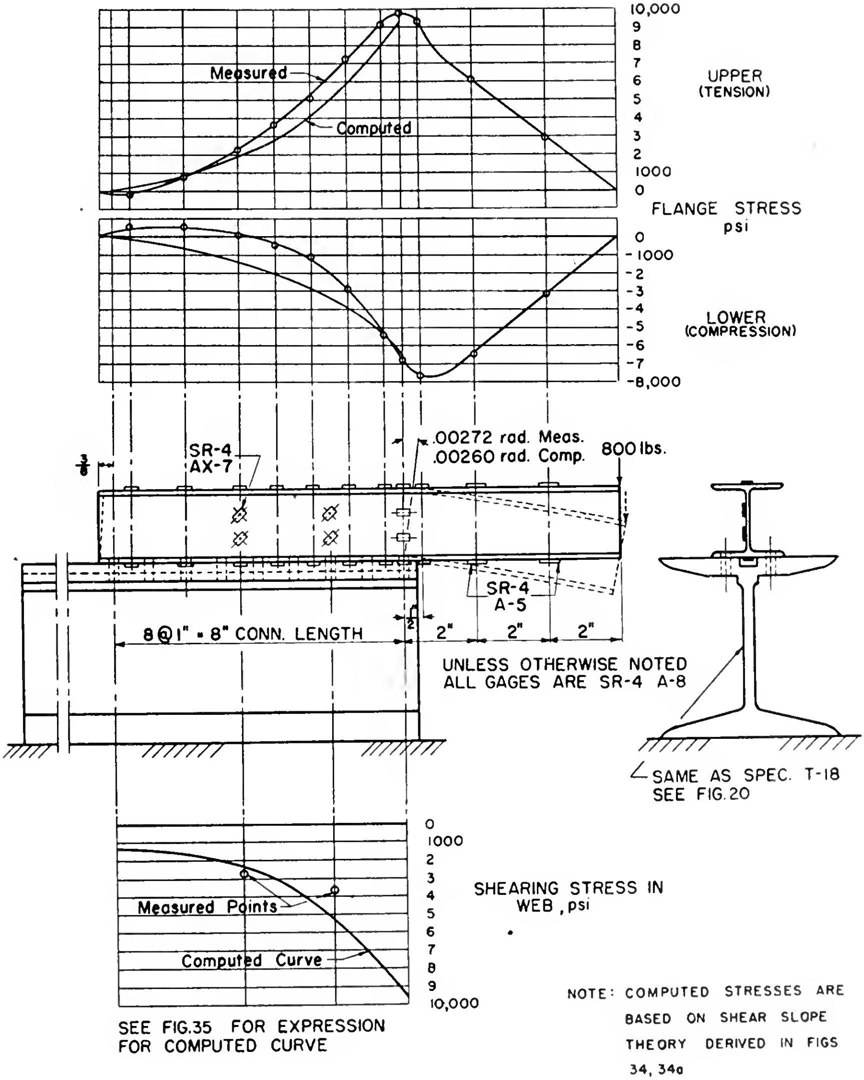


FIG. 31

SPECIMEN C

RESULTS OF TEST C8 AND

COMPARISON WITH COMPUTED VALUES

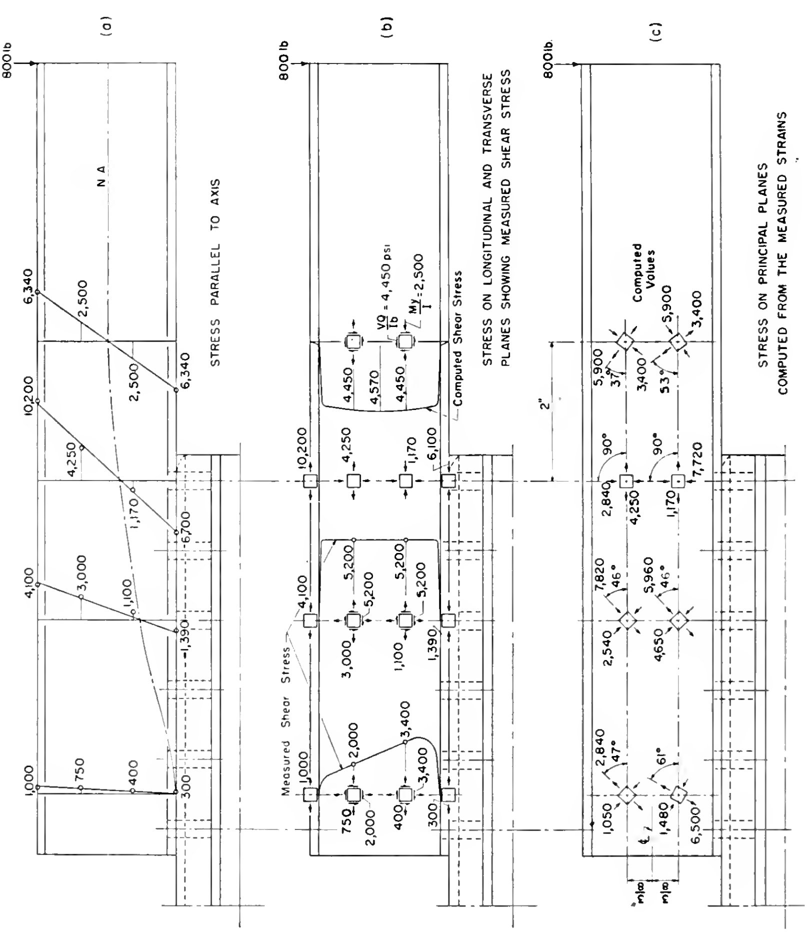


FIG. 32 RESULTS OF TEST C5 ON SPECIMEN C

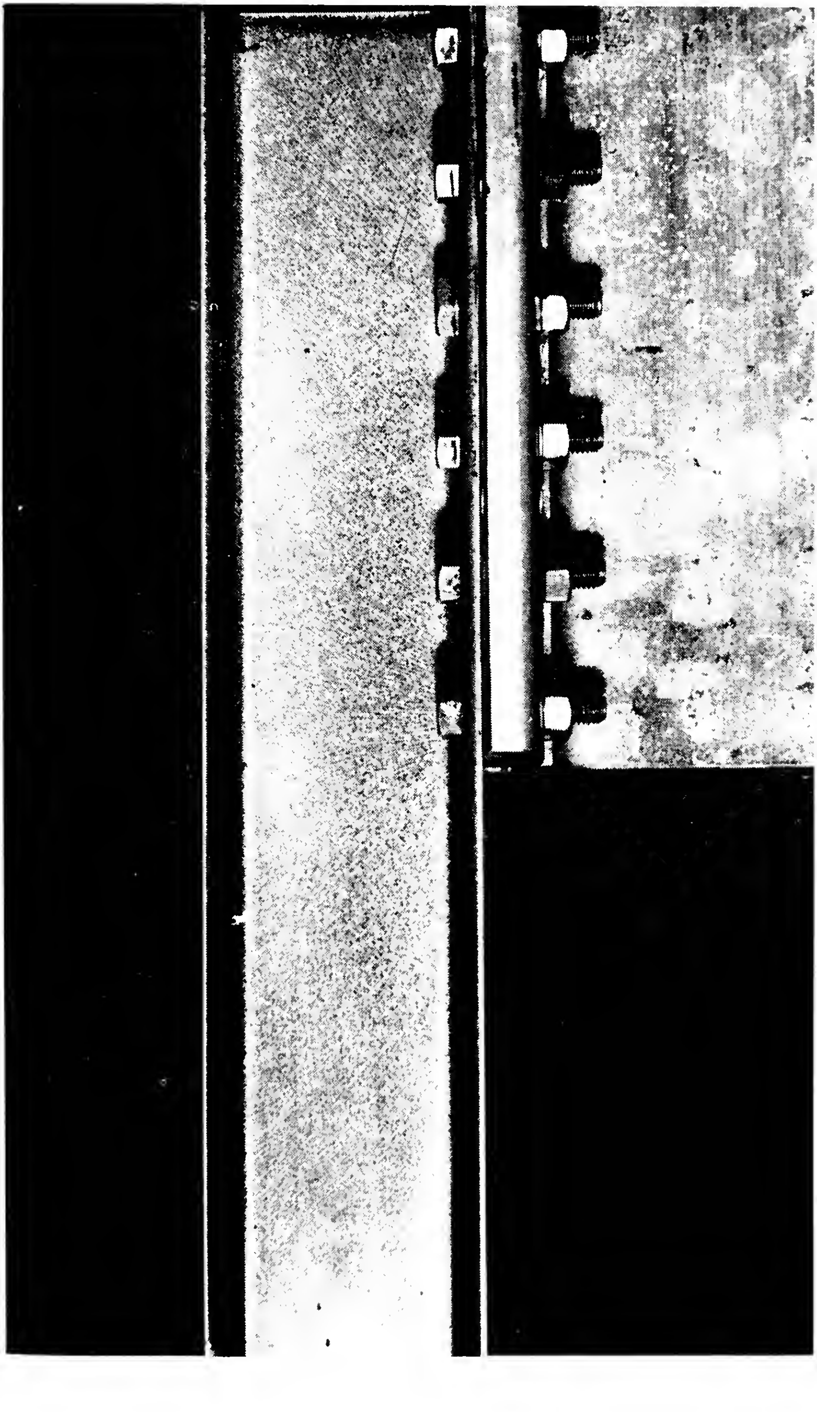


Fig. 32a—Principal plane directions disclosed by Stresscoat, specimen C, test C–5.

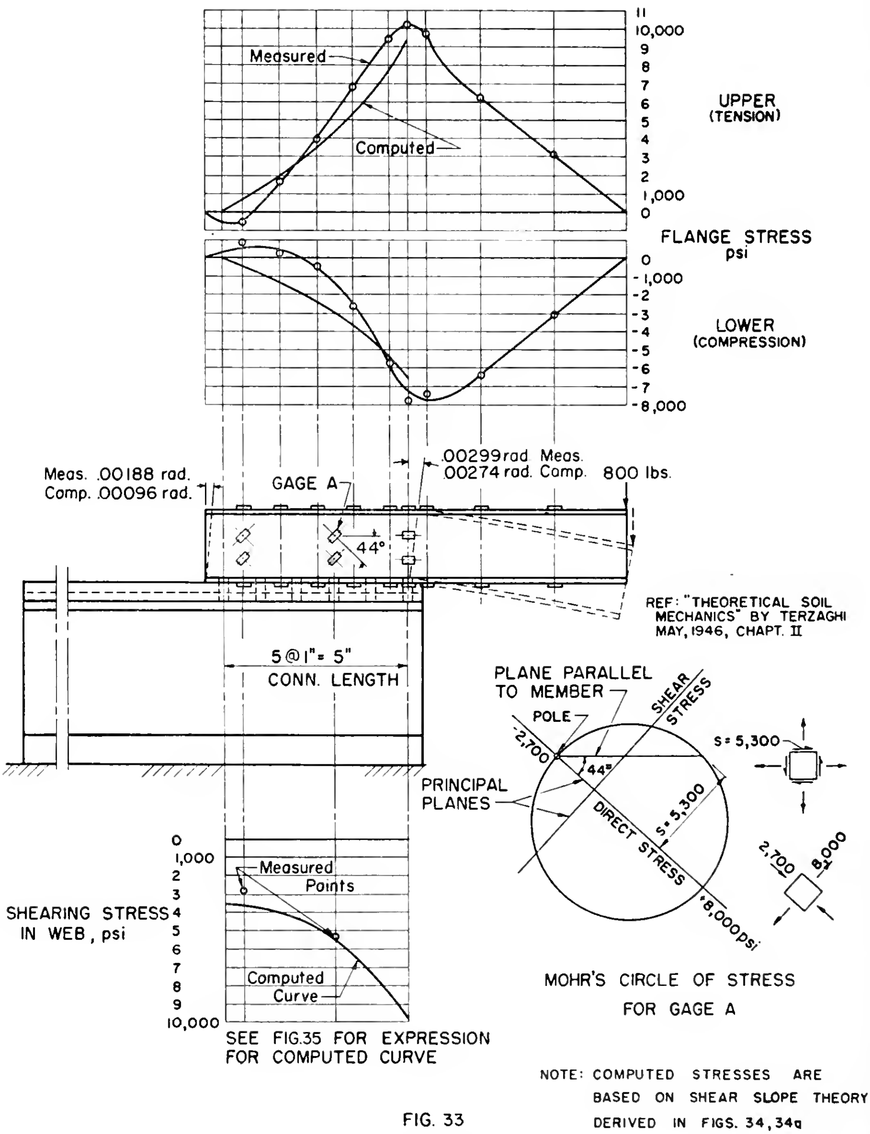
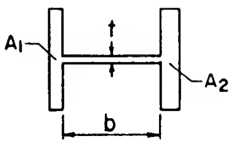
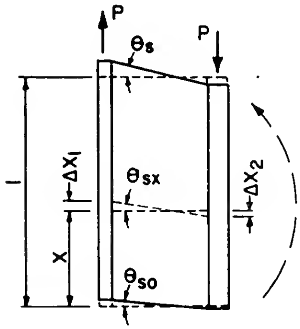


FIG. 33

SPECIMEN C

RESULTS OF TEST C5 AND COMPARISON WITH COMPUTED VALUES





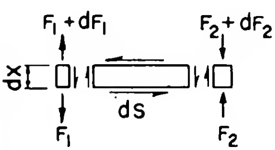
$$\theta_{sx} = \theta_{so} + \frac{\Delta X_1 + \Delta X_2}{b}$$

$$\Delta X_1 = \int_0^x \frac{\sigma_1}{E}\, dx$$

$$\Delta X_2 = \int_0^x \frac{\sigma_1}{E}\, dx$$

$$\theta_{sx} = \frac{S}{G} = \theta_{so} + \frac{1}{Eb}\left(\int_0^x \sigma_1 dx + \int_0^x \sigma_2 dx\right)$$

(1) $$s' = \frac{G}{Eb}(\sigma_1 + \sigma_2)$$



$$dF_1 = dS = dF_2$$

$$d\sigma_1 \cdot A_1 = s \cdot t \cdot dx = d\sigma_2 \cdot A_2$$

(2) $$\sigma_1' = \frac{s \cdot t}{A_1}$$

$$\sigma_2' = \frac{s \cdot t}{A_2}$$

SOLVING (1) & (2)

$$s'' = \frac{G}{Eb}(\sigma_1' + \sigma_2') = \frac{G}{Eb}\left(\frac{s \cdot t}{A_1} + \frac{s \cdot t}{A_2}\right)$$

$$s'' - \frac{Gt}{Eb}\left(\frac{A_1 + A_2}{A_1 \cdot A_2}\right)s = 0$$

THE SOLUTION TO THIS EQUATION IS

$$s = C_1 e^{kx} + C_2 e^{-kx} \quad ; \quad k^2 = \frac{Gt}{Eb}\left(\frac{A_1 + A_2}{A_1 \cdot A_2}\right)$$

EVALUATING C_1 & C_2

$$s' = C_1 k e^{kx} - C_2 k e^{-kx} = \frac{G}{Eb}(\sigma_1 + \sigma_2)$$

for $x = 0$, σ_1 & $\sigma_2 = 0$; $C_1 = C_2$

for $x = l$, $\sigma_1 = \frac{P}{A_1}$, $\sigma_2 = \frac{P}{A_2}$

$$C_1 = C_2 = \frac{P}{A_1 \cdot A_2}(A_1 + A_2)\frac{G}{Ebk}\left(\frac{1}{e^{kl} - e^{-kl}}\right)$$

USING THIS VALUE OF C_1 & C_2 AND RECALLING THAT $\theta_{sx} = \frac{S}{G}$

$$\theta_{sx} = \frac{P}{A_1 \cdot A_2}(A_1 + A_2)\frac{1}{Ebk}\frac{\cosh kx}{\sinh kl}$$

NOMENCLATURE:

σ_1 & σ_2 = UNIT STRESS IN THE FLANGES

S = SHEARING STRESS IN THE WEB

E = MODULUS OF ELASTICITY FOR FLANGE MATERIAL

G = MODULUS OF RIGIDITY FOR WEB MATERIAL

FIG. 34

DERIVATION OF EXPRESSION FOR SHEAR SLOPE

FROM FIG. 34, $\sigma_1' = \frac{s \cdot t}{A_1}$

$$\sigma_1' = \frac{t}{A_1}\left[\frac{P}{A_1 \cdot A_2}(A_1 + A_2)\frac{G}{Ebk}\,\frac{1}{\sinh kl}\right]\int \cosh kx$$

$$\sigma_1 = \frac{n}{k}\sinh kx + C$$

WHERE "n" IS THE CONSTANT ABOVE

EVALUATING C:

for $x = 0$, $\sigma_1 = 0$; $C = 0$

THEN,

$$\sigma_1 = \frac{P}{A_1}\,\frac{\sinh kx}{\sinh kl}$$

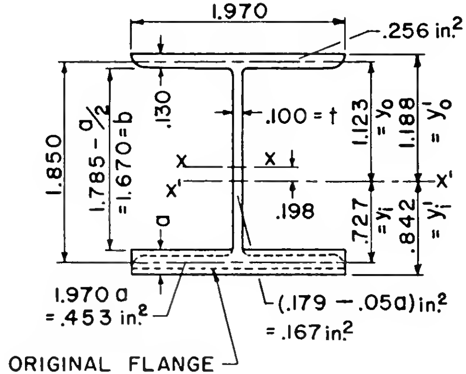
SIMILARLY,

$$\sigma_2 = \frac{P}{A_2}\,\frac{\sinh kx}{\sinh kl}$$

NOTE: EXPRESSIONS FOR σ_1 & σ_2 FOLLOW DIRECTLY FROM THE DERIVATION GIVEN IN FIG. 34

FIG. 34a EXPRESSION FOR FLANGE STRESS

PROPERTIES OF ASSUMED HANGER SECTION FOR SHEAR SLOPE ANALYSIS



COMPUTE a:

$$.727 = \frac{(.256\cdot 1.850) + (.179 - .05a)(.893 + .25a)}{.256 + (.179 - .05a) + 1.970a}$$

$a = .230 \text{ in.}^2$

$I_{x'-x'} = .612 \text{ in.}^4$

APPLIED EXPRESSION FOR SHEAR SLOPE (SEE FIG. 34 FOR GENERAL EXPRESSION AND TERMS)

$A_1 = .309 \text{ in.}^2$ STRESS AT CENTROID $A_1 = \frac{M\cdot 1.123}{.612} = 1.835M$

$A_2 = .484 \text{ in.}^2$ " " " $A_2 = \frac{M\cdot .727}{.612} = 1.189M$

P ON $A_1 = 1.835M\cdot .309 = .566M$

P ON $A_2 = 1.189M\cdot .484 = .564M$ AVG. P = .565 M

$A_1 + A_2 = .793 \text{ in.}^2$ $b = 1.670''$ $E = 9{,}850{,}000$ psi

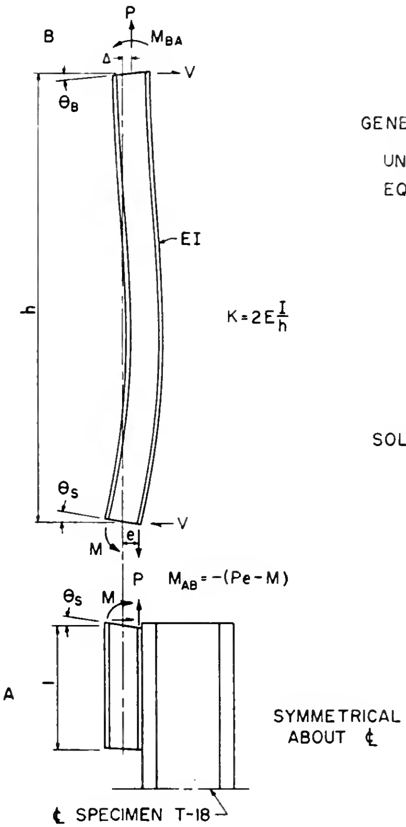
$A_1\cdot A_2 = .149 \text{ in.}^4$ $t = .100''$ $G = 3{,}630{,}000$ psi

$$k^2 = \frac{3.63\cdot .100}{9.85\cdot 1.670}\left(\frac{.793}{.149}\right) \qquad \theta_{sx} = \frac{.565M}{.149}(.793)\cdot\frac{1}{E\cdot 1.670\cdot .342}\cdot\frac{\cosh kx}{\sinh kl}$$

$$k = .342 \qquad \theta_{sx} = .000000535\,M\cdot\frac{\cosh kx}{\sinh kl}$$

FIG. 35

EXPRESSION FOR SHEAR SLOPE APPLIED TO MODEL HANGER SECTION



GENERAL SOLUTION

UNKNOWN: θ_S, M

EQUATIONS: 1. $M_{AB} = -(Pe - M)$

2. $\theta_S = cM \frac{\cosh kl}{\sinh kl}$ (SEE FIG. 34)

SLOPE - DEFLECTION EQUATION FOR HANGER

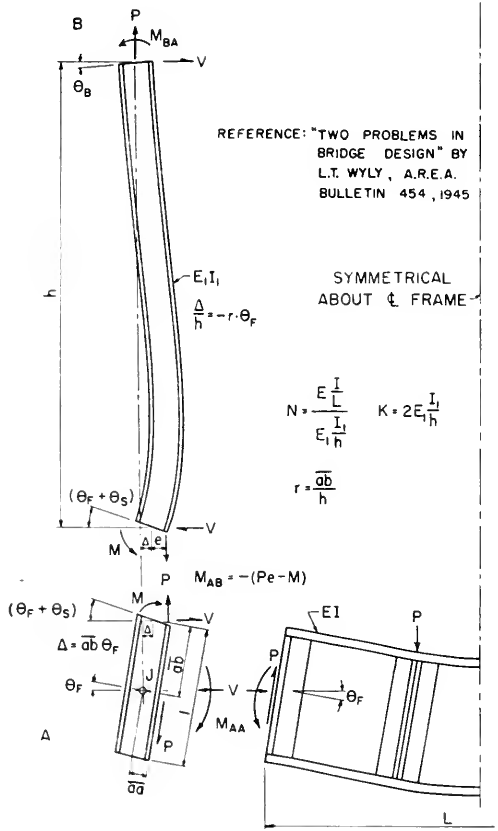
$$M_{AB} = K\left[-2\theta_S - \theta_B + 3\frac{\Delta}{h}\right] = -(Pe-M)$$

FOR SIGN CONVENTION, SEE FIG. 37

SOLVE 1. & 2. SIMULTANEOUSLY

FOR RESULTS OF TESTS ON SPECIMEN T-18 SEE FIGS. 21-27

FIG. 36 PROCEDURE FOR ANALYSIS OF SPECIMEN T-18



RIGID FRAME SOLUTION

UNKNOWN: θ_F, θ_S, M

EQUATIONS: 1. $\Sigma M_{JA} = V\overline{ab} + M_{AB} + M_{AA} + P\overline{aa} = 0$

2. $M_{AB} = -(Pe - M)$

3. $\theta_S = CM\frac{\cosh kl}{\sinh kl}$ (SEE FIG. 34)

WHERE C = A CONSTANT

SIGN CONVENTION

+θ +MOMENT

SLOPE - DEFLECTION EQUATIONS FOR HANGER

$$M_{AB} = K\left[-2(\theta_F + \theta_S) - \theta_B - 3r\theta_F\right]$$

$$= K\left[-(2+3r)\theta_F - 2\theta_S - \theta_B\right]$$

$$M_{BA} = K\left[-(1+3r)\theta_F - \theta_S - 2\theta_B\right]$$

FOR MEMBERS OF VARYING MOMENT OF INERTIA SEE PART I OF THIS SYMPOSIUM

EXPRESSION FOR $V\overline{ab}$

$$V\overline{ab} = \frac{M_{AB} + M_{BA}}{h}\overline{ab}$$

$$= K\left[-(3+6r)\theta_F - 3\theta_S - 3\theta_B\right]$$

SLOPE - DEFLECTION EQUATION FOR FLOORBEAM

$$M_{AA} = M_{F_A} + KN(-\theta_F)$$

EQUATION I.

$$-\left[N + r(6+6r) + 2\right]\theta_F - (2+3r)\theta_S - (1+3r)\theta_B = -\frac{M_{F_A} + P\overline{aa}}{K}$$

FIG. 37

GENERAL ANALYSIS
OF
FLOORBEAM AND HANGER FRAME
INCLUDING EFFECT OF SHEAR SLOPE

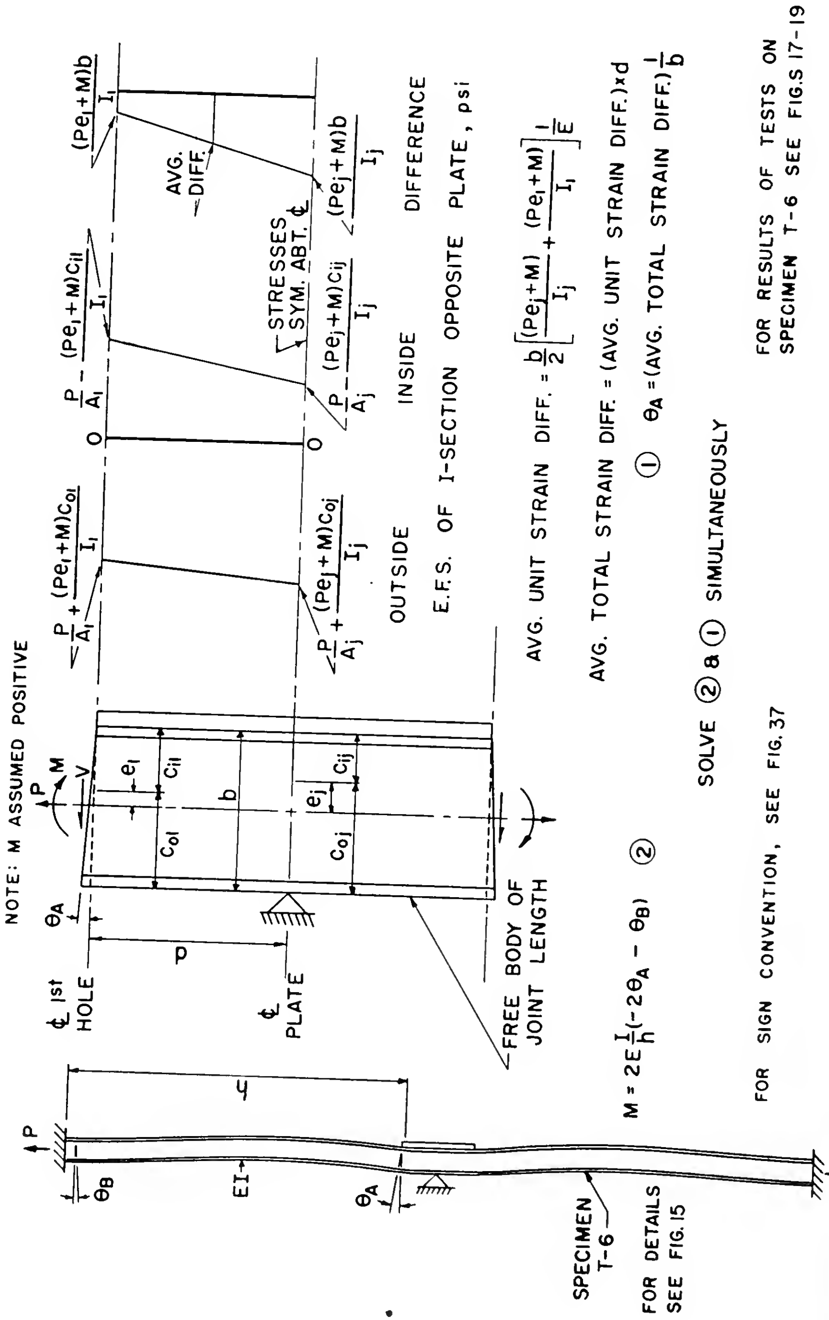
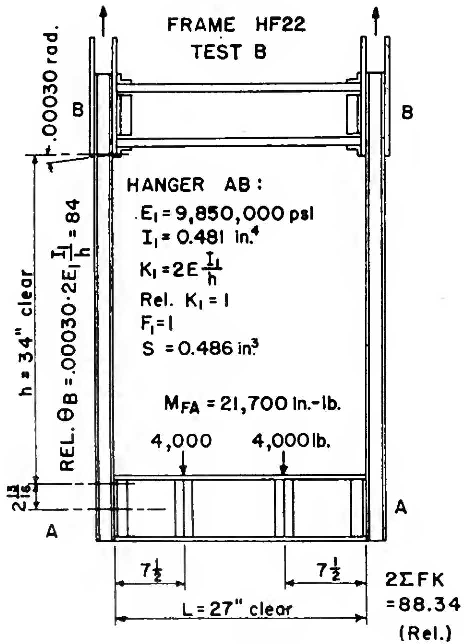


FIG. 38 PROCEDURE FOR ANALYSIS OF SPECIMEN T-6



FLOORBEAM AA:

E = 10,350,000 psi
I = 31.4 in.^{4}
Rel. K = 86.34
$F = \frac{1}{2}$

FINAL VALUES:

$M_{AB} = -410 - 61 - 87 - 595 = -1{,}153$ in.-lb.

$M_{BA} = -79 - 61 - 44 - 298 = -482$ "

STEP I:

STANDARD ANALYSIS

$$M_{AA} = M_{FA} + FK(-2\theta_{1A})$$
$$M_{AB} = \qquad F_1K_1(-2\theta_{1A} - \theta_B)$$
$$0 = M_{FA} - 2\Sigma FK \cdot \theta_{1A} - F_1K_1\theta_B$$
$$\theta_{1A} = \frac{M_{FA}}{2\Sigma FK} - \frac{F_1K_1}{2\Sigma FK}\cdot\theta_B$$
$$= 247 \text{ (Relative)}$$

$M_{1AB} = -410$ in.-lb.

$M_{1BA} = -79$ "

$V_{1AB} = 14.4$ lb.

STEP IIa:

EFFECT OF Δ

Rel. $\Delta_{AB} = 2\frac{13}{16}\cdot\theta_{1A}$

$$M_{2\frac{\Delta}{h}AB} = 3\left[-\frac{2\frac{13}{16}\cdot 247}{34}\right]$$
$$= -61 \text{ in.-lb.}$$

$V_{2AB} = 3.6$ lb.

STEP IIb:

EFFECT OF ΣM_{JA}

$\Sigma M_{JA} = +3{,}850$ in.-lb.

$$\theta_{2A} = \frac{\Sigma M_{JA}}{2\Sigma FK} = 43.6$$

$M_{2\theta AB} = 1\cdot(-2\cdot 43.6) = -87$ in.-lb.

$M_{2\theta BA} = 1\cdot(-1\cdot 43.6) = -44$ "

M_{AB} FROM STEPS I, IIa, IIb = −558 in.-lb.

STEP III:

EFFECT OF SHEAR SLOPE
(See FIG.37 & Analysis of HF22)

$-m$ = Increment of M_{AB} from θ_S
FINAL $M_{AB} = -(558 + m) = -(Pe - M)$

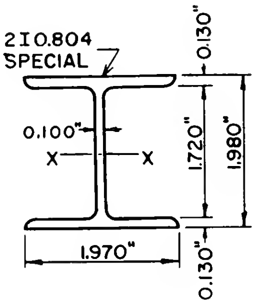
$M = Pe - 558 - m$

1. $\theta_S = .440\times10^{-6}M = .440(3{,}580 - 558 - m)\cdot10^{-6}$

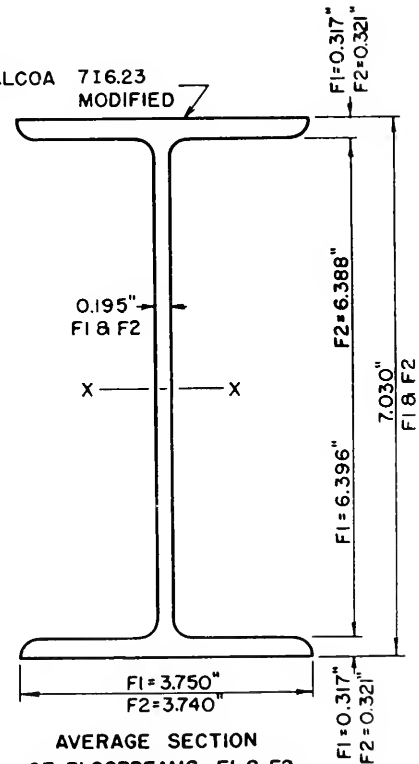
2. $-m = 2E_1\frac{I_1}{h}(-2\theta_S)$

SOLVE 1 & 2. FOR m = 595 in.-lb.
(Add $\frac{1}{2}$ this increment to M_{BA})

FIG. 39 ANALYSIS OF FRAME HF22 BY MODIFIED S-D INCLUDING SHEAR SLOPE



AVERAGE SECTION OF
HANGERS H1, H2, H3, H4 & H5



AVERAGE SECTION
OF FLOORBEAMS F1 & F2

PROPERTIES OF SECTIONS:

MEMBER	MAT'L.	* E lbs./in.^{2}	* G lbs./in.^{2}	AREA in.^{2}	I_{xx} in.^{4}
All Hangers	Al. 61S-T	9.85	3.63	0.686	0.481
Floorbeam F1	Al. 24S-T	10.35	—	3.70	31.4
Floorbeam F2	Al. 24S-T	10.35	—	3.65	31.4

* x 1,000,000

FIG. 40 HANGER AND FLOORBEAM SECTIONS

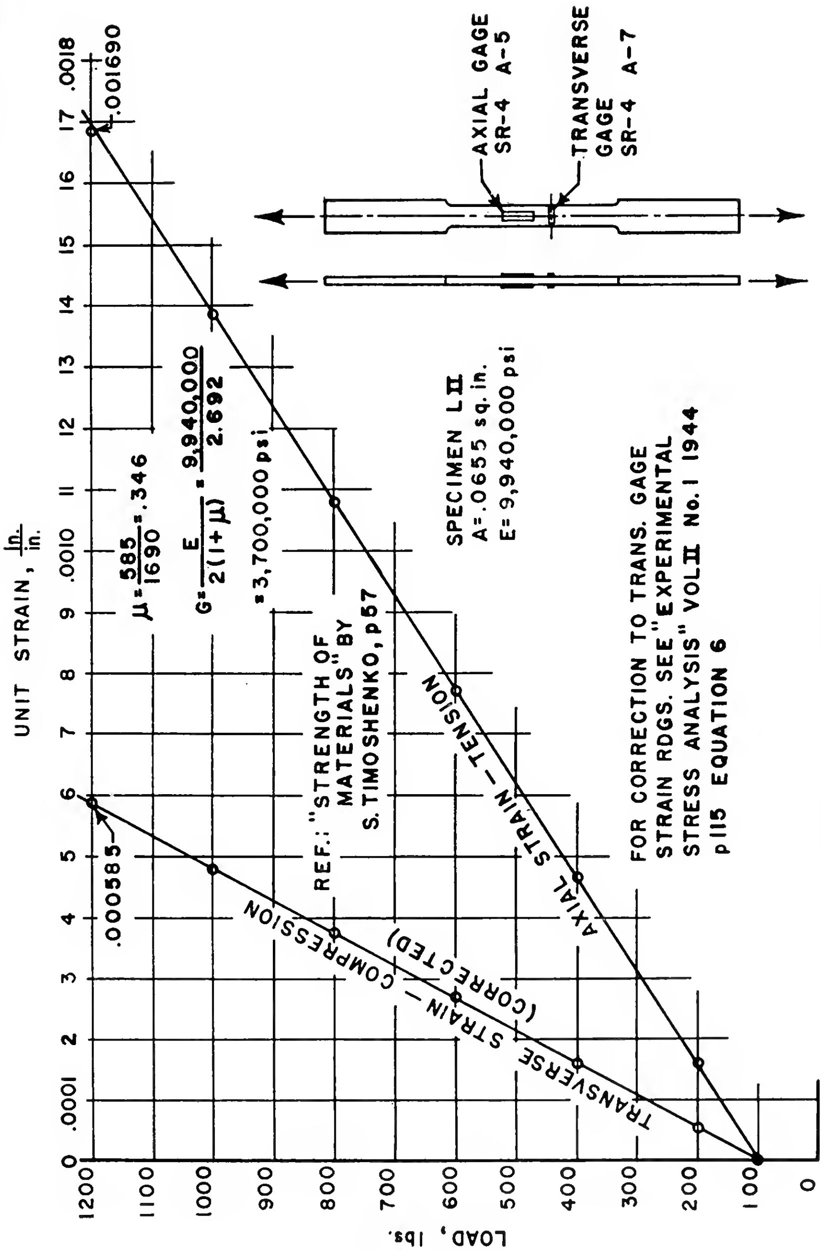
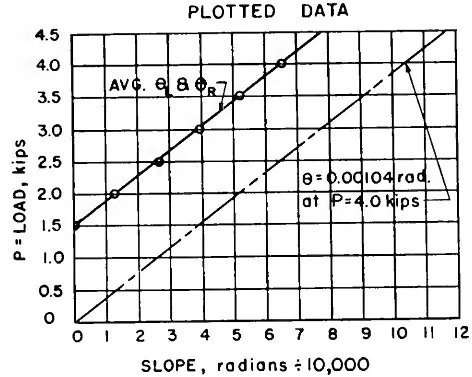


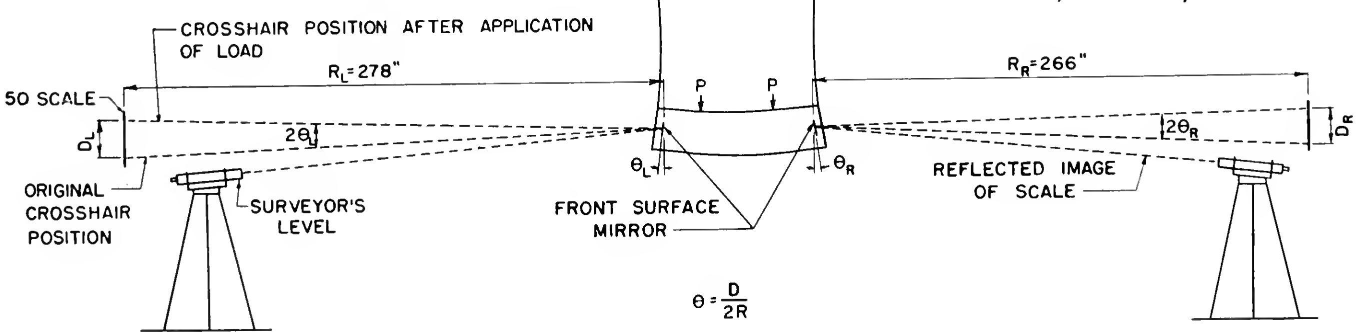
FIG. 41 EXPERIMENTAL DETERMINATION OF SHEARING MODULUS

END ROTATION OF FLOORBEAM
SLOPE DATA TAKEN AS PART OF TEST B

SIDE		P = LOAD, lbs.					
		1500	2000	2500	3000	3500	4000
LEFT	SCALE RDG.	30.10	29.65	29.15	28.70	28.25	27.80
	D_L, in.	0	.09	.19	.28	.37	.46
	θ_L, rad.	0	.000162	.000342	.000504	.000665	.000827
RIGHT	SCALE RDG.	18.00	17.75	17.50	17.20	17.00	16.75
	D_R, in	0	.05	.10	.15	.20	.25
	θ_R, rad.	0	.000094	.000188	.000282	.000376	.000476
AVG. θ_L & θ_R, rad.		0	.000128	.000265	.000393	.000520	.000651

NOTE: Zero end of scale is up.





$$\theta = \frac{D}{2R}$$

FIG. 42

METHOD FOR MEASURING SLOPES, EXPERIMENTAL DATA AND PLOTTED RESULTS

ANALYSIS OF SPECIMEN C - TEST C8

REF.: FIG. 31
" 34
" 35

COMPUTATION OF SHEAR SLOPE

USE THE EQUATION FOR θ_{sx} DERIVED IN FIG. 35.

FOR TEST C8, $l = 8''$ | $kl = 2.736$
$x = 8''$ | $\cosh kx = 7.758$
$M = 800 \times 6 = 4{,}800$ in.-lb. | $\sinh kl = 7.693$

$$\theta_{sx} = .000000535 \times 4{,}800 \times \frac{7.758}{7.693} = .00260 \text{ rad.}$$

THIS IS THE COMPUTED VALUE SHOWN IN FIG. 31.

COMPUTATION OF SHEAR STRESS IN THE WEB

RECALLING FROM FIG. 34 THAT $\theta_{sx} = \frac{s}{G}$ (SEE DERIVATION OF EQUATION I. IN THIS FIGURE), AND REFERRING TO FIG. 40 FOR THE VALUE OF G,

$$\text{shear stress, } s = .00260 \times 3{,}630{,}000 = 9{,}450 \text{ psi}$$

THIS IS THE VALUE OF SHEAR STRESS SHOWN IN FIG. 31 PLOTTED AT THE ℄ OF THE 1st BOLT HOLE.

COMPUTATION OF FLANGE STRESS

EQUATIONS FOR THE INSIDE AND OUTSIDE FLANGE STRESSES ARE DERIVED IN FIG. 34a.

TO OBTAIN A VALUE FOR THE $\frac{P}{A}$ TERM USED IN THESE EQUATIONS, COMPUTE THE EFS AT THE

Fig. 43—Analysis of specimen C.

ANALYSIS OF SPECIMEN C (CONTINUED)

AT THE ℄ OF THE 1st HOLE, BASED ON THE ASSUMED SECTION OF FIG. 35. FOR THE OUTSIDE FLANGE THIS VALUE WOULD BE

$$\frac{P}{A_1} = \frac{4{,}800 \times 1.188}{.612} = 9{,}300 \text{ psi tension}$$

NOW, THE OUTSIDE FLANGE STRESS AT ANY OTHER POINT, SAY AT $x = 2''$, MAY BE COMPUTED AS FOLLOWS:

$l = 8''$	$x = 2''$	
$kl = 2.736$	$kx = .684$	$\sigma_1 = 9{,}300 \times \frac{.739}{7.693} = 900$ psi
$\sinh kl = 7.693$	$\sinh kx = .739$	

THIS IS THE VALUE OF OUTSIDE FLANGE STRESS PLOTTED IN FIG. 31 AT ℄ OF THE 7th HOLE.

ANALYSIS OF SPECIMEN T-18

TO DEMONSTRATE USE OF THE PROCEDURE GIVEN IN FIG. 36, A VALUE OF θ_S PLOTTED IN FIG. 28 WILL BE COMPUTED.

EQUATION I.

$$K = \frac{19{,}700{,}000 \times .481}{24} = 395{,}000$$

$P = 8{,}000$ lb.
$e = .895''$
$Pe = 7{,}160$ in.-lb.

$$M_{AB} = 395{,}000(-2\theta_S) = -7{,}160 + M$$

EQUATION 2.

USE THE EXPRESSION FOR θ_{SX} DERIVED IN FIG. 35, TAKING $l = 5''$

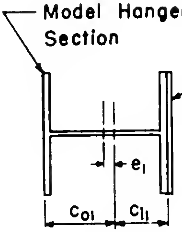
$$\theta_S = .00000571\ M$$

SOLVE I. & 2. FOR $\theta_S = .00282$ rad., WHICH IS THE VALUE PLOTTED IN FIG. 28 FOR A 5" CONNECTED LENGTH.

Fig. 44—Analysis of specimen C (cont'd.). Analysis of specimen T–18.

ANALYSIS OF SPECIMEN T-6 WITH $\frac{1}{8}''$ PLATE

REFERENCE: FIG. 38

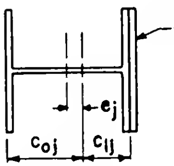


$c_{i1} = .834''$ $\quad A_1 = .809\ \text{in}^2$ $\quad e_1 = .156''$

$c_{o1} = 1.146''$ $\quad I_1 = .590\ \text{in}^4$

$$\frac{Pe_1 + M}{I_1} = 2{,}120 + 1.695M$$

SECTION AT ℄ 1st HOLE



$c_{ij} = .712''$ $\quad A_j = .932\ \text{in}^2$ $\quad e_j = .268''$

$c_{oj} = 1.268''$ $\quad I_j = .678\ \text{in}^4$

$$\frac{Pe_j + M}{I_j} = 3{,}160 + 1.478M$$

SECTION AT ℄ JOINT

$P = 8{,}000$ lb. $\qquad d = 2\frac{1}{2}''$ $\qquad b = 1.98''$ $\qquad 2E\frac{I}{h} = 365{,}000$

EQUATION 1.

$$\theta_A = \frac{d}{2E}\Big[(3{,}160 + 1.478M) + (2{,}120 + 1.695M)\Big]$$

$$M = 2{,}480{,}000 \cdot \theta_A - 1{,}667$$

EQUATION 2.

$$\theta_B = -.00009 \text{ rad.}$$

$$M = 365{,}000(-2\theta_A - \theta_B) = -730{,}000 \cdot \theta_A + 33$$

SOLVING EQUATIONS 1. & 2.

$$\theta_A = +.00053 \text{ rad.}$$

FOR RESULTS OF TESTS ON SPECIMEN T-6 SEE FIG.S 17-19

Fig. 45—Analysis of specimen T-6.

ANALYSES OF FRAMES

REFERENCE: FIG. 37

VALUES COMMON TO ALL FRAMES

$E_1 = 9{,}850{,}000$ psi
$E = 10{,}350{,}000$ psi
$I_1 = .481$ in.^{4}
$I = 31.4$ in.^{4}
$S = .486$ In.^{3}

$N = \frac{10.35 \cdot 31.4}{9.85 \cdot .481} \cdot \frac{h}{27}$
$= 2.54\,h$

$P = 4{,}000$ lb.
$e = .895''$

$M_{FA} = +21{,}700$ in. lb.
$P\bar{a}\bar{a} = +3{,}960$ "
$Pe = 3{,}580$ "

ANALYSIS OF FRAME HF22 TEST B SEE FIG. 9

$h = 34''$
$N = 86.34$

$r = \frac{2\frac{13}{16}}{34}$

$\theta_B = -.00030$ rad.
$K = 279{,}000$

$\frac{M_{FA} + P\bar{a}\bar{a}}{K} = .09197$

$-[N + r(6 + 6r) + 2] = -88.88$ hereafter called A
$-(2 + 3r) = -2.25$ " " B
$-(1 + 3r) = -1.25$ " " C

EQUATION 1.

$$-88.88\,\theta_F - 2.25\,\theta_S - 1.25\,\theta_B = -.09197$$
$$88.88\,\theta_F = .09235 - 2.25\,\theta_S$$

EQUATION 2.

$$M_{AB} = -3{,}580 + M = 279{,}000(-2.25\theta_F - 2\theta_S - \theta_B)$$
$$-2.25\theta_S = -.01313 + .000003584\,M + 2\theta_S$$

EQUATION 3.

Assuming inside flange fixed, $\theta_{SX} = \frac{P}{A_1} \cdot \frac{1}{Ebk} \cdot \frac{\cosh kx}{\sinh kl}$ (SEE FIG. 34)

$k^2 = \frac{Gt}{EbA_1}$
$k = .268$

$A_1 = .309$ in.^{2}
$b = 1.670''$ (SEE FIG. 35)
$P = .565\,M$

For $l = 6\frac{1}{8}''$
$kl = 1.640$
$\cosh kl = 2.675$
$\sinh kl = 2.481$

Now $\theta_S = .000000440\,M$

SOLVING EQUATIONS 1., 2. & 3.

$\theta_F = +.00101$ rad.
$\theta_S = +.00107$ rad.
$M = +2{,}430$ in. lb.

$M_{AB} = 279{,}000[-2.25\theta_F - 2\theta_S - \theta_B] = -1{,}150$ in. lb.
$M_{BA} = 279{,}000[-1.25\theta_F - \theta_S - 2\theta_B] = -483$ "
EFS at A = 2.36 ksi
" " B = .99 "

Fig. 46—Analysis of frame HF22.

ANALYSIS OF FRAME HF32 TESTS C & E_1 SEE FIG.11

$h = 20''$ $\quad r = \dfrac{2\frac{13}{16}}{20} = .141$ $\quad \theta_B = -.00040$ rad. $\quad \dfrac{M_{F_A} + P\bar{a}\bar{a}}{K} = .05414$

$N = 50.81$ $\quad K = 474{,}000$

$A = -53.78$
$B = -2.42$ (SEE ANALYSIS OF HF22 ABOVE)
$C = -1.42$

EQUATION 1.

$$-53.78\,\theta_F - 2.42\theta_S - 1.42\theta_B = -.05414$$
$$53.78\theta_F = .05471 - 2.42\theta_S$$

EQUATION 2.

$$M_{AB} = -3{,}580 + M = 474{,}000[-2.42\theta_F - 2\theta_S - \theta_B]$$
$$-2.42\theta_F = -.00795 + .000002110M + 2\theta_S$$

EQUATION 3.

$\theta_S = .000000440M$ (SEE ANALYSIS OF HF22 ABOVE)

SOLVING EQUATIONS 1., 2. & 3.

$\theta_F = +.00099$ rad. $\quad M_{AB} = -1{,}720$ in.lb. $\quad$ EFS at A = 3.50 ksi
$\theta_S = +.00082$ rad. $\quad M_{BA} = -677$ " $\quad$ " " B = 1.39 "
$M = +1{,}860$ in. lb.

ANALYSIS OF FRAME HF11 TEST A SEE FIG.S 8,9

$h = 29\frac{1}{4}''$ $\quad r = \dfrac{7\frac{5}{8}}{29\frac{1}{4}} = .261$ $\quad \theta_B = -.00030$ rad. $\quad \dfrac{M_{FA} + P\bar{a}\bar{a}}{K} = .07920$

$N = 74.31$ $\quad K = 324{,}000$

$A = -78.28$
$B = -2.78$ (SEE ANALYSIS OF HF22 ABOVE)
$C = -1.78$

EQUATION 1.

$$-78.28\theta_F - 2.78\theta_S - 1.78\theta_B = -.07920$$
$$78.28\theta_F = .07974 - 2.78\theta_S$$

EQUATION 2.

$$M_{AB} = -3{,}580 + M = 324{,}000[-2.78\,\theta_F - 2\theta_S - \theta_B]$$
$$-2.78\theta_F = -.01135 + .000003086M + 2\theta_S$$

Fig. 47—Analysis of frame HF32. Analysis of frame HF11.

▲

ANALYSIS OF FRAME HF11 (CONTINUED)

EQUATION 3.

$k = .268$ $\cosh kl = 9.552$ (SEE ANALYSIS OF HF22)

$l = 11''$ $\sinh kl = 9.498$

$kl = 2.948$ $\theta_S = .000000418\,M$

SOLVING EQUATIONS 1., 2. & 3.

$\theta_F = +.00097$ rad. $M_{AB} = -1{,}370$ in. lb. EFS at A = 2.82 ksi

$\theta_S = +.00090$ rad. $M_{BA} = -658$ " " " B = 1.35 "

$M = +2{,}210$ in. lb.

ANALYSIS OF FRAME HF512 TEST E2 SEE FIG. 13

$h = 20''$ upper

$26''$ lower

$N = 66.05$

$r = \dfrac{2\frac{13}{16}}{26} = .108$

$K = 364{,}000$

$\dfrac{M_{F_A} + P\bar{a}\bar{a}}{K} = .07049$

EXPRESSION FOR θ_B AT MIDDLE FLOORBEAM CONNECTION (SEE FIG.S 37, 38 AND ANALYSIS OF SPECIMEN T-6 ABOVE)

$P = 4{,}000$ lb. $d = 2\frac{7}{8}''$

$\dfrac{Pe_i - M_{BA}}{I_i} = 1{,}058 - 1.695\,M_{BA}$

$\theta_B = -\dfrac{d}{2E}(2{,}639 - 3.170\,M_{BA})$

$\dfrac{Pe_j - M_{BA}}{I_j} = 1{,}581 - 1.475\,M_{BA}$

RECALL M_{BA} FROM FIG. 37 AND OBTAIN

$$\theta_B = -.00029 - .167\,\theta_F - .126\,\theta_S$$

$A = -58.99^{x}$

$B = -2.32$ (SEE ANALYSIS OF HF22 ABOVE)

$C = -1.32$

x THIS VALUE BASED ON COMPUTATIONS WHICH INCLUDE THE EFFECT OF VARIABLE I IN THE LOWER FLOOR-BEAM. SEE COMPUTATIONS FOLLOWING.

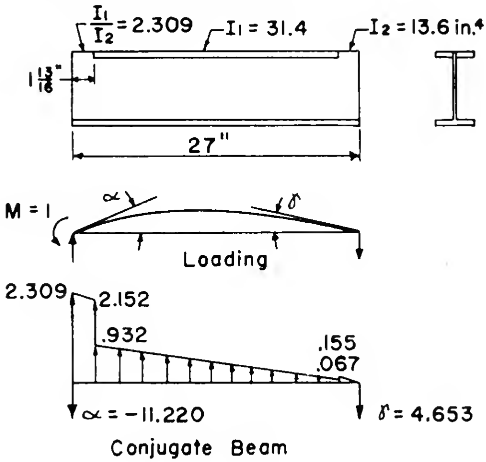
Fig. 48—Analysis of frame HF11 (cont'd.). Analysis of frame HF512.

ANALYSIS OF FRAME HF512 (CONTINUED)

SLOPE-DEFLECTION EQUATION FOR FLOORBEAM F1

REFERENCE: SEE PART I OF THIS SYMPOSIUM

COMPUTING CONSTANTS



SEE FIG. 3 FOR DETAILS OF F1.

$$C_1 = C_3 = \frac{\alpha}{\alpha^2 - \gamma^2} = .108$$

$$C_2 = \frac{\gamma}{\alpha^2 - \gamma^2} = .045$$

$$C_{AB} = \frac{.108}{2\cdot(\frac{1}{27})} = 1.458$$

$$C' = \frac{.045}{2\cdot(\frac{1}{27})} = .606$$

Note: Conj. beam loads are in relative values of EI, the value EI_1 being taken as unity.

REWRITING THE SLOPE-DEFL. EQUATION FOR THE FLOORBEAM (SEE FIG. 37)

$$M_{AA} = M_{F_A} + KN(-1.458\,\theta_F + .606\,\theta_F) = M_{F_A} + K(.852N)(-\theta_F)$$

NOW IN EQUATION I.

$$-\left[.852N + r(6+6r) + 2\right] = -58.99$$

EQUATION I.

$$-58.99\,\theta_F - 2.32\,\theta_S + 1.32 \quad .00029 + .167\,\theta_F + .126\,\theta_S = -.07049$$

$$58.77\,\theta_F = .07087 - 2.16\,\theta_S$$

Fig. 49—Analysis of frame HF512 (cont'd.).

ANALYSIS OF FRAME HF512 (CONTINUED)

EQUATION 2.

$$M_{AB} = -3{,}580 + M = 364{,}000\left[-2.32\,\theta_F - 2\theta_S + (.00029 + .167\theta_F + .126\theta_S)\right]$$

$$-2.16M = -.01013 + .00000275M + 1.87\theta_S$$

EQUATION 3.

$\theta_S = .000000440M$ (SEE ANALYSIS OF HF22 ABOVE)

SOLVING EQUATIONS 1., 2. & 3

$\theta_F = +.00117$ rad.	$\theta_B = -.00061$ rad.	
$\theta_S = +.00094$ rad	$M_{AB} = -1{,}460$ in. lb.	EFS at A = 3.01 ksi
$M = +2{,}120$ in. lb.	$M_{BA} = -\ 462$ in. lb.	" " B = .96 "

Fig. 50—Analysis of frame HF512 (cont'd.).

Part 4

Experimental and Analytical Studies of the Stress Distribution in a Floorbeam Hanger Frame Model Cut From a Solid Plate

By M. B. Scott* and W. J. Grady, Jr.*

Introduction

Previous papers of this report have presented a general method of analysis for rigid-frame structures. The method is essentially a modified slope deflection procedure which assumes the members deform only in their clear length with the joint material acting as rigid blocks. A further development evaluates the effect of the shear slope within these rigid block joints and includes it in the analysis. The material to be presented now is essentially of a follow-up nature on these two procedures. The purposes of the data presented here can be summarized as follows:

1. To present a boundry case regarding the relative importance of the shear slope in the analysis. In this case the cross section of the members are solid rectangles. The situation is one in which the web thickness becomes equal to the flange width.
2. To provide a specific and complete example of the use of the general method of analysis along with similar material for the shear slope effects.
3. To verify experimentally the validity of the stresses computed by this procedure.

The discussion will be directed toward these specific items.

Test Frame and Procedure

A picture of the test specimen used in this investigation is shown in Fig. 1. The specimen was cut from a solid block of 24 ST aluminum. The dimensions and details of the frame are shown in Fig. 2. The proportions of the frame were so chosen that the frame represents a scaled down model of an actual hanger crossframe. The various parts simulate the prototype in the matter of relative stiffness, geometrical properties of the members, and the method of application of the loads.

The monolithic frame eliminated the need for any of the usual joint connections, and thereby also eliminated the effects of these connections upon the stresses in the frame. It was felt that such a monolithic frame would provide one of the best possible practical checks on the validity of the analysis under consideration. Extraneous secondary factors could be kept to the minimum, thus giving a check on the method itself free from modifying influences. The most troublesome effects still remaining were the stress concentrations around the inside corners of the frame. These concentrations were eased somewhat by small radius fillets at these junctures.

The test procedure involved applying load to the frame by means of a Baldwin-Southwark hydraulic testing machine. The load was applied through a special steel loading fixture, the details of which are shown in Fig. 3. The loading was carefully adjusted and controlled by this means. The stresses and rotations resulting from these loads were

* Associate Professor of Structural Engineering and Instructor in Engineering Mechanics, respectively, at Purdue University.

then carefully measured at selected points. Strains were gaged with SR–4 strain gages, type A–7. The rotations were measured by observations made with an engineer's transit as shown in Fig. 8. These measured quantities were then compared with the computed values found in the analysis. The results of these comparisons will be given below.

The physical properties of the 24 ST aluminum were determined by a standard ASTM tensile test performed on a specimen cut from the same block. The yield strength was found to be 37,500 psi, and the modulus of elasticity, E, was found to be 10,740,000 psi.

Analysis and Test Results

The analysis of the model frame, using the modified slope deflection method presented earlier, is shown in Fig. 4. Here the step-by-step procedure has been used and a summary of the results from each step has been tabulated. It can be seen from the summary that the solution converges rapidly. The following results were obtained.

$M_{AB} = -526$ in lb
$M_{BA} = -173$ in lb
$\theta_A = +0.002310$ radians

In effecting this solution use was made of the measured slope angle at the top of the column, i.e., θ_B was taken as -0.000682 radians. Due to physical limitations the angle had to be measured 0.429 in below the top of the clear column height. Here it was found to be -0.000764 radians (counter clockwise) as shown in Fig. 8. This value was then corrected to the top of the column and was used as -0.000682 radians in the analysis in Fig. 4.

The use of the measured slope at B was required because of the uncertainties involved at that joint. There are a number of factors at joint B which will not be evaluated in this study because they seemed to be extraneous to the problem at hand. Briefly, in passing, some of these factors are: (a) The pin, press fitted into the rigid block joint at its center, disturbs somewhat the stress distribution in the block joint. This effect is hard to gage. Perhaps of equal importance is the fact that the pin was not completely free to rotate in the loading fixture. The friction between pin and the supporting steel link provided a restraint which affects the action at that point; and (b) The interaction between the crossbeam BC and the column BA is very much open to question. On the inside face of the vertical member, BA, where it joins the horizontal crossbeam, the vertical fibers carrying the load are considerably restrained by the horizontal fibers of the crossbeam. These fibers can rather rapidly "unload." Thus, the fibers do not elongate very much at this point. On the outside of the columns, however, the situation is quite different and the vertical fibers can elongate almost as perfectly elastic fibers clear up to, at least, the vicinity of the joint center. Measurements plotted in Fig. 10 show that these fibers remain highly stressed up to about the joint center, but drop off rapidly above the pin. This phenomenon would produce the effect of a large additional rotation being imposed upon the upper end of the column where it joins the rigid block joint. This is a condition which may warrant further investigation. Preliminary calculations indicate that this effect probably could be computed. However, for the purposes of this discussion the problem is by-passed and the measured value of the slope at B will be used.

Attention is now directed to Fig. 5. In this figure the frame is analyzed by a more conventionally accepted procedure. Here the standard slope deflection procedure has been followed, using center-to-center dimensions, but using a variable moment of inertia for the members. As shown on the figure, the moment of inertia is taken as being a constant finite value throughout its clear length, but of infinite value within the joint material.

The slope deflection equations must be altered to conform to the variable moment of inertia assumption. The altered equations are shown in Fig. 5 along with the fixed end moment revised to fit the situation. These were solved as shown and yield the following values:

$M_{AB} = -527$ in lb (Adjusted to top of hanger clear height)
$M_{BA} = -173$ in lb " " " " " " "
$\theta = +.002310$ radians

These can be seen to be in almost perfect agreement with the results from Fig. 4.

The analysis in Fig. 5 is presented merely to show that the modified slope deflection procedure, using the step-by-step method of solution, yields the same results as this more commonly accepted procedure. The familiar moment–distribution method, using variable moment of inertia constants, could also have been shown. This method of solution is not presented here but it, too, would yield results identical with those shown in Fig. 5. However, the modified method has the advantage of being more graphic and easy to visualize, and at the same time requires no modifications to the standard slope deflection equations.

The moments arrived at by this type of analysis still are at variance with the moments found from the strain measurements made in the frame. The comparison of computed and measured moments is indicated on the final moment diagram shown in Fig. 4. To get moments which more closely approach the measured values, we now compute the additional moments set up due to the shear slope in the block joint at A. These additional moments are computed separately and are added to those already computed in Fig. 4.

Fig. 6 shows the method of evaluating the shear-slope angle in the block joint at A. As can be seen in Fig. 6, the shear deformations in the block cause an appreciable additional angle change at the top of the block. In Fig. 7 this angle has been computed for the model frame and is shown to be:

$\theta_S = +0.000257$ radians

Also in Fig. 7 the step-by-step procedure is again used to compute the additional moments set up in the frame due to this shear slope angle. These additional values are then combined with those obtained from the analysis of Fig. 4 and the results summarized in Fig. 7. This is a most convenient and practical way to handle the shear slope effects. The regular analysis and the shear slope effects can be computed separately and then combined in a final step.

Substantial agreement between these final values and the measured values can be seen from the following comparisons:

Quantity	*Computed Value*		*Measured Value*	
M_{AB}	-584.6 in lb	(see Fig. 7)	-593 in lb	(see Fig. 4)
M_{BA}	-202.3 in lb	(see Fig. 7)	-197 in lb	(see Fig. 4)
θ_A	$+0.002299$ rad.	(see Fig. 7)	$+0.002320$ rad.	(see Fig. 8)
$\theta_A + \theta_S$	$+0.002556$ rad.	(see Fig. 7)	$+0.002590$ rad.	(see Fig. 8)

Further comparisons between computed and measured values in the model are shown in Figs. 9 and 10. Fig. 9 is presented as typical of the data taken at all sections. This plot establishes that, within the range of accuracy achieved in this test, all measured strains varied linearily with the applied load. It is felt that this linearity indicates that no additional bending effects in the column, due to the eccentricity of the direct load or the deformations of the columns, were measureable. This indicates that, at least for members as slender as the ones in this model, axial loads on the member do not materially affect the validity of the usual slope deflection equations developed for flexure only.

Fig. 10 shows the plot of measured and computed bending moments, measured and computed extreme fiber stresses, and measured and computed total load in the columns. Substantial agreement between measured and computed values is apparent, except perhaps at points at the extreme ends of the column. At these points (particularly on the inside fiber) the measured stresses were very much affected by local stress concentrations at the junction of horizontal and vertical members. Some data were taken indicating the stress existing in the rigid block inside the block joint itself. This has been plotted as indicated on the second graph from the right in Fig. 10.

Fig. 11 is presented for comparison purposes only. It shows the quantitative results which would be obtained by analyzing the frame by several of the usual methods of analysis. The wide variation in results is striking. Also apparent is the substantial agreement between the measured values and the values obtained by the combined analysis used in this report.

Conclusions

The following conclusions can be stated from data presented in this report.

1. The shear slope angle in members having even very thick webs is a very real and measureable quantity. In this frame at joint A the shear slope was computed to be 0.000257 radians while the measured value was shown to be 0.000270 radians.
2. Even in thick web members the shear slope angle substantially affects the bending stresses in a frame. In this case the web thickness was equal to flange width, but the shear slope effects increased the bending moments by as much as 14½ percent.
3. The modified analysis, when combined with shear slope, gave computed stresses in the frame which were in substantial agreement with actual measured stresses. This attests to the validity of this method of analyzing such frames.
4. The modified slope deflection analysis as presented in this report yields results which are identical with results from the usual standard methods using variable moments of inertia for the component members, the advantage of the modified method here being that it required no modifications to the standard slope deflection equations for prismatic members.

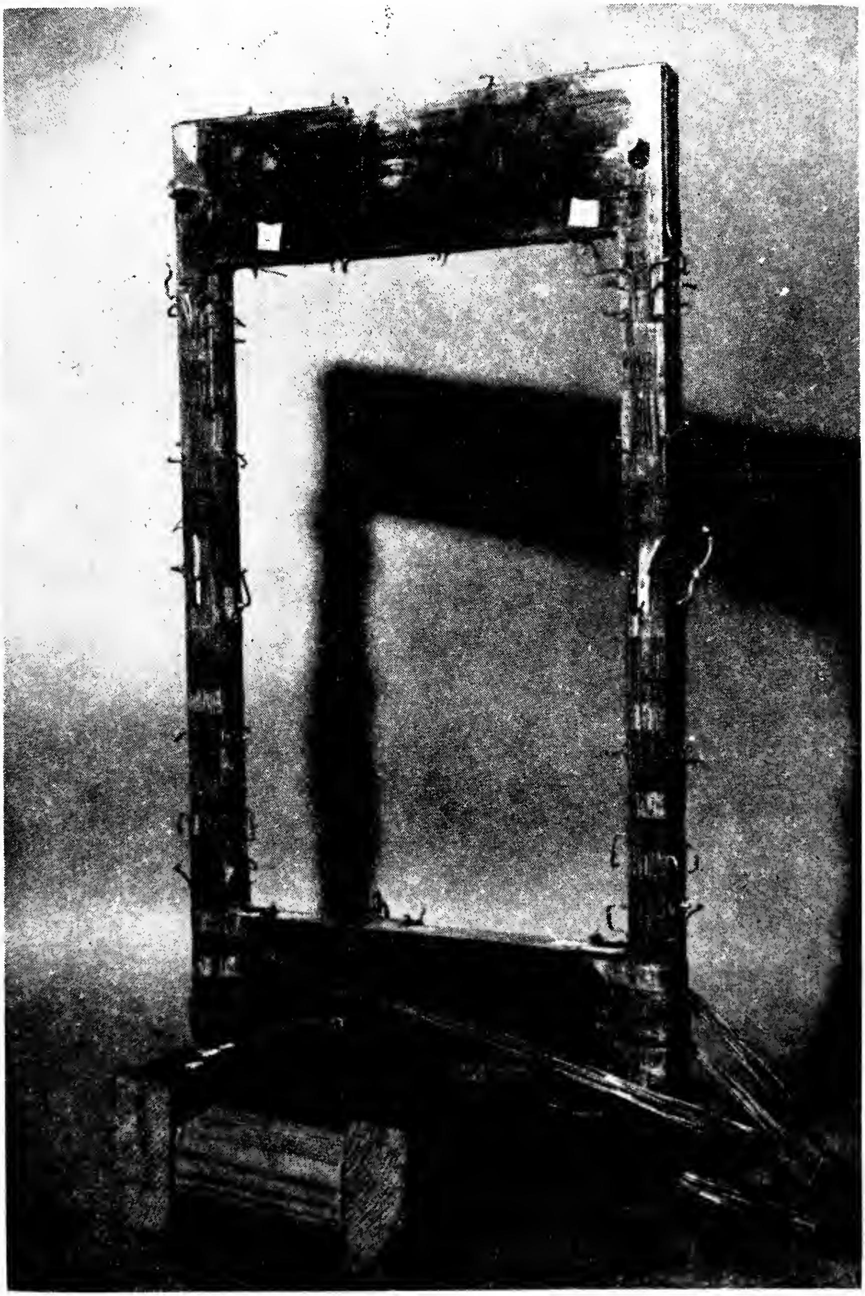


Fig. 1—Model frame ready for test.

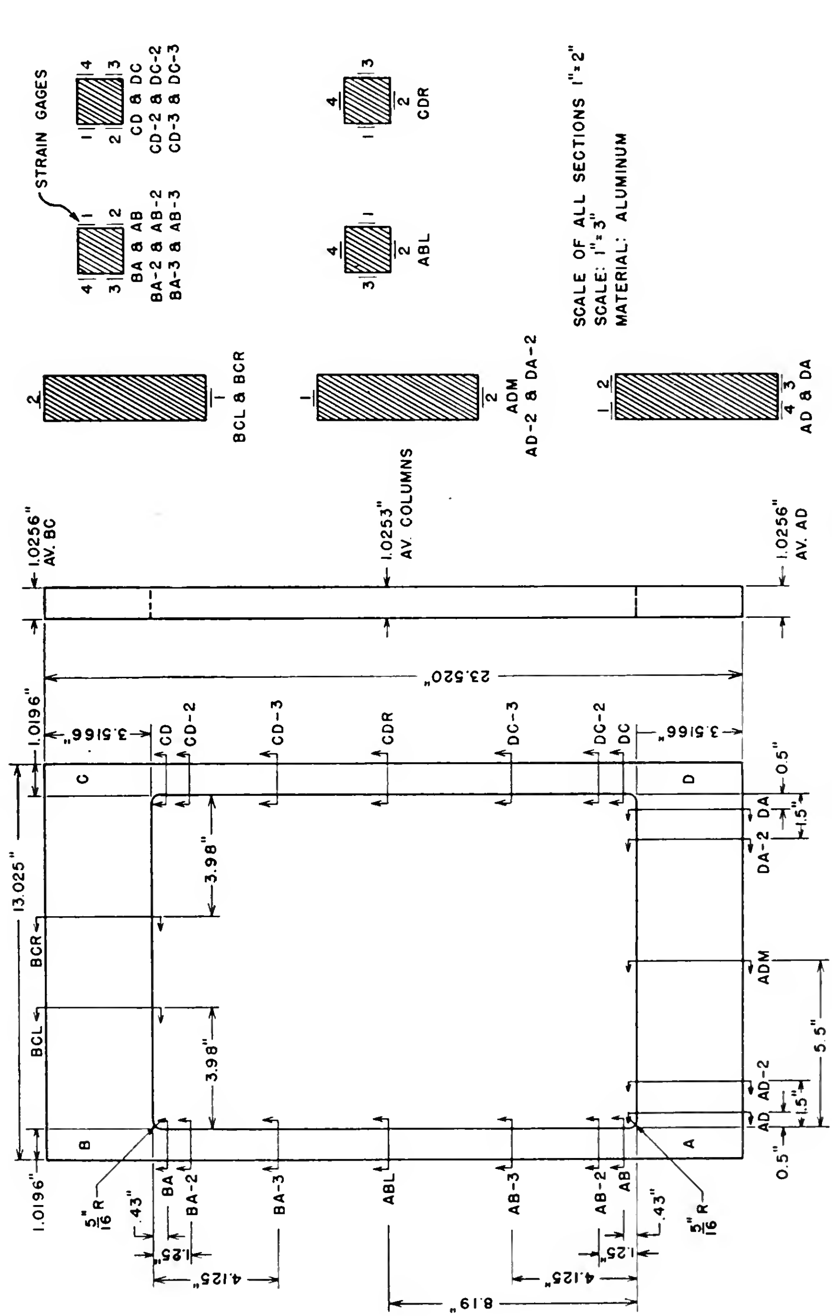


Fig. 2—Detail of test specimen with strain gage positions.

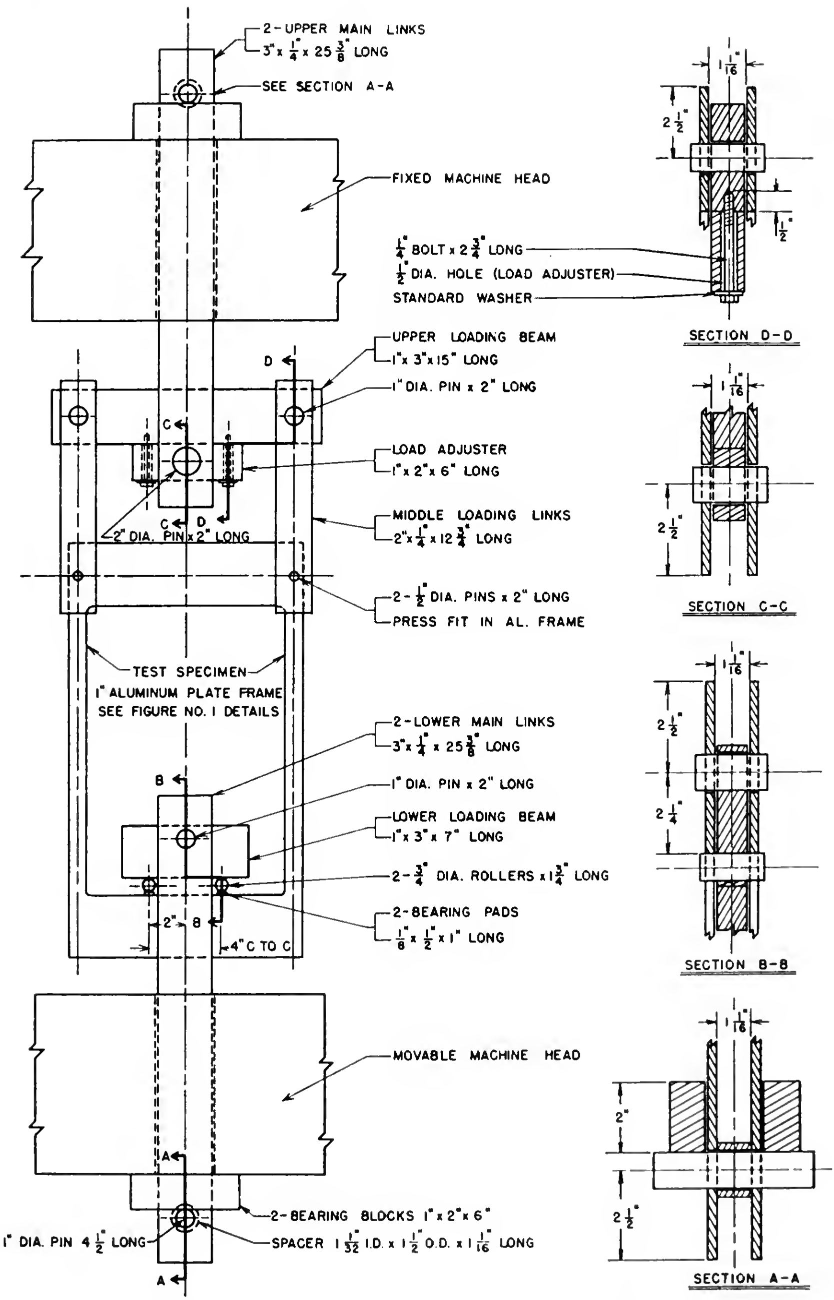


Fig. 3—Loading fixtures, assembly and details.

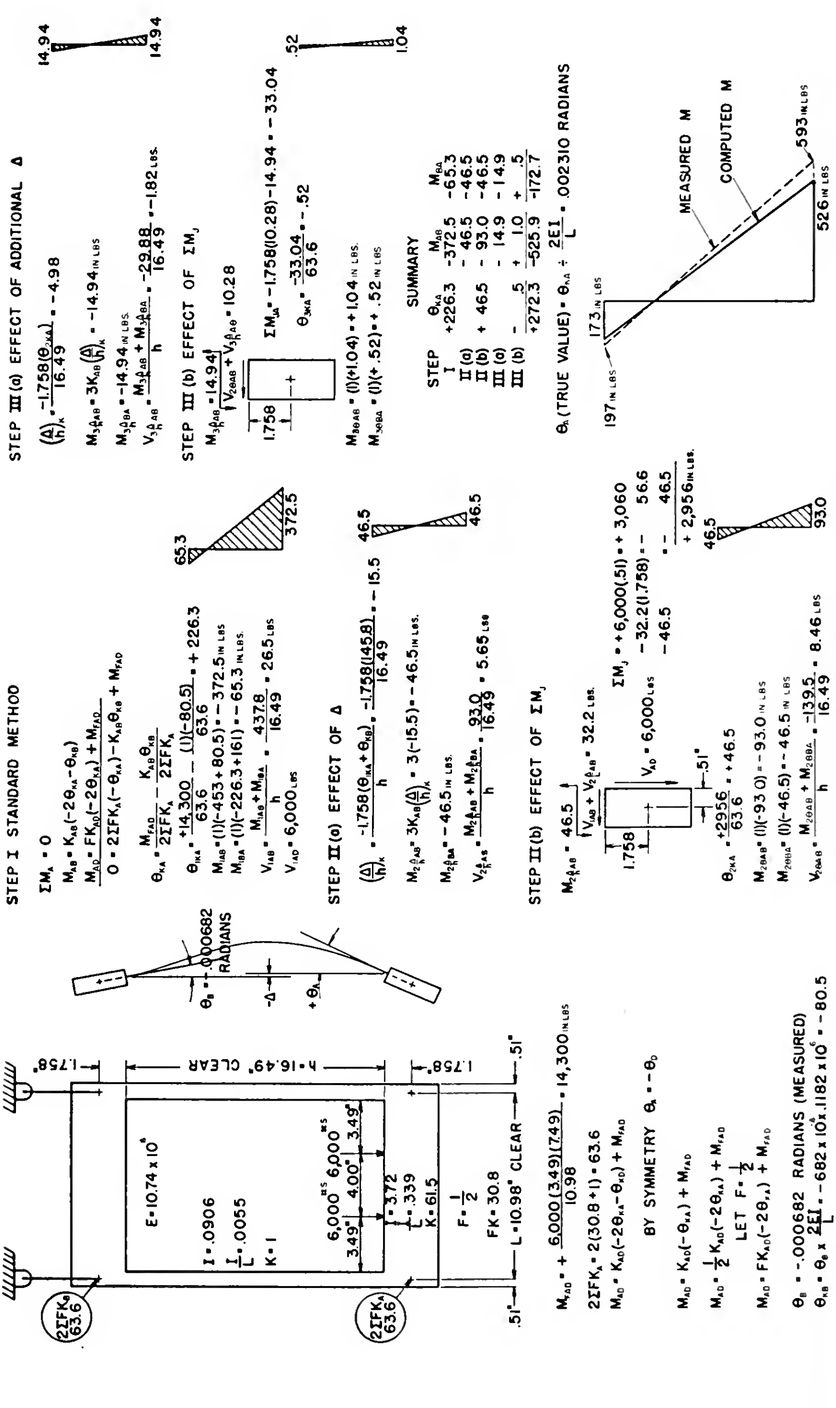


Fig. 4—Modified slope deflection analysis.

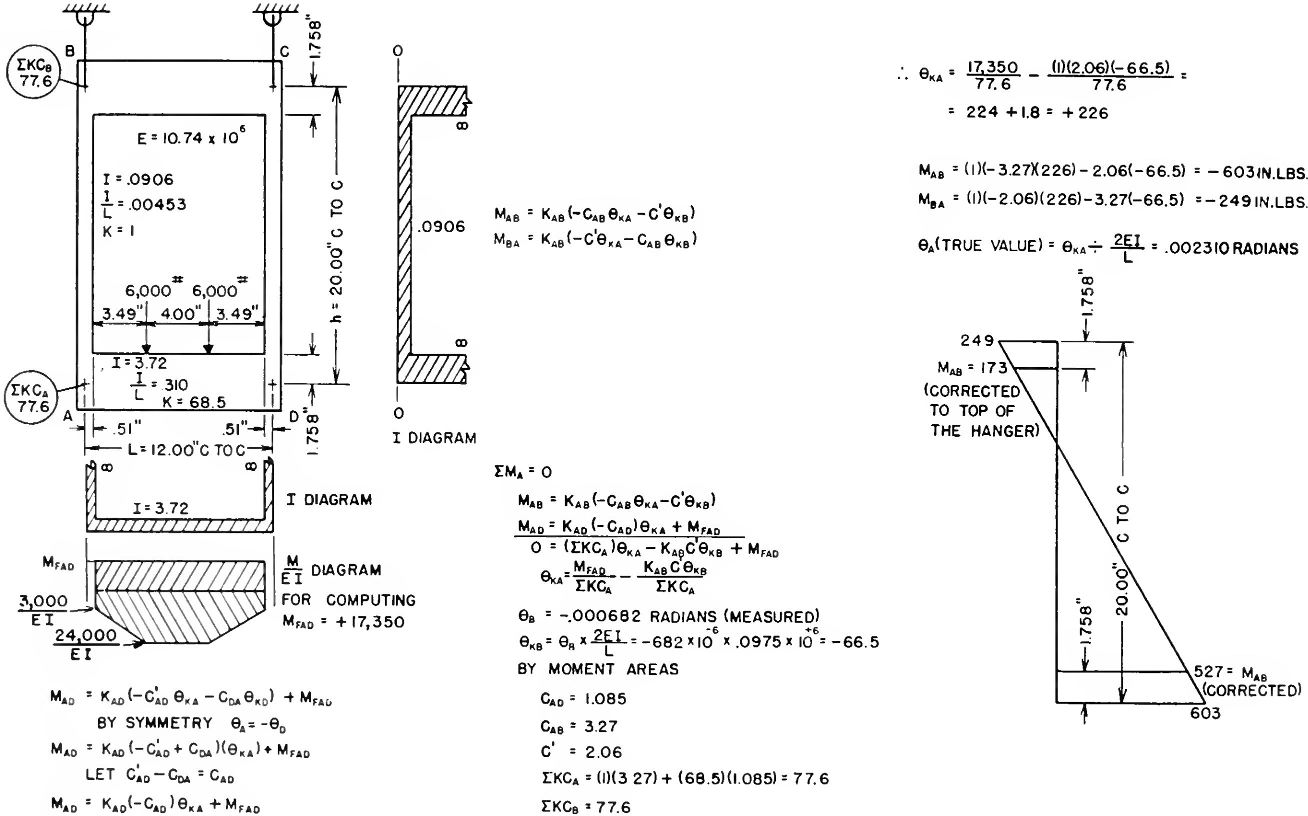
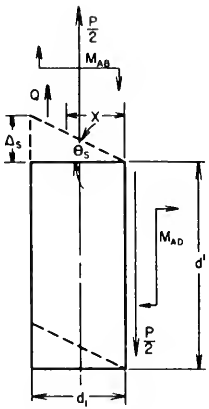
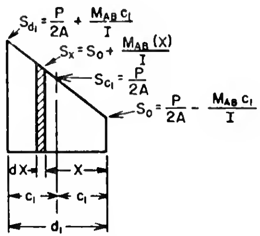


Fig. 5—Analysis using variable I.





STRESS VARIATION AT THE TOP OF THE BLOCK

BLOCK JOINT AT "A" OF d THICKNESS

Δ_s IS DEFORMATION DUE TO SHEAR

EXTERNAL WORK = INTERNAL WORK

$$W_E = W_I$$

$$W_E = \frac{1}{2} M_{AB}\,\theta_s + \frac{1}{2} \times \frac{P}{2} \times \frac{\Delta_s}{2} = \frac{1}{8}(4M_{AB} + Pd_1)\,\theta_s$$

$$W_I = \int_0^{d_1} \frac{Q^2\,dX}{2A_1G}$$

WHERE Q = FORCE ON THE BLOCK TO THE LEFT OF X

A_1 = LONGITUDINAL AREA = dd'

G = MODULUS OF RIGIDITY = MODULUS OF ELASTICITY IN SHEAR

$$W_I = \frac{1}{A_1G}\int_0^{d_1} \left[\frac{Sd_1 + SX}{2}(d_1 - X)d\right]^2 dX$$

$$W_I = \frac{1}{8A_1G}\int_0^{d_1} \left[\left(\frac{P}{2A} + \frac{M_{AB}c_1}{I} + \frac{P}{2A} - \frac{M_{AB}c_1}{I} + \frac{M_{AB}X}{I}\right)(d_1 - X)d\right]^2 dX$$

$$W_I = \frac{1}{8A_1G}\int_0^{d_1} \left\{-d\left[\frac{M_{AB}}{I}X^2 - \left(\frac{M_{AB}d_1}{I} - \frac{P}{A}\right)X - \frac{Pd_1}{A}\right]\right\}^2 dX$$

LET $a = \frac{M_{AB}}{I}$, $b = \frac{M_{AB}d_1}{I} - \frac{P}{A}$, $c = \frac{Pd_1}{A}$.

$$W_I = \frac{1}{8A_1G}\int_0^{d_1} d^2(aX^2 - bX - c)^2\,dX$$

$$W_I = \frac{1}{240A_1G}\left[6a^2d_1^5 - 15abd_1^4 + 10(b^2 - 2ac)d_1^3 + 30bcd_1^2 + 30c^2d_1\right]$$

EQUATING $W_I = W_E$ & SOLVING FOR θ_s

$$\theta_s = \frac{d^2}{(4M_{AB} + Pd_1)(30A_1G)}\left[6a^2d_1^5 - 15abd_1^4 + 10(b^2 - 2ac)d_1^3 + 30bcd_1^2 + 30c^2d_1\right]$$

OR, SUBSTITUTING VALUES OF a, b, & c

$$\theta_s = \frac{d^2}{(4M_{AB} + Pd_1)(30A_1G)}\left[\frac{d_1^5}{I^2}(M_{AB})^2 + \frac{5d_1^4}{AI}M_{AB} + \left(\frac{P}{A}\right)^2(10d_1^3)\right]$$

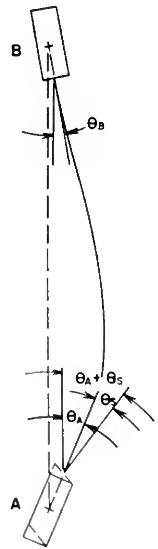
FOR THIS FRAME

d_1 = 1.0196 IN	I = .0906 IN^4
d = 1.0256 IN	$A = dd_1$ = 1.045 IN^2
$G = \frac{3}{8} \times 10.74 \times 10^6 = 4.03 \times 10^6$	$A_1 = d_1d'$ = 3.61 IN^2
P = 12,000 LBS.	d' = 3.5166 IN

THEREFORE

$$\theta_s = \frac{603 \times 10^{-6}}{M_{AB} + 3060}(134.5 \times 10^{-6} M_{AB}^2 + .685 M_{AB} + 1400)$$

Fig. 6—Derivation of shear slope angle.



EFFECT OF SHEAR SLOPE AT JOINT A

θ_S IS THE ADDITIONAL ROTATION OF THE BOTTOM OF THE COLUMN DUE TO SHEAR DEFORMATION OF THE BLOCK JOINT. THE EXPRESSION FOR THIS ANGLE IS DERIVED IN FIGURE 6.

$$\theta_S = \frac{603 \times 10^6}{M_{AB} + 3060}(134.5 \times 10^{-6} M_{AB}^2 + .685 M_{AB} + 1400)$$

$M_{AB} = -526$ FROM FIGURE 4

$\theta_S = .000257$ RADIANS

$$\theta_{KS} = \theta_S \times \frac{2EI}{L} = 257 \times 10^{-6} \times .1182 \times 10^6 = +30.4$$

STEP I STANDARD METHOD

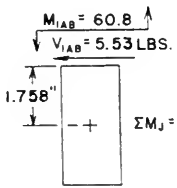
$M_{1AB} = K_{AB}(-2\theta_{KS}) = (1)(-60.8) = -60.8$ IN. LBS.

$M_{1BA} = K_{BA}(-\theta_{KS}) = (1)(-30.4) = -30.4$ IN.LBS.

$$V_{1AB} = \frac{M_{1AB} + M_{1BA}}{h} = \frac{-91.2}{16.49} = -5.53 \text{ LBS.}$$

STEP II (a) NO Δ EFFECT

STEP II (b) EFFECT OF ΣM_{JA}



$\Sigma M_J = -1.758(5.53) - 60.8 = -70.5$ IN.LBS.

STEP II (b) (CONTINUED)

$$\theta_{2KS} = \frac{M_{JA}}{2\Sigma FK_A} = \frac{-70.5}{63.6} = -1.11$$

$M_{2\theta AB} = K_{AB}(-2\theta_{2KS}) = (1)(+2.22) = +2.22$ IN.LBS.

$M_{2\theta BA} = K_{BA}(-\theta_{2KS}) = (1)(+1.11) = +1.11$ IN.LBS.

FINAL SUMMARY

	θ_{KA}	$\theta_{KA} + \theta_{KS}$	M_{AB}	M_{BA}
FIGURE 4	+272.8	+272.8	−526.0 IN.LBS.	−173.0 IN.LBS.
SHEAR θ_S	0.0	+ 30.4		
STEP I			− 60.8 IN.LBS.	− 30.4 IN.LBS.
STEP II (b)	− 1.1	− 1.1	+ 2.2 IN.LBS.	+ 1.1 IN.LBS.
	+271.7	+302.1	−584.6 IN.LBS.	−202.3 IN.LBS.

$$\theta_A \text{(TRUE VALUE)} = \theta_{KA} \div \frac{2EI}{L} = \frac{+271.7}{.1182 \times 10^6} = 0.002299 \text{ RADIANS}$$

$$\theta_A + \theta_S \text{(TRUE VALUE)} = (\theta_{KA} + \theta_{KS}) \div \frac{2EI}{L} = \frac{+302.1}{.1182 \times 10^6} = 0.002556 \text{ RADIANS}$$

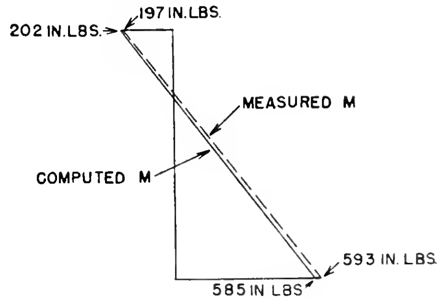
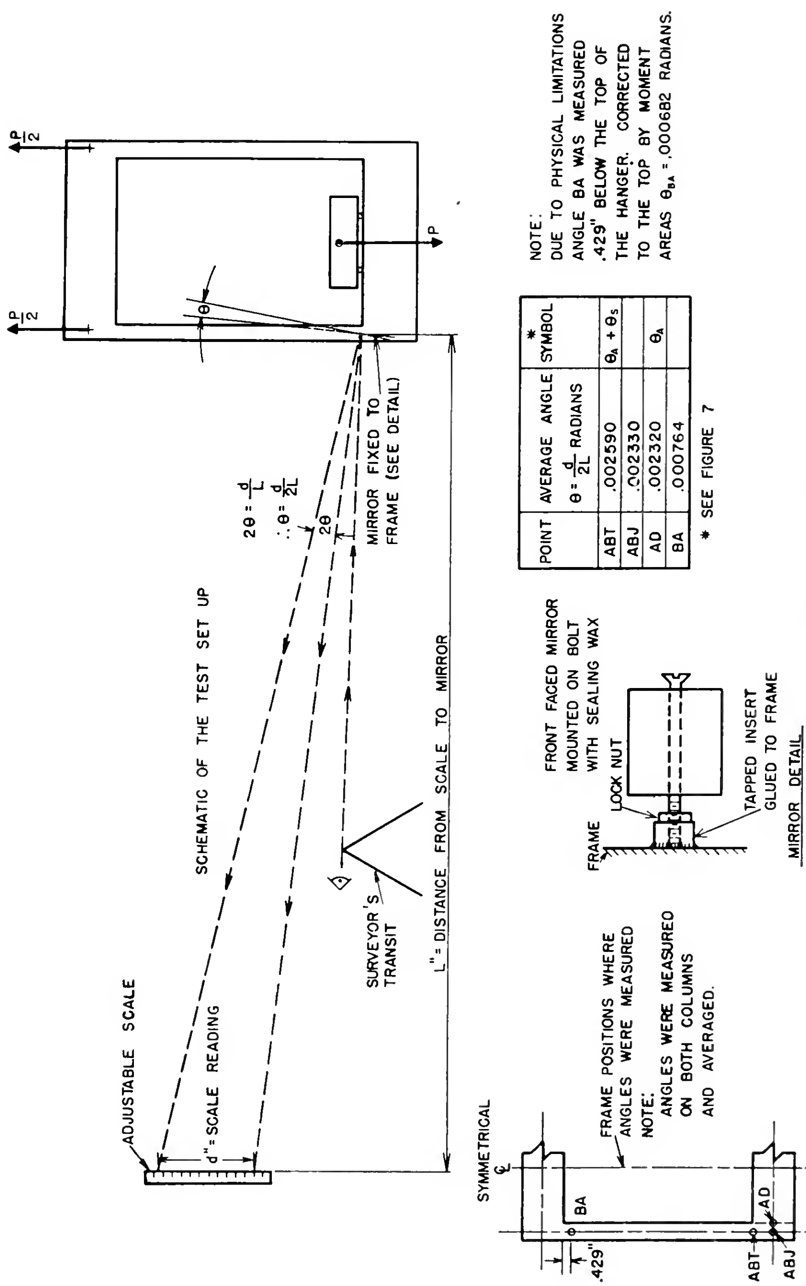


Fig. 7—Combined analysis of the frame.



POINT	AVERAGE ANGLE $\theta = \frac{d}{2L}$ RADIANS	* SYMBOL
ABT	.002590	$\theta_A + \theta_S$
ABJ	.002330	
AD	.002320	θ_A
BA	.000764	

* SEE FIGURE 7

Fig. 8—Angle measurement test.

TABLE OF MEASURED STRAINS								
COMPUTED FROM FIGURE 7								
SECTION	AB-3				DC-3			
LOAD	3000	6000	9000	12000	3000	6000	9000	12000
EXTREME FIBER (OUTSIDE)	183	368	554	742	185	368	552	742
EXTREME FIBER (INSIDE)	79	158	241	328	77	154	236	324
DIRECT (NEUTRAL AXIS)	131	263	398	534	130	260	393	532
BENDING (OUTSIDE & INSIDE)	52	105	157	208	53	106	157	208

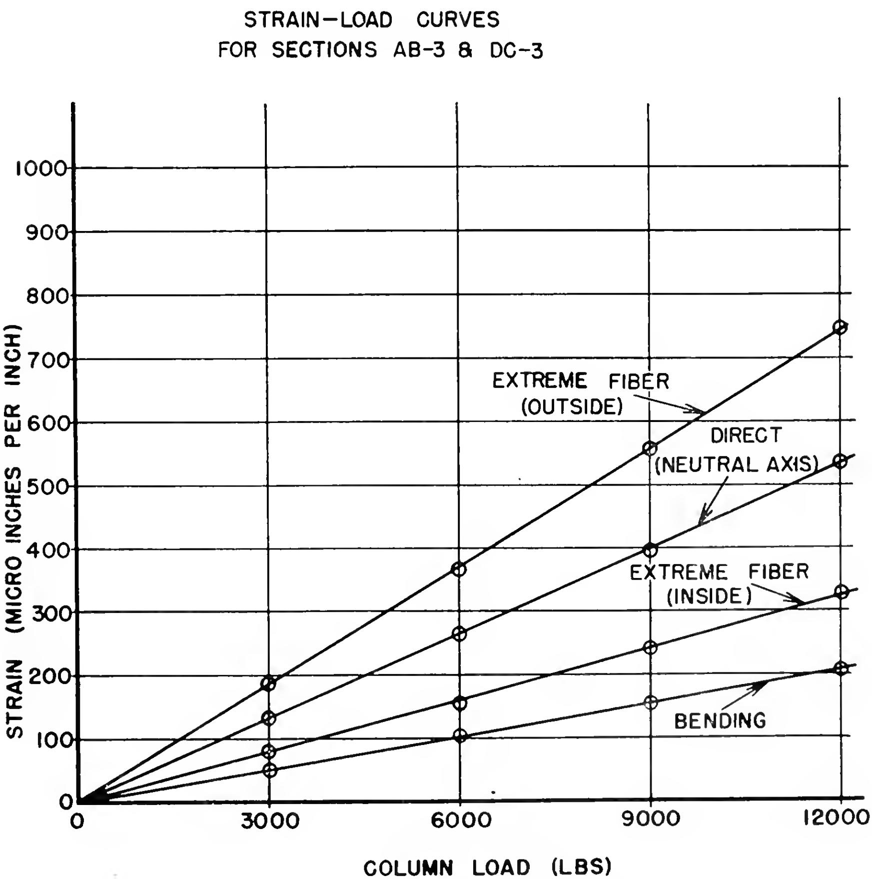


Fig. 9—Typical strain vs load curves.

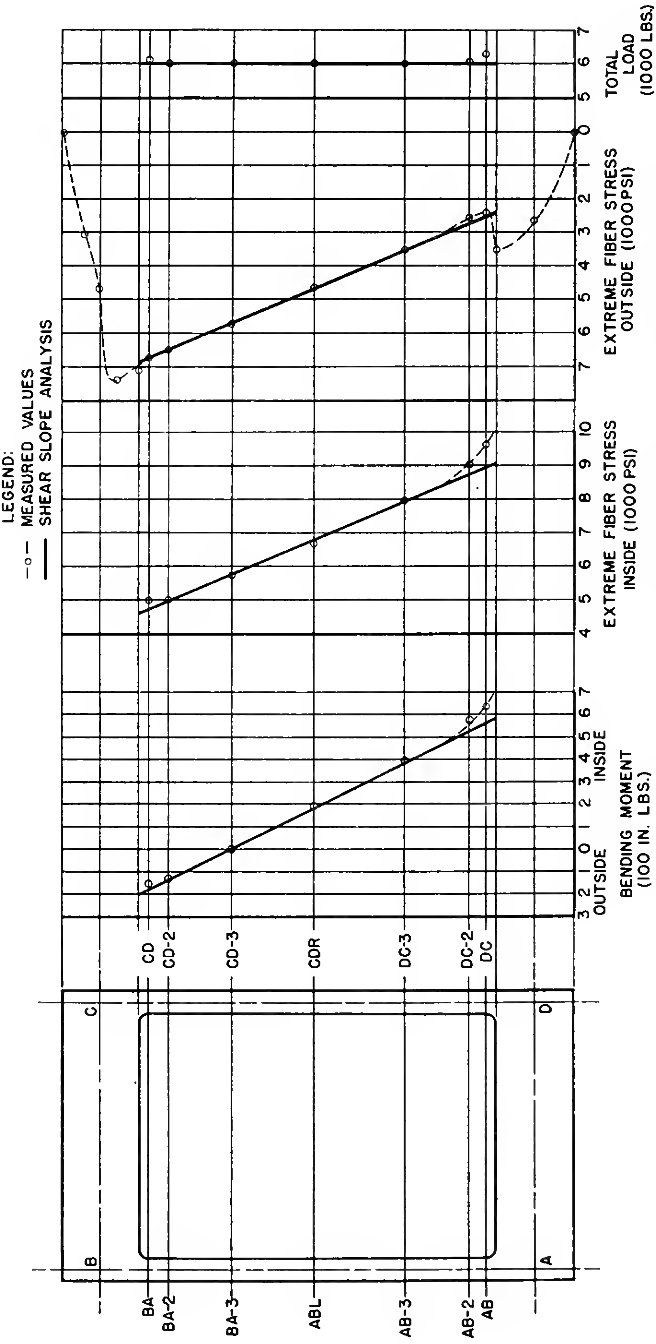


Fig. 10—Graphical comparison of computed values to measured values of moment, stress and load.

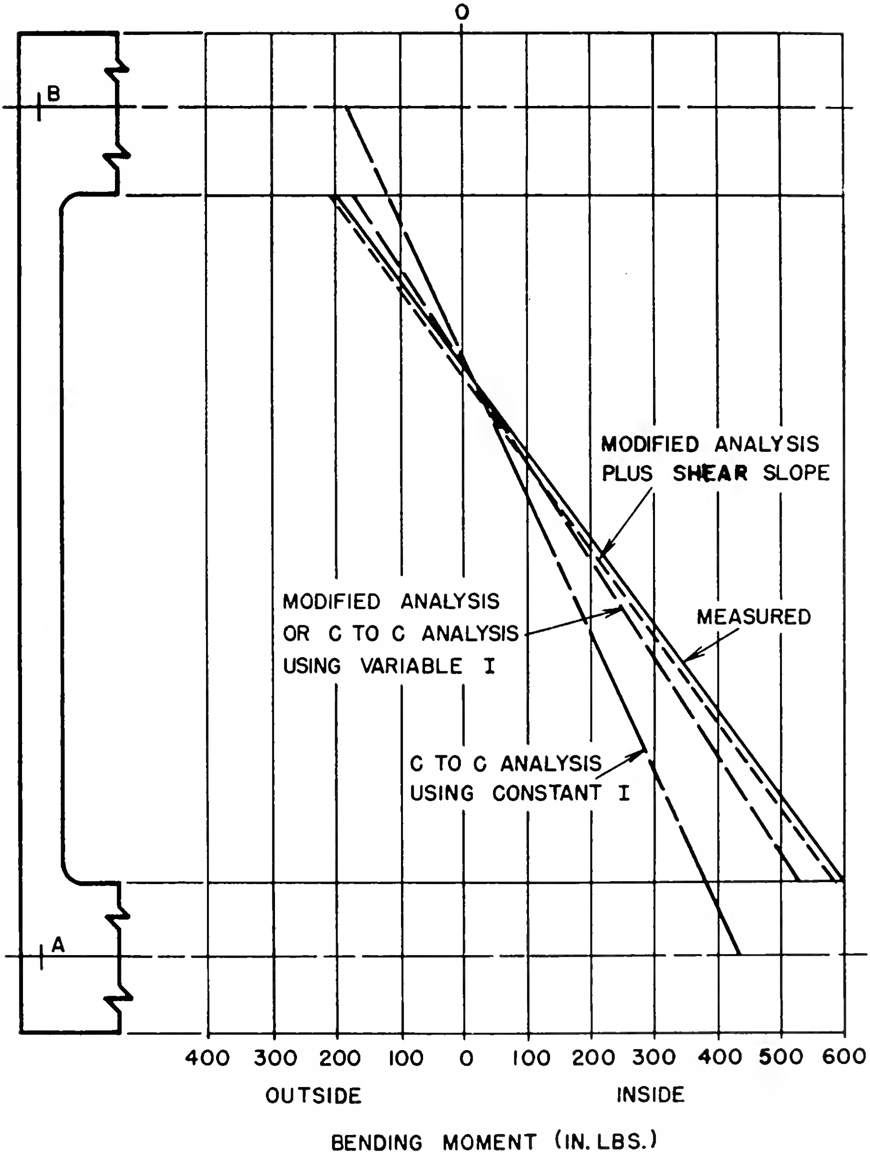


Fig. 11—Frame bending moments by different methods of computation.

Part 5

Results of Field Tests on Bascule Bridges

By the AAR Research Staff

Introduction

The failure of the counterweight truss member of a bascule bridge on the Great Northern Railway in 1948 focused attention on this type of structure. Consequently, the AAR Research Staff was requested by five different railroads to conduct tests on their bascule bridges to determine the magnitude of the stresses resulting from the opening and closing of the bridge.

The data presented in this part of the report summarizes the results obtained on the five bridges tested. The stresses were measured principally in the counterweight truss member between the counterweight and the counterweight trunnion, as an analytical study indicated that high stresses would occur on the underside of this member near the counterweight. As shown in the analytical study of the stresses in this type of bridge (Part 2 of this report), the principal member tested is subjected to a direct compressive stress when the bridge is in the closed position, and then reverses to a direct tensile stress when the bridge is in the open position. In addition, high secondary stresses are induced by the concrete counterweight, so that the stress on the underside of the member near the counterweight is nearly zero when the bridge is in the closed position and reached a maximum tension when the bridge was in the open position. In addition to the readings taken on the principal member, readings were also taken on other counterweight truss members of a few of the bridges but, in general, the stresses were quite small in these other members.

The principal purpose in conducting these tests was to determine the range of stress induced in the principal member when the bridge was moved slowly from the closed position to a fully opened position, and these stresses are reported under "Results of Static Tests" in this part of the report. However, in most of the bridges tested it was observed that considerable vibration resulted when either the brakes were applied to slow down the bridge or the power was turned on to start the bridge movement. To secure some data on the magnitude of the stresses resulting from these vibrations, the dynamic strain gage equipment was used on two of the bridges to secure a continuous record of the strains. These stresses are reported under "Results of Dynamic Tests". A few readings were taken with the dynamic strain gage equipment under regular trains operating over the bridge, but the stresses in the counterweight truss members were small. No effort was made to determine the stresses in the main truss members.

The tests on all five bridges were conducted at the request of the railroads and the salaries and expenses of the personnel operating the instruments were borne entirely by each railroad. The tests were carried out under the general direction of G. M. Magee, research engineer, Engineering Division, Association of American Railroads. The conduct of the tests, analysis of data and preparation of this part of the report were in charge of E. J. Ruble, structural engineer, Research Staff, AAR, assisted by A. A. Sirel, assistant structural engineer.

Instruments

The electrical type instruments used in the tests on the bascule bridges were the same as those used in previous tests of railroad structures and were fully described in the proceedings, Vol. 52, 1951, page 152. The gages were of the SR4 wire resistance type and were used for both the static and dynamic readings. The static readings were secured by the use of a portable strain indicator, while dynamic readings were taken with two 12-element oscillographs, power units, and amplifiers.

Results of Static Tests

Peoria and Pekin Union Railway Bridge

The first bascule bridge tested is over the Illinois River at Peoria, Ill., on the Peoria and Pekin Union Railway. The superstructure consists of a double-track, heel-trunnion-type bascule having a span of 160 ft, balanced with a concrete counterweight, as shown by the line diagram at the top of Fig. 1. The structure was built in 1909 and the records indicate that the structure had been opened about 25,000 times up to the time of the tests, in September 1948.

An analytical study of the direct and secondary effects indicated that stresses of considerable magnitude existed on the underside of the principal counterweight member C–14—C–16, near the gusset plate at joint C–16. Accordingly, the strains were measured in this member at Section 1–1 located slightly inside the gusset plates, as shown in Fig. 1. The strains were measured at 12 locations on each truss by the portable strains indicator, and the stresses determined from these strain readings are shown in the table on Fig. 1 for the bridge partially opened and completely opened. The gages were located between the rivets so that the stresses shown can be considered as those applying to the gross section.

A study of the table of "Recorded Stress Range" on Fig. 1 indicates that a maximum stress range of 36,090 psi was recorded in the south truss at the edge of the lower outside chord angle, gage location 11, while a stress range of 40,530 psi was recorded at the edge of the lower inside angle, gage location 36. The stress range values shown in this table are the static stresses resulting from moving the bridge to the completely open position from the closed position, and would be increased by the vibrational effects produced by any acceleration due to braking or traction.

The railway company considered the stresses occurring in this bridge entirely too high and immediately initiated plans to reinforce the highly stressed members.

Illinois Central Railroad Bridge

This bridge is over the Chicago River at 16th and Clark St., Chicago, Ill., on the Illinois Central Railroad. The superstructure consists of a double-track, heel-trunnion-type bascule having a span of 219 ft 4 in, balanced with 2 concrete counterweight wings, as shown by the line diagram at the top of Fig. 2. The bridge was originally built in 1917 and had a span of 260 ft. The bridge was relocated and its span length reduced to its present length in 1930. An analytical study of the stresses in the counterweight trusses made at the time the bridge was rebuilt indicated that high stresses would occur in the principal member 32–36, so this member was reinforced. It is estimated that the structure had been opened about 20,000 times up to the time of the tests, in September 1949.

Strain gage readings were secured with the portable strain indicator on all members framing into joint 36 of the north truss, except member 36–38, which is entirely encased in concrete, and the locations of the gages in the members tested are shown on Figs. 2

and 3. Two different sections were selected for the gage locations on member 32–36. Section 1–1 was selected as it was at the end of the reinforcement, and section 2–2 was selected as maximum stresses would normally occur close to the gusset plate. However, gages could only be placed on the upper part of this member at section 2–2 as the lower half of the member was entirely encased by the concrete counterweight. The stresses determined from the measured strains in the north truss of this bridge are shown in the tables of "Recorded Stress Range" shown on Figs. 2 and 3. The gages were located between the rivets so that the stresses shown can be considered as those applying to the gross section.

A study of the tables of stresses on Figs. 2 and 3 indicates that the maximum stresses were recorded with the bridge fully opened, and that a maximum stress of 23,640 psi was recorded in member 32–36 at section 1–1, at the edge of the lower outside chord angle, gage position 5. However, there was not a great deal of difference between any of the stresses on the underside of this member, the smallest being 18,910 psi at gage position 7. The stresses in the other counterweight truss members framing into joint 36 were quite low, the maximum occurring in member 35–36, section 4–4, where a stress of 11,985 psi was recorded at gage position 18.

Baltimore and Ohio Railroad Bridge

The bridge shown by the line diagram on Fig. 4 spans the Calumet River in South Chicago, Ill., and is on the main line of the Baltimore & Ohio Railroad. The superstructure consists of a double-track, heel-trunnion-type bascule having a span of 235 ft. The bridge was built in 1914 and the records indicate that it had been opened about 86,000 times up to the time of the tests, in July 1950.

Strain gage readings were secured on the gross section of all the members framing into joint 34 of both trusses, except member 34–38, which is entirely encased in concrete. The locations of all the SR4 wire gages and the recorded stress range in the members are shown on Figs. 5 to 10, incl. For example, the location of the gages and the recorded stress range in member 32–34 are shown on Fig. 5. The stress range for various positions of the bridge were recorded in this member of the south truss, but only for the full open position in this member of the north truss. The average of all the stresses recorded at the eight gage positions is shown in the table, and this value is the change in the direct stress in the member. The difference between the maximum recorded stress at any particular gage and the average or direct stress is the bending or secondary stress in the member.

A maximum stress range of 39,210 psi was recorded in member 32–34, south truss, at gage position 8, Fig. 5, while the stress range at gage position 7 was 33,900 psi. The gage at position 8 of the north truss did not record, but a stress of only 24,150 psi was recorded at position 7 of this truss. While trying to account for this variation in stress between the two trusses at gage position 7, it was found that this member in the north truss had a fatigue or progressive crack at a location inside the gusset plate. This fatigue crack was not discernible except when the bridge was in the open position.

Upon the discovery of the fatigue crack in member 32–34 of the north truss, immediate temporary repairs were made by welding on a reinforcing angle and plate, as shown on Figs. 6 and 7. Additional readings were then taken at the same locations as the original readings, section 1–1, Fig. 6, and at additional sections 6–6, 7–7, 8–8, and 9–9, Fig. 7. Section 6–6 is through the member where the fatigue crack developed; section 7–7 through the member at the end of the reinforcing plate; section 8–8 through the member at the end of the reinforcing angle, and section 9–9 through the member near the gusset plate at joint 32. It can be seen from the tabulation of stresses on Fig. 7 that the temporary reinforcement on the north truss apparently reduced the stress range in this member at section 6–6, as stresses at gage locations 1 to 6, incl., north truss, are considerably below those recorded at positions 1 to 4 incl., south truss. Study of the stress tabulations on Figs. 5, 6 and 7 indicate that member 32–34 was subjected to a stress range of at least 42,750 psi, and that the maximum stress occurs in the member on a section well inside the gusset plate.

The location of the strain gages and the stress range recorded in the other three main members framing into joint 34 are shown in Figs. 8, 9 and 10. In general, the stresses were quite moderate, with the maximum occurring in member 34–36, Fig. 8, where a stress range of 24,150 psi was recorded at gage position 5 of the north truss.

Upon completion of the temporary repairs to member 32–34, details of permanent repairs were rushed to completion, whereby the section of this member was practically doubled near joint 34. Upon delivery of the structural steel, members 32–34 of both trusses were reinforced with the bridge in the half-open position, as calculations indicated that the direct stress in the member is about zero for this position.

Chicago and North Western Railway Bridge

The bridge shown by the line diagram on Fig. 11 spans the north branch of the Chicago River in Chicago, Ill., and is on the Chicago & North Western Railway. The superstructure consists of a triple-track skewed heel-trunnion-type bascule, with the longest truss having a span of 186 ft. The bridge was built in 1916, and it is estimated that it had been opened only about 15,000 times at the time of the tests, in August 1950.

Strain gage readings were secured with the dynamic strain gage equipment on the gross area of member 18–24 at both joint 18 and 24, member 20–24 at joint 24, member 20–21 at joint 21, and member 21–24 at joint 24. The locations of all the SR4 wire gages on these members are shown on Figs. 12, 13 and 14. It was necessary to cut holes in the concrete counterweight encasement around member 21–24, at joint 24, before the gages could be placed on this member (see Fig. 13, section 7–7).

A study of the tables of stresses shown on Figs. 12, 13 and 14 for the various positions of the bridge indicates that the maximum stresses occurred in member 18–24 at section 3–3, where a stress of 37,950 psi was recorded in the edge of the lower chord angle of the north truss, gage location 19, and a stress of 37,800 psi was recorded in the lower chord angle of the south truss, gage location 17. It should be pointed out that the stresses on a section inside the gusset plates were greater than those at the edge of the gusset. It can be seen from the table of stress ranges for member 21–24, Fig. 13, that there was a considerable reduction in the stresses on this side of joint 24, as the maximum stress was only 12,600 psi at gage position 1. The large reduction in stress is undoubtedly the result of good bond between the concrete encasement and the steel.

The railway company considered the stress range occurring in member 18–24 entirely too high, and immediately initiated plans to reinforce the member near joint 24. The reinforcement added to this member is shown on the upper diagram of Fig. 15, and was fastened to the original steel by high-strength bolts.

Upon completion of the reinforcement of this bridge, additional strain gage readings were taken at the sections and gage locations shown on Fig. 15. Section 8–8 was selected because it is through the maximum reinforced steel area, as well as at the edge of the gusset plate. Section 9–9 was selected at the end of the eight 6-in by ½-in reinforcement plates, and section 10–10 near the concrete encasement.

It can be seen from the table of "Recorded Stress Range" on Fig. 15 that the reinforcement was effective in reducing the stresses at the edge of the gusset plate, but apparently the 6-in by ½-in reinforcement plates were not extended far enough into the gusset plate to reduce materially the stresses on a section inside the gusset plates, as a stress of 38,850 psi was recorded on the edge of the lower chord angle of the south truss, gage position 8.

Texas & Pacific Railway Bridge

The bridge shown by the line diagram on Fig. 16 is located in Plaquemine, La., on the Texas & Pacific Railway. The superstructure consists of a double-track, heel-trunnion-type bascule, with a span of 145 ft. The bridge was built in 1922 and it is estimated that it had been opened only about 42,000 times up to the time of the tests, in May 1951. In building this bridge the designers increased the size of the principal member 23–27 at joint 27 on account of the high secondary stresses induced by the concrete counterweight.

Strain gage readings were secured with the dynamic strain gage equipment on the gross area of the principal member 23–27 at three sections, as shown on Fig. 16. The locations of the SR4 wire gages on the member at the three sections are shown by the diagrams at the top of Fig. 17. The gages were placed on the member at section 1–1 to determine the magnitude of the stresses on the minimum steel area at the end of the reinforcement.

It can be seen from the table of "Recorded Stress Range" on Fig. 17 that the maximum stresses occurred at section 1–1, where a stress of 32,800 psi was recorded in the south truss, gage position 8, and a stress of 33,300 psi was recorded in the north truss at gage position 7 when the bridge was opened at an angle of 75 deg with the horizontal, which is considered fully opened. The maximum stress recorded at section 2–2 was 20,400 psi at gage position 11 of the north truss. It is apparent that the additional steel that was added to this member on account of the calculated secondary stresses should have extended closer to joint 23.

As mentioned previously, the bridge had been opened only about 42,000 times, and of this total number of openings only about 1,000 had been at an angle of 75 deg.

Results of Dynamic Tests

The tests conducted on the bascule bridges of the Texas & Pacific in Plaquemine, La., and the Chicago & North Western bridge in Chicago, afforded an opportunity to secure some data on the stresses in the principal counterweight truss member resulting from the vibrations induced by the application of power to start the movement of the bridge or the application of the brakes to slow down the movement of the bridge.

The stress in the principal member of the Texas & Pacific bridge resulting from the vibrations was about 1,000 psi, or about 3 percent of the static stress of 33,300 psi recorded in this member. The bridge on the Chicago & North Western had not yet been properly balanced and adjusted after removing some of the concrete counterweight and reinforcing the highly stressed member, consequently it was not operating as smoothly as the Plaquemine bridge, and the results of this poor operation are reflected in the magnitude of the vibrational stresses. A total vibrational stress of 4,200 psi was recorded on the Chicago & North Western bridge in the principal member, which is about 11 percent of the recorded static stress of 38,850 psi.

Results of Laboratory Fatigue Tests

Laboratory investigations conducted on various structural joints within recent years are beginning to indicate more precisely the relation between number of cycles of applied load to failure of the joint and the magnitude of the stress. In these tests, large structural joints fastened with rivets of various grips and patterns have been tested to failure under repeated loads. In some cases the stress varied from zero or near zero to a maximum, while in other tests the stress varied from a compressive stress to a tensile stress of equal magnitude.

The results of a large number of tests on joints subjected to a stress range varying from near zero to a maximum on the gross section are shown by the curve on Fig. 18. The plotted values on this diagram were taken from tests conducted on riveted double-lap joints by the University of Illinois and reported in University of Illinois Engineering Experiment Station Bulletin 302. The curve drawn through these values up to 62,000 psi, which is the static strength of the joint, represents the average S–N curve of a riveted double-lap joint. For example, a riveted joint subjected to a stress of 40,000 psi on the gross section should fail after about 50,000 cycles of load, but should withstand about 300,000 cycles of load if the stress is reduced to 25,000 psi on the gross section.

The results of a number of tests of riveted joints subjected to a stress range varying from a compressive stress to an equal tensile stress on the gross section are shown on Fig. 19, and the curve drawn through these values represents the average S–N curve. For example, a riveted joint subjected to a stress varying from 20,000 psi compression to 20,000 psi tension on the gross area for a total stress range of 40,000 psi should fail after about 70,000 cycles.

As explained previously, the range of stress occurring in the principal member of the five bascule bridges was reliably determined by the strain gage readings, but the exact amount of tension or compression in the member was not determined. The analytical study in Part 2 of this full report indicates that the stress on the underside of the member varies from near zero when the bridge is closed to a maximum tension when the birdge is fully opened. However, it can be seen by comparing the average S–N curves for riveted joints on Figs. 18 and 19 that a riveted joint subjected to a range of 40,000 psi will fail at about 50,000 cycles if the stress is all tension, and at about 70,000 cycles if there is complete reversal. It is apparent from these values that it is not necessary to determine the exact magnitude of either the tensile or compressive stress in these bridges, as long as we know the range of stress.

Conclusions

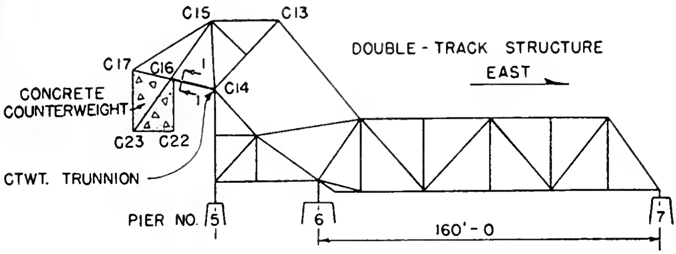
The data covering the results of tests conducted on five bascule bridges and presented in this part of this report appear to justify the following conclusions regarding heel-trunnion bascule bridges:

1. The static stress range in the principal member between the concrete counterweight and pinion will be about 40,000 psi on the gross area on the underside of the member near the center panel point.
2. The maximum stress is likely to occur on a section inside the gusset plates.
3. The dynamic effects resulting from starting and stopping the bridge will increase the static stress range by about 10 percent.

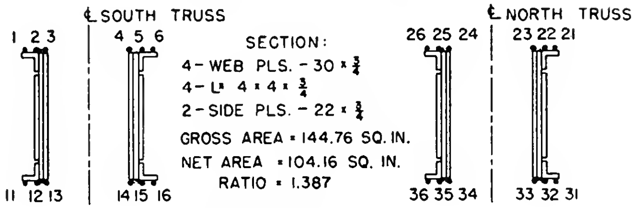
4. Laboratory tests have shown that the fatigue life of a riveted structural joint subjected to a stress range of 40,000 psi will be about 50,000 cycles. Accordingly, any heel-trunnion bascule bridge which has been opened a number of times approaching this figure should have the principal member inspected for fatigue cracks.
5. A fatigue crack in the principal member is not likely to be discernible, except when the bridge is in the open position.

Acknowledgment

The Committee on Iron and Steel Structures and the American Railway Engineering Association are deeply indebted to the Peoria & Pekin Union Railway, the Illinois Central Railroad, the Baltimore and Ohio Railroad, the Chicago and North Western Railway, and the Texas and Pacific Railway for the use of the data covering these tests.



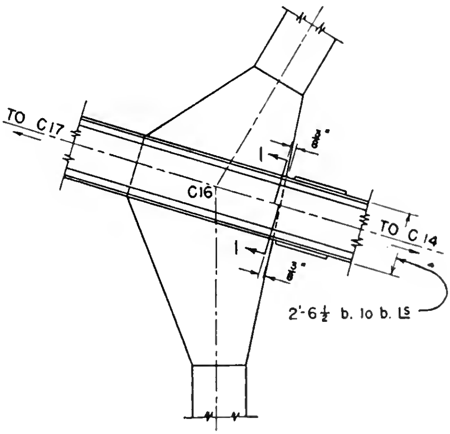
ELEVATION OF SPAN



SECTION 1-1
LOCATION OF GAGES

RECORDED STRESS RANGE			
TRUSS	GAGE NO.	BRIDGE PARTIALLY OPENED	BRIDGE COMPLETELY OPENED
SOUTH	1	+ 1,350	+ 3,060
	2	− 300	+ 750
	3	+ 1,500	+ 5,100
	4	+ 2,160	+ 1,110
	5	+ 810	+ 2,190
	6	− 1,620	− 960
	11	+32,100	+ 36,090
	12	+25,890	+ 29,910
	13	+25,950	+ 30,600
	14	+25,800	+ 30,150
	15	+24,720	+ 29,040
	16	+28,200	+ 32,610
NORTH	21	− 6,150	− 5,160
	22	− 2,160	− 1,140
	23	− 1,740	+ 240
	24	+ 840	+ 2,760
	25	+ 1,800	+ 3,150
	26	+ 3,900	+ 5,100
	31	+30,270	+ 34,500
	32	+23,700	+ 33,300
	33	+26,700	+ 30,990
	34	+25,650	+ 29,700
	35	+27,210	+ 31,350
	36	+35,430	+ 40,530

NOTE: STRESSES SHOWN ARE ON GROSS SECTION IN PSI.
+ TENSION
− COMPRESSION

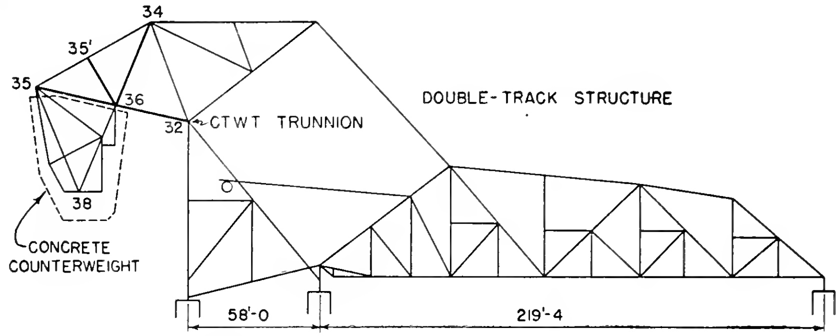


ELEV. OF JOINT C 16

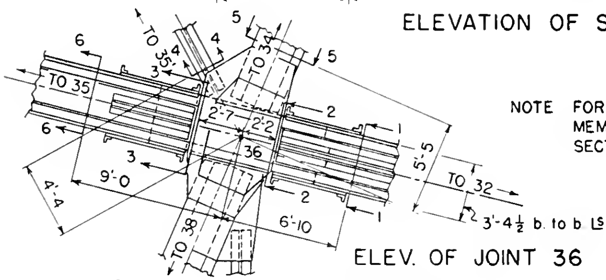
FIG. 1

P & P U. R.R. BRIDGE TESTS
160'-0 THROUGH TRUSS BASCULE SPAN
OPEN TIMBER FLOOR

LOCATION OF TEST MEMBER
RECORDED STRESS RANGE
IN COUNTERWEIGHT TRUSS MEMBER C14 - C16



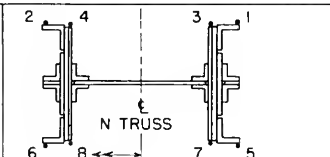
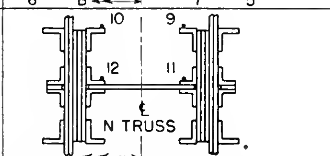
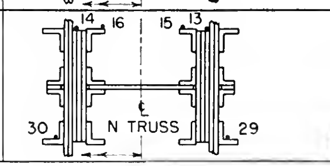
ELEVATION OF SPAN



NOTE FOR MAIN MATERIAL MEMBER 32-35-36, SEE SECTION 6-6, FIG. 3

ELEV. OF JOINT 36

RECORDED STRESS RANGE

LOCATION OF GAGES			GAGE	POSITION OF BRIDGE: ¼ OPEN	½ OPEN	¾ OPEN	FULL OPEN
MEMBER 32-36	SECTION 1-1		1	− 2,955	− 3,510	− 645	− 75
			2	− 3,285	− 3,360	− 795	+ 600
			3	− 2,730	− 2,895	− 480	+ 180
			4	− 2,295	− 330	+ 795	+ 2,325
			5	+ 2,740	+ 11,670	+ 16,575	+ 23,640
			6	+ 3,075	+ 10,545	+ 14,655	+ 20,145
			7	+ 3,060	+ 9,885	+ 13,935	+ 18,910
			8	+ 3,825	+ 11,925	+ 16,410	+ 22,860
	SECTION 2-2		9	− 1,155	+ 1,350	+ 2,190	+ 3,045
			10	− 2,010	− 420	+ 60	+ 75
			11	− 1,500	+ 585	+ 1,515	+ 2,235
			12	− 1,620	+ 660	+ 1,620	+ 2,220
MEMBER 35-36	SECTION 3-3		13	− 465	+ 3,000	+ 4,725	+ 6,810
			14	− 690	+ 2,265	+ 3,600	+ 4,450
			15	− 1,530	+ 795	+ 1,875	+ 3,600
			16	− 1,320	+ 930	+ 2,145	+ 3,000
			29	− 1,755	+ 2,190	+ 3,375	+ 5,325
			30	− 1,395	+ 2,640	+ 4,305	+ 7,140

NOTE STRESSES SHOWN ARE ON GROSS SECTION IN PSI.
\+ TENSION
− COMPRESSION

FIG. 2
I.C.R.R. BRIDGE TESTS
219'-4 THROUGH TRUSS BASCULE SPAN
OPEN TIMBER FLOOR

LOCATION OF TEST MEMBERS
RECORDED STRESS RANGE
IN COUNTERWEIGHT TRUSS MEMBER 32-36-35

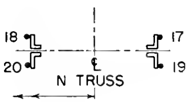
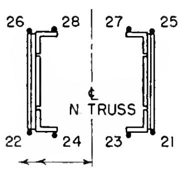
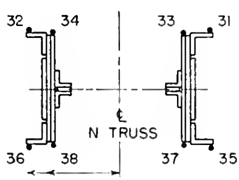
MEMBER 35' - 36
SECTION 4-4
$4 - L^S - 5 \times 3\frac{1}{2} \times \frac{3}{8}$
GROSS AREA = 12.20 SQ IN
NET AREA = 10.51 SQ IN.

MEMBER 34 - 36
SECTION 5-5
$4 - L^S - 8 \times 8 \times \frac{5}{8}$
4 - WEB PLS. - $36 \times \frac{11}{16}$
GROSS AREA = 137.44 SQ. IN.
NET AREA = 115.94 SQ. IN.

MEMBER 35 - 36
SECTION 6-6
$4 - L^S - 8 \times 8 \times \frac{11}{16}$
$4 - L^S - 6 \times 6 \times \frac{11}{16}$
2 - WEB PLS. - $40 \times \frac{11}{16}$
2 - WEB PLS. - $40 \times \frac{5}{8}$
2 - SIDE PLS. - $24 \times \frac{11}{16}$
GROSS AREA = 211.24 SQ. IN.
NET AREA = 178.99 SQ. IN.

NOTE: FOR LOCATION OF SECTIONS, SEE FIGURE 2

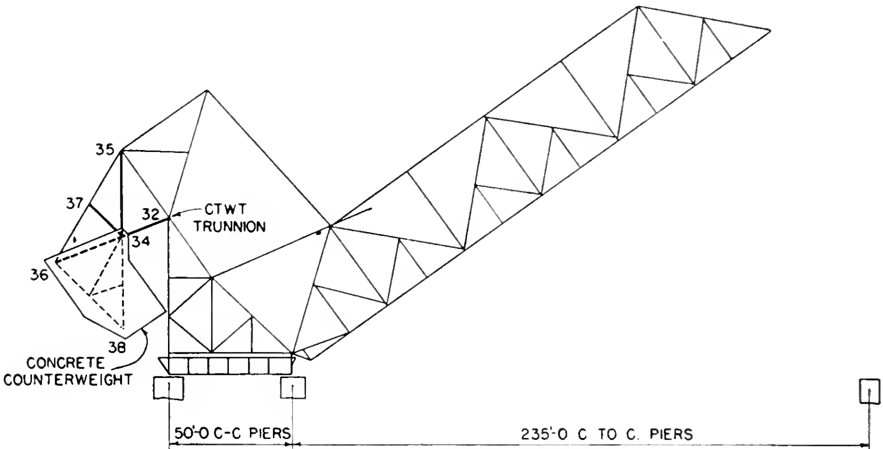
RECORDED STRESS RANGE

LOCATION OF GAGES			GAGE	POSITION OF BRIDGE			
				$\frac{1}{4}$ OPEN	$\frac{1}{2}$ OPEN	$\frac{3}{4}$ OPEN	FULL OPEN
MEMBER 35'-36	SECTION 4-4		17	− 1,065	+ 1,290	+ 2,700	+ 3,630
			18	+ 705	+ 5,340	+ 7,980	+ 11,985
			19	− 975	+ 1,365	+ 1,860	+ 3,300
			20	− 900	+ 1,320	+ 2,520	+ 2,835
MEMBER 34-36	SECTION 5-5		21	− 240	+ 2,355	+ 3,585	+ 4,140
			22	+ 735	+ 4,665	+ 6,450	+ 8,130
			23	− 1,350	+ 4,965	+ 6,870	+ 8,760
			24	+ 555	+ 4,765	+ 6,900	+ 8,925
			25	− 1,665	− 765	− 1,005	− 2,895
			26	− 2,205	− 1,230	− 1,290	− 2,850
			27	− 2,190	− 1,260	− 1,620	− 3,805
			28	− 2,010	− 1,635	− 2,535	− 5,685
MEMBER 35-36	SECTION 6-6		31	− 255	+ 8,635	+ 4,750	+ 8,860
			32	− 735	+ 3,450	+ 5,340	+ 9,840
			33	− 435	+ 3,060	+ 5,100	+ 8,430
			34	− 375	+ 3,180	+ 5,175	+ 6,975
			35	− 840	+ 2,220	+ 3,735	+ 5,880
			36	− 645	+ 1,330	+ 3,525	+ 6,285
			37	− 1,080	+ 1,620	+ 3,020	+ 4,725
			38	− 1,125	+ 1,560	+ 2,835	+ 4,425

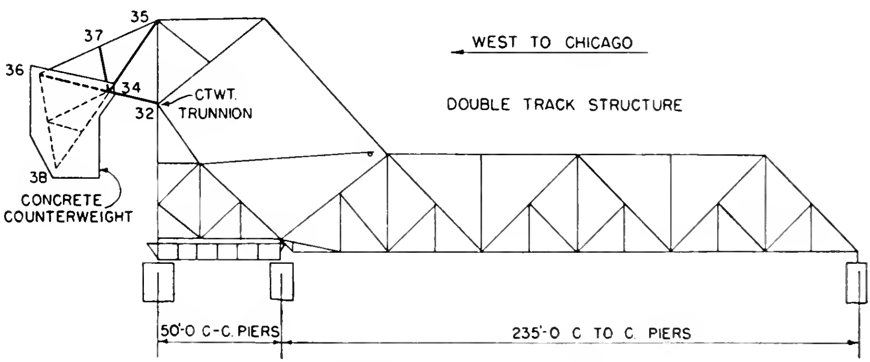
NOTE: STRESSES SHOWN ARE ON GROSS SECTION IN PSI.
\+ TENSION
− COMPRESSION

FIG. 3
I.C.R.R. BRIDGE TESTS
219'-4 THROUGH TRUSS BASCULE SPAN
OPEN TIMBER FLOOR

COUNTERWEIGHT TRUSS MEMBERS 35'-36, 34-36, & 35-36
RECORDED STRESS RANGE



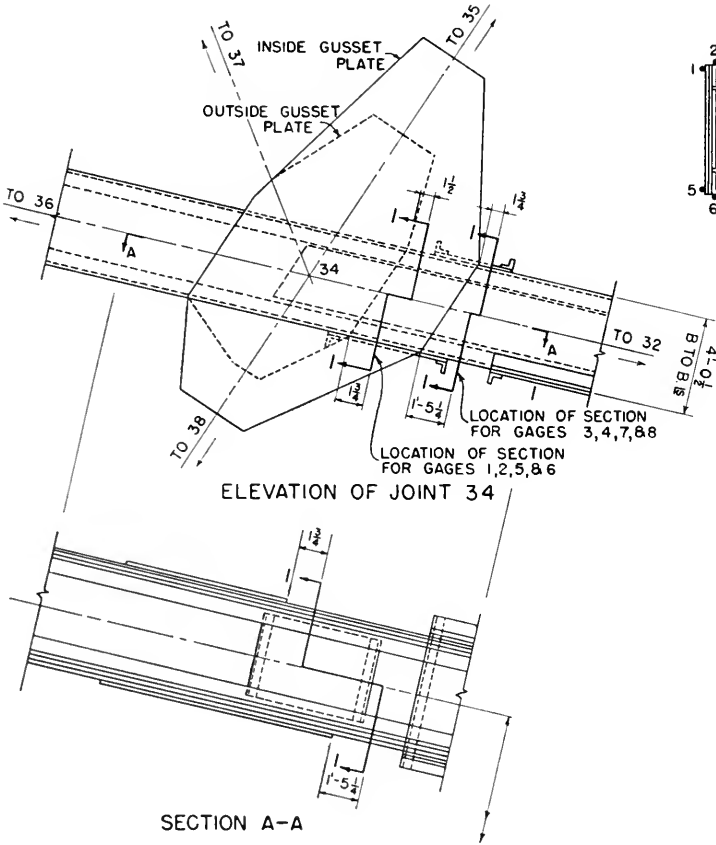
BRIDGE IN OPEN POSITION

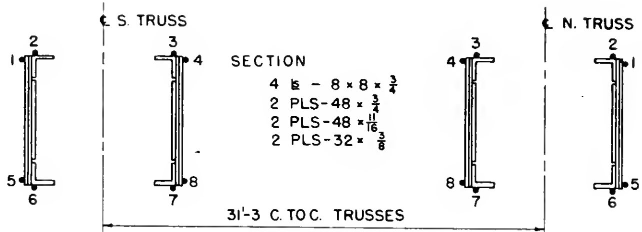


BRIDGE IN CLOSED POSITION

FIG 4
B & O. R.R. BRIDGE TESTS
235'-0 THROUGH TRUSS BASCULE SPAN
OPEN TIMBER FLOOR

LOCATION OF TEST MEMBERS





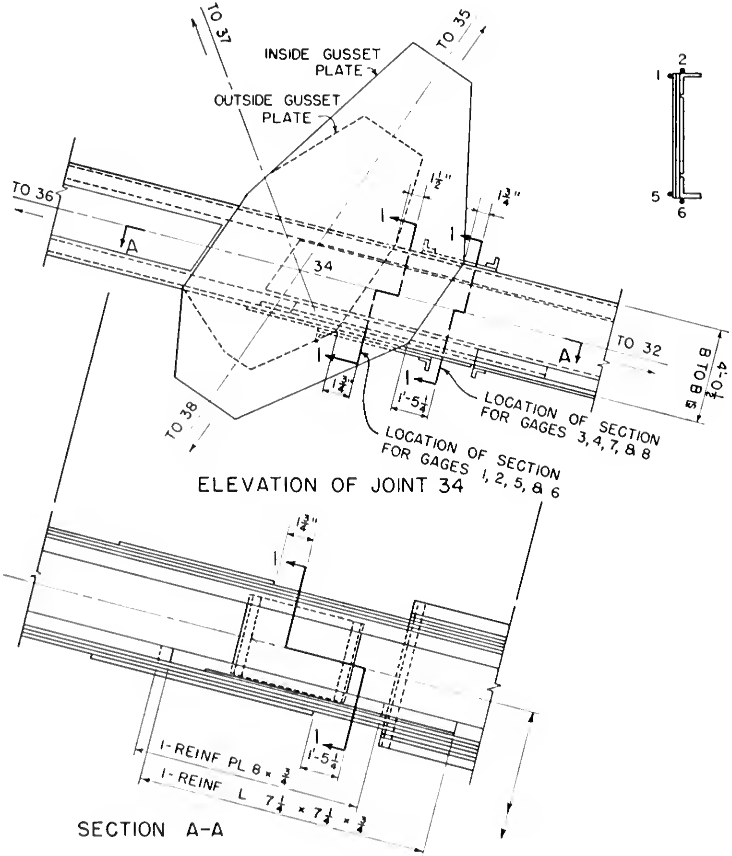
SECTION 1-1

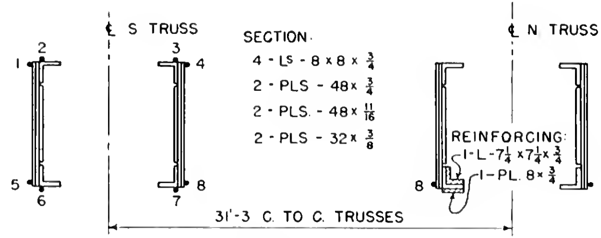
RECORDED STRESS RANGE

GAGE NO.	SOUTH TRUSS				NORTH TRUSS
	POSITION OF BRIDGE				
	¼ OPEN	½ OPEN	¾ OPEN	FULL OPEN	FULL OPEN
1	+ 3,150	+ 8,550	+12,650	+18,300	+ 20,700
2	+ 4,890	+ 5,940	+ 9,750	+13,950	+ 14,700
3	+ 1,050	+ 3,860	+ 7,050	+10,650	+ 13,200
4	+ 1,050	+ 4,950	+ 9,870	+15,450	+ 15,300
5	+ 7,450	+16,050	+23,010	+31,050	+ 31,350
6	+ 5,250	+ 11,850	+17,790	+22,800	+ 24,150
7	+ 9,000	+ 18,000	+24,600	+33,900	+ 24,150
8	+11,850	+ 22,050	+27,750	+39,210	
AVE.	+ 5,460	+ 11,410	+16,560	+23,160	
BENDING	6,390	10,640	11,190	16,050	

NOTE. STRESSES SHOWN ARE ON GROSS SECTION IN PSI
+ TENSION

FIG. 5
B & O. R.R. BRIDGE TESTS
235' THROUGH TRUSS BASCULE SPAN
OPEN TIMBER FLOOR
COUNTERWEIGHT TRUSS MEMBER 32-34
RECORDED STRESS RANGE





SECTION 1-1

RECORDED STRESS RANGE

	BRIDGE IN FULL OPEN POSITION	
GAGE NO	SOUTH TRUSS	NORTH TRUSS
1	+ 18,240	
2	+ 13,740	
3	+ 9,900	
4	+ 14,400	
5	+ 28,650	+ 28,590
6	+ 22,740	
7	+ 33,000	
8	+ 42,750	+ 34,350
AVE.	+ 22,930	
BENDING	+ 19,820	

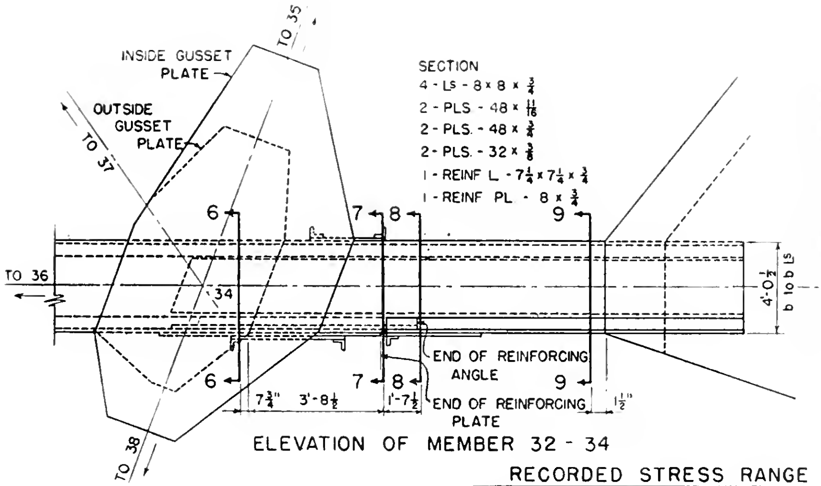
NOTE STRESSES SHOWN ARE ON GROSS SECTION IN PSI
\+ TENSION

FIG 6

B & O R R BRIDGE TESTS
235'-0 THROUGH TRUSS BASCULE SPAN
OPEN TIMBER FLOOR

COUNTERWEIGHT TRUSS MEMBER 32-34
REINFORCED ON NORTH TRUSS

RECORDED STRESS RANGE



ELEVATION OF MEMBER 32 - 34

RECORDED STRESS RANGE

SECTION	BRIDGE IN FULL OPEN POSITION		
	GAGE NO.	SOUTH TRUSS	NORTH TRUSS
6-6	1	+ 26,850	+ 10,650
	2	+ 30,810	+ 24,150
	3	+ 34,500	+ 31,590
	4	+ 42,720	+ 23,640
	5		+ 27,060
	6		+ 15,360
7-7	8		+ 23,340
8-8	9		+ 22,560
9-9	11		+ 24,750
	12		+ 31,800
	13		+ 15,840
	14		+ 12,390

NOTE: STRESSES SHOWN ARE ON GROSS SECTION IN PSI
+ TENSION

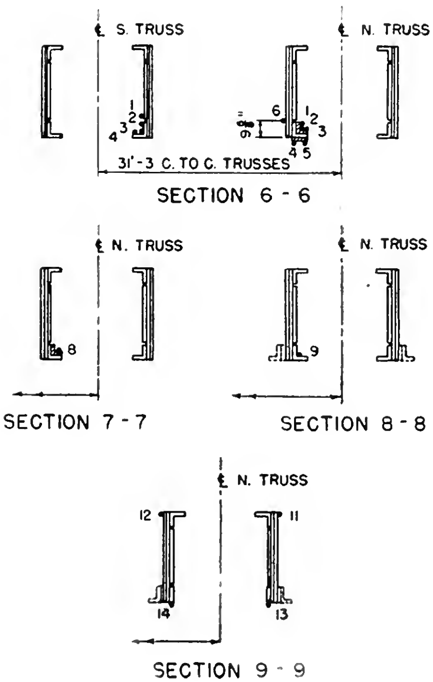
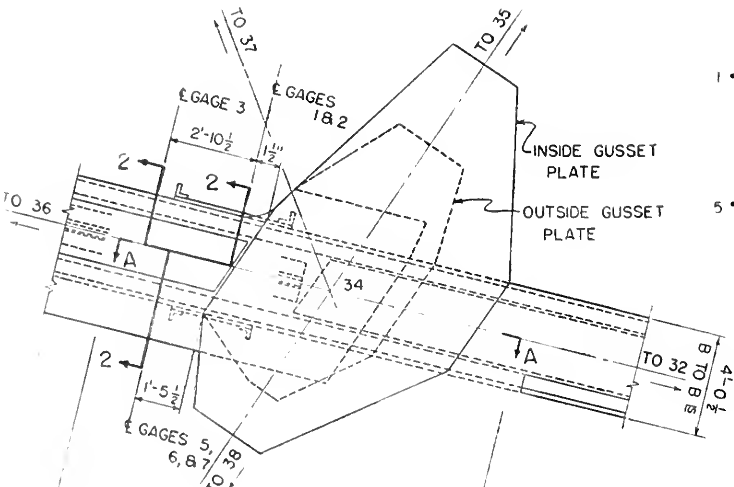
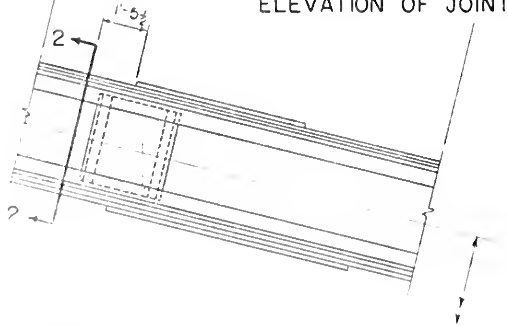


FIG 7
B & O RR. BRIDGE TESTS
235'-0 THROUGH TRUSS BASCULE SPAN
OPEN TIMBER FLOOR

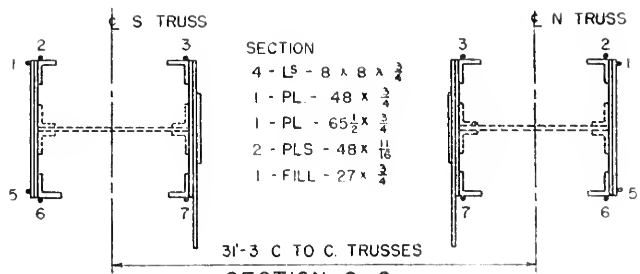
COUNTERWEIGHT TRUSS MEMBER 32-34
REINFORCED ON NORTH TRUSS
RECORDED STRESS RANGE



ELEVATION OF JOINT 34



SECTION A-A



SECTION 2-2

RECORDED STRESS RANGE

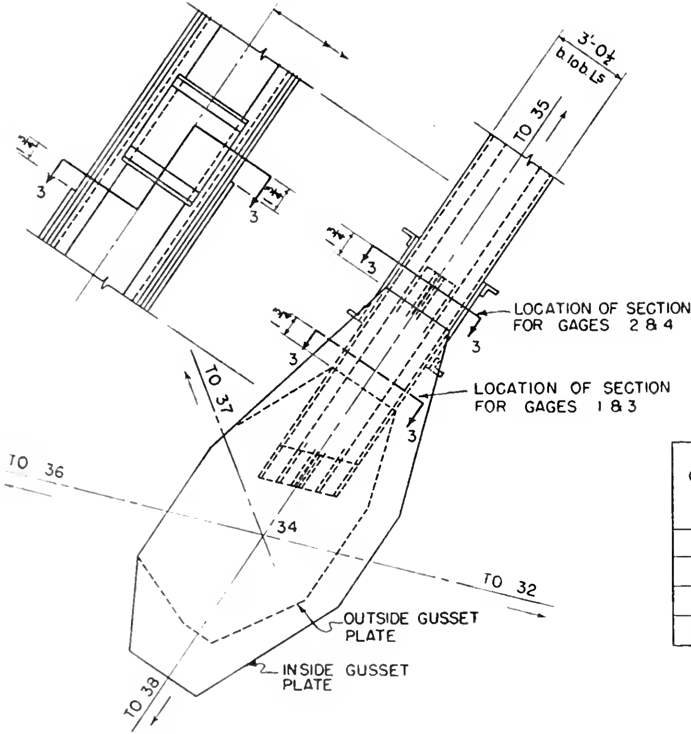
GAGE NO.	SOUTH TRUSS				N. TRUSS
	POSITION OF BRIDGE				
	¼ OPEN	½ OPEN	¾ OPEN	FULL OPEN	FULL OPEN
1	+ 1,950	+ 5,100	+ 8,010	+ 11,550	+ 11,760
2	+ 1,500	+ 4,200	+ 6,810	+ 9,180	+ 10,200
3	+ 450	+ 900	+ 3,330	+ 3,000	+ 3,900
5	+ 4,800	+ 9,510	+ 16,680	+ 20,550	+ 24,150
6	+ 4,590	+10,350	+ 15,450	+ 19,350	+ 20,190
7	+ 960	+ 2,250	+ 3,750	+ 4,350	+ 6,300

NOTE STRESSES SHOWN ARE ON GROSS SECTION IN PSI
\+ TENSION

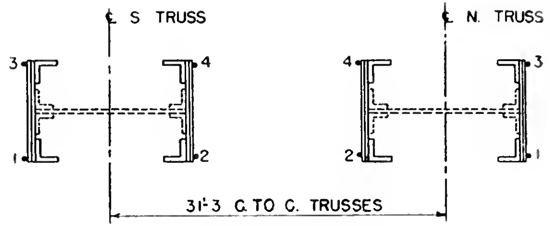
FIG. 8

B & O R.R BRIDGE TESTS
235'-0 THROUGH TRUSS BASCULE SPAN
OPEN TIMBER FLOOR

COUNTERWEIGHT TRUSS MEMBER 34-36
RECORDED STRESS RANGE



ELEVATION OF JOINT 34



SECTION 3-3

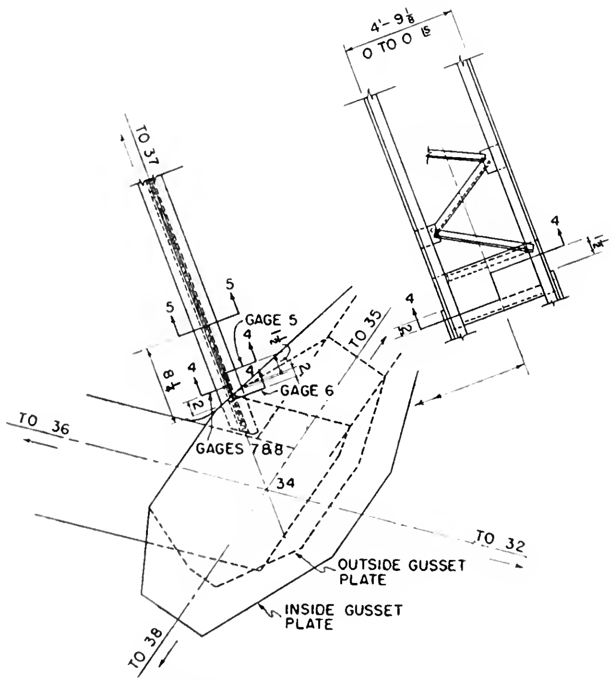
SECTION
4 Ls 8 × 8 × ¾
2-PLS. 36 × ¾
2-PLS 36 × ⅝

RECORDED STRESS RANGE

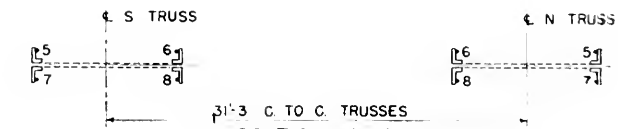
GAGE NO	SOUTH TRUSS				NORTH TRUSS
	POSITION OF BRIDGE				
	¼ OPEN	½ OPEN	¾ OPEN	FULL OPEN	FULL OPEN
1	+1,200	+2,850	+2,940	+3,450	+5,250
2	+4,260	+7,950	+9,840	+11,400	+12,150
3	+ 900	+1,200	+ 840	−1,500	− 300
4	+ 750	+1,140	+ 330	−2,850	−1,800

NOTE STRESSES SHOWN ARE ON GROSS SECTION IN PSI
+ TENSION
− COMPRESSION

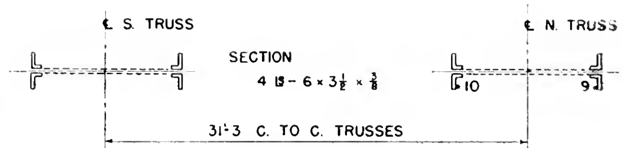
FIG. 9
B & O RR. BRIDGE TESTS
235' THROUGH TRUSS BASCULE SPAN
OPEN TIMBER FLOOR
COUNTERWEIGHT TRUSS MEMBER 34-35
RECORDED STRESS RANGE



ELEVATION OF JOINT 34



SECTION 4-4



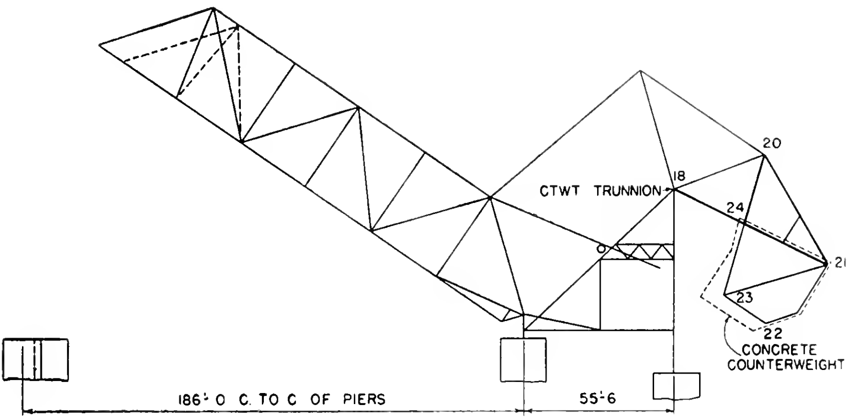
SECTION 5-5

RECORDED STRESS RANGE

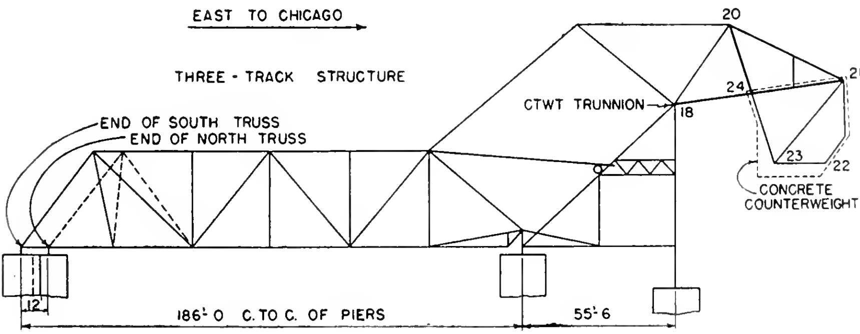
GAGE NO	SOUTH TRUSS				NORTH TRUSS
	POSITION OF BRIDGE				
	¼ OPEN	½ OPEN	¾ OPEN	FULL OPEN	FULL OPEN
5	+ 1,500	+ 4,500	+ 7,290	+ 11,100	+ 10,650
6	+ 1,740	+ 4,350	+ 7,050	+ 10,350	+ 12,000
7	+ 1,350	+ 2,790	+ 3,900	+ 4,200	+ 6,300
8	+ 900	+ 1,950	+ 1,200	- 300	- 750
9					+ 8,700
10					0

NOTE STRESSES SHOWN ARE ON GROSS SECTION IN PSI
\+ TENSION
\- COMPRESSION

FIG 10
B.&O. RR BRIDGE TESTS
235' THROUGH TRUSS BASCULE SPAN
OPEN TIMBER FLOOR
COUNTERWEIGHT TRUSS MEMBER 34-37
RECORDED STRESS RANGE

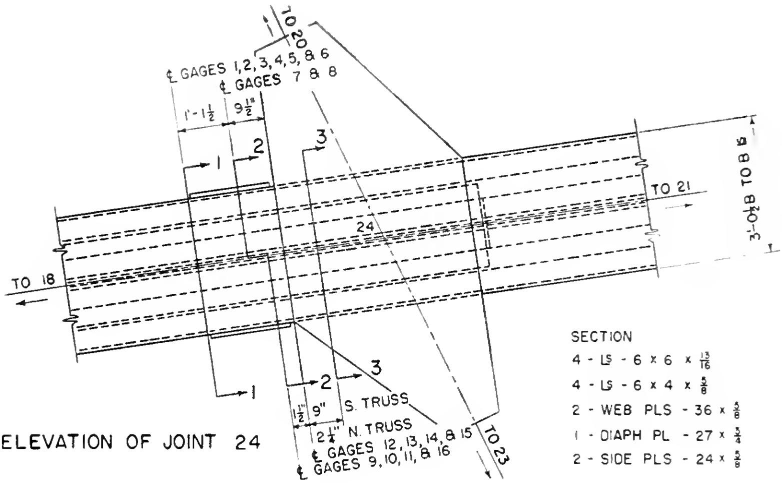


BRIDGE IN OPEN POSITION

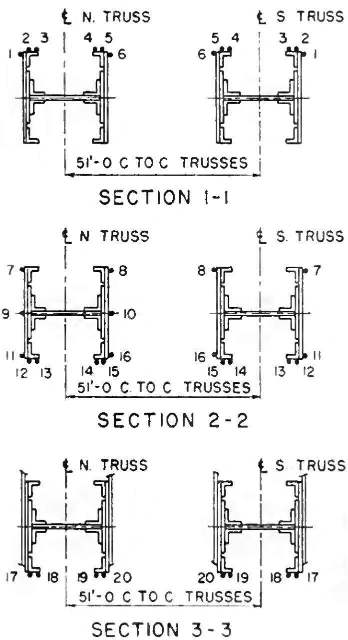


BRIDGE IN CLOSED POSITION

FIG 11
C & NW RY BRIDGE TESTS
186'-0 THROUGH TRUSS BASCULE SPAN
OPEN TIMBER FLOOR
LOCATION OF TEST MEMBERS



ELEVATION OF JOINT 24

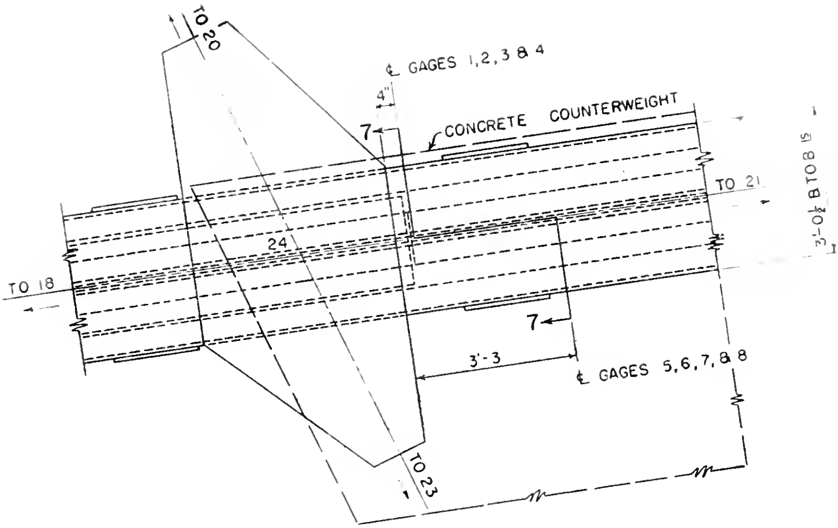


RECORDED STRESS RANGE

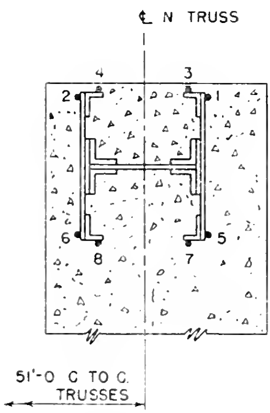
SECTION	GAGE NO	NORTH TRUSS				SOUTH TRUSS			
		POSITION OF BRIDGE				POSITION OF BRIDGE			
		3/8 OPEN	1/2 OPEN	3/4 OPEN	FULL OPEN	1/8 OPEN	1/2 OPEN	3/4 OPEN	FULL OPEN
1-1	1	3,600	5,250	7,500	9,750	300	3,900	6,150	8,700
	2	4,200	6,000	8,250	10,500	540	4,290	6,840	9,510
	3	5,400	7,800	10,650	13,950	900	6,150	9,600	12,900
	4	4,500	6,900	11,550	16,650	1,350	7,950	12,750	16,200
	5	3,900	5,500	10,050	12,750	1,050	7,050	12,300	15,750
	6	3,150	4,950	9,300	12,300	720	6,060	10,260	13,800
2-2	7	2,850	3,750	5,850	7,650	3,300	3,150	4,950	7,140
	8	2,550	3,750	7,050	9,300	600	5,160	9,000	11,910
	9	6,300	8,550	13,350	17,550				
	10	6,300	8,550	13,800	18,150				
	11	11,250	14,850	22,500	30,450	2,400	12,750	20,550	29,400
	12	11,550	15,450	22,800	30,450	2,850	13,710	21,450	30,300
	13	12,900	16,050	22,200	28,200	3,450	15,510	23,250	31,800
	14	11,250	14,250	19,950	25,650	3,000	14,100	21,000	28,650
	15	12,300	15,900	23,100	30,000	3,000	14,850	23,550	33,300
	16	13,350	17,250	25,200	32,850	2,850	13,950	22,800	33,000
3-3	17	11,250	14,850	21,600	28,650	3,900	17,100	27,150	37,800
	18	12,600	15,450	20,850	26,550	3,960	18,060	26,910	36,300
	19	19,350	24,150	31,800	37,950	3,300	14,850	22,500	31,050
	20	9,600	12,450	18,900	25,500	2,100	12,300	20,100	29,640

NOTE: STRESSES SHOWN ARE TENSILE ON GROSS SECTION IN PSI

FIG 12
C & N W RY BRIDGE TESTS
186'-0 THROUGH TRUSS BASCULE SPAN
OPEN TIMBER FLOOR
COUNTERWEIGHT TRUSS MEMBER 18 - 24
RECORDED STRESS RANGE



ELEVATION OF JOINT 24



SECTION 7-7

SECTION.
4-Ls 6 × 6 × 13/16
4-Ls 6 × 4 × 5/8
2-WEB PLS. 36 × 3/8
1-DIAPH. PL. 27 × 3/4
2-FILL PLS. 12¾ × 5/8

RECORDED STRESS RANGE

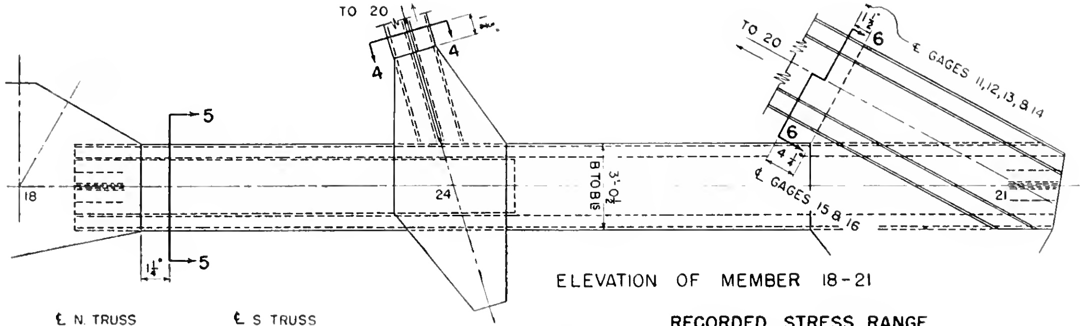
GAGE NO.	POSITION OF BRIDGE			
	¼ OPEN	½ OPEN	¾ OPEN	FULL OPEN
1	+ 2,300	+ 5,100	+ 9,200	+ 12,600
2	+ 1,500	+ 3,200	+ 5,800	+ 8,200
3	+ 1,700	+ 4,000	+ 7,000	+ 9,900
4	+ 1,200	+ 2,700	+ 5,700	+ 8,600
5	+ 1,300	+ 2,800	+ 5,000	+ 7,000
6	+ 1,000	+ 2,100	+ 3,600	+ 4,600
7	+ 1,100	+ 2,500	+ 4,000	+ 5,400
8	+ 1,000	+ 2,300	+ 3,600	+ 4,700

NOTE: STRESSES SHOWN ARE ON GROSS SECTION IN PSI
\+ TENSION

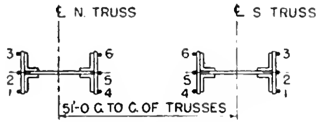
FIG 13

C & N W RY BRIDGE TESTS
136'-0 THRU TRUSS BASCULE SPAN
OPEN TIMBER FLOOR

COUNTERWEIGHT TRUSS MEMBER 21-24
RECORDED STRESS RANGE

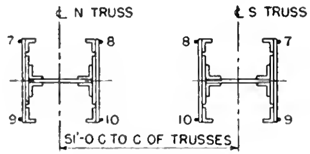


ELEVATION OF MEMBER 18-21



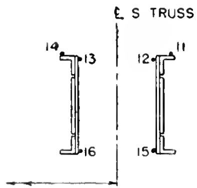
SECTION 4—4

SECTION:
4 ∟ - 8×6×3/8
2 SIDE PLS - 18×½
1 DIAPH. PL. - 28×3/8



SECTION 5-5

SECTION
4 ∟ - 6×6×13/16
4 ∟ - 6×4×3/8
2 WEB PLS. - 36×5/8
1 DIAPH. PL. - 27×3/4
2 SIDE PLS. - 24×5/8



SECTION 6-6

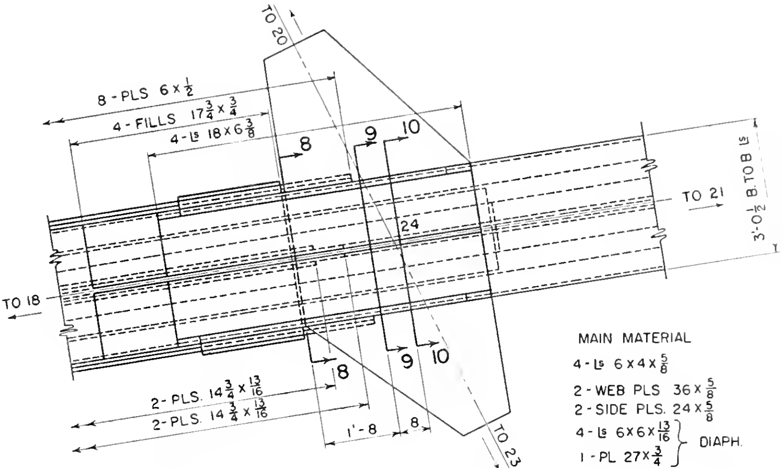
SECTION
4 ∟ 8×6×11/16
2 WEB PLS - 42×13/16
2 SIDE PLS 26×11/16

RECORDED STRESS RANGE

MEMBER	SECTION	GAGE NO	NORTH TRUSS — POSITION OF BRIDGE: 3/8 OPEN	½ OPEN	¾ OPEN	FULL OPEN	SOUTH TRUSS — POSITION OF BRIDGE: 1/8 OPEN	½ OPEN	¾ OPEN	FULL OPEN
20-24	4-4	1	+5,400	+6,900	+8,700	+9,450	+1,590	+6,390	+8,490	+10,410
		2	+3,000	+3,450	+3,300	+1,650	+ 990	+3,540	+3,540	+ 1,860
		3	+ 900	+ 300	- 1,800	-5,400	+ 450	+ 300	-2,700	-8,550
		4	+6,150	+7,650	+10,050	+12,150	+1,710	+7,050	+9,900	+12,450
		5	+4,200	+5,100	+5,550	+4,950	+1,050	+3,750	+4,200	+2,850
		6	+1,200	+ 900	- 1,200	-4,800	+ 600	+ 600	- 1,650	-6,600
18-24	5-5	7	+9,300	+12,150	+17,100	+21,000	+1,650	+9,150	+14,850	+20,550
		8	+10,650	+13,500	+18,450	+22,650	+3,210	+13,260	+19,560	+26,100
		9	+7,050	+9,900	+15,300	+20,250	+1,500	+10,950	+17,100	+25,200
		10	+12,000	+16,200	+23,250	+30,450	+2,760	+13,860	+20,460	+28,110
20-21	6-6	11					-450	-3,150	-5,200	-8,400
		12					-660	-4,260	-6,960	-11,550
		13					-750	-4,740	-8,100	-13,050
		14					-510	-2,910	-4,860	-8,100
		15					-600	-4,050	-8,250	-11,250
		16					-780	-4,440	-7,440	-12,750

NOTE STRESSES SHOWN ARE ON GROSS SECTION IN PSI.
+ TENSION
− COMPRESSION

FIG. 14
C. & N. W. RY. BRIDGE TESTS
186'-0 THRU TRUSS BASCULE SPAN
OPEN TIMBER FLOOR
COUNTERWEIGHT TRUSS MEMBERS 18-24, 20 21, 20-24
RECORDED STRESS RANGE



ELEVATION-JOINT 24

MAIN MATERIAL

4 - Ls $6 \times 4 \times \frac{5}{8}$

2 - WEB PLS $36 \times \frac{5}{8}$

2 - SIDE PLS. $24 \times \frac{5}{8}$

4 - Ls $6 \times 6 \times \frac{13}{16}$ } DIAPH.

1 - PL $27 \times \frac{3}{4}$ }

REINFORCEMENT MATERIAL
SECTION 8-8

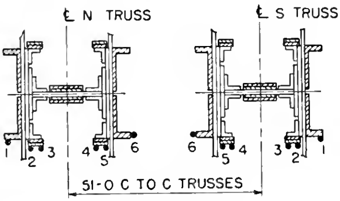
8 - PLS. $6 \times \frac{1}{2}$

4 - Ls $18 \times 6\frac{3}{8}$

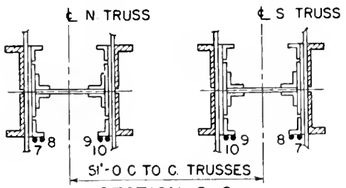
(CUT FROM W.F. BM 36 X 182)

4 - DIAPH. PLS $14\frac{3}{4} \times \frac{13}{16}$

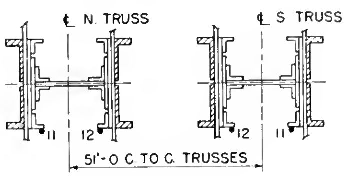
4 - FILLS $17\frac{3}{4} \times \frac{3}{4}$



SECTION 8-8



SECTION 9-9



SECTION 10-10

NOTE REINFORCEMENT MATERIAL
SHOWN CROSS-HATCHED

RECORDED STRESS RANGE

SECTION	GAGE NO.	NORTH TRUSS				SOUTH TRUSS			
		POSITION OF BRIDGE				POSITION OF BRIDGE			
		$\frac{1}{4}$ OPEN	$\frac{1}{2}$ OPEN	$\frac{3}{4}$ OPEN	FULL OPEN	$\frac{1}{4}$ OPEN	$\frac{1}{2}$ OPEN	$\frac{3}{4}$ OPEN	FULL OPEN
8-8	1	4,500	8,400	11,250	13,200	6,150	10,350	14,100	16,650
	2	4,800	8,700	10,950	12,750	5,550	10,200	14,250	17,550
	3	3,600	6,150	7,950	9,150	4,950	8,700	12,600	15,750
	4	2,100	3,600	4,650	5,700	4,650	8,400	12,000	14,700
	5	4,350	7,650	9,450	10,650	5,400	9,600	13,800	16,950
	6	5,400	9,300	12,150	14,250	4,500	7,950	11,250	13,500
9-9	7	4,350	8,400	12,000	14,700	5,400	9,450	13,950	17,700
	8	6,300	12,300	17,100	20,550	11,550	21,450	31,050	38,850
	9	6,300	12,450	17,100	20,700	11,250	19,950	28,500	35,100
	10	5,100	9,900	13,500	16,500	4,800	8,850	13,050	16,650
10-10	11	4,950	10,050	14,100	17,100	5,550	9,750	13,950	17,550
	12	5,100	10,350	14,400	17,550	5,550	9,600	13,950	18,150

NOTE: STRESSES SHOWN ARE TENSILE ON GROSS SECTION IN PSI.

FIG. 15

C & N W RY BRIDGE TESTS
186'-0 THROUGH TRUSS BASCULE SPAN
OPEN TIMBER FLOOR

COUNTERWEIGHT TRUSS MEMBER 18-24
REINFORCED ON BOTH TRUSSES

RECORDED STRESS RANGE

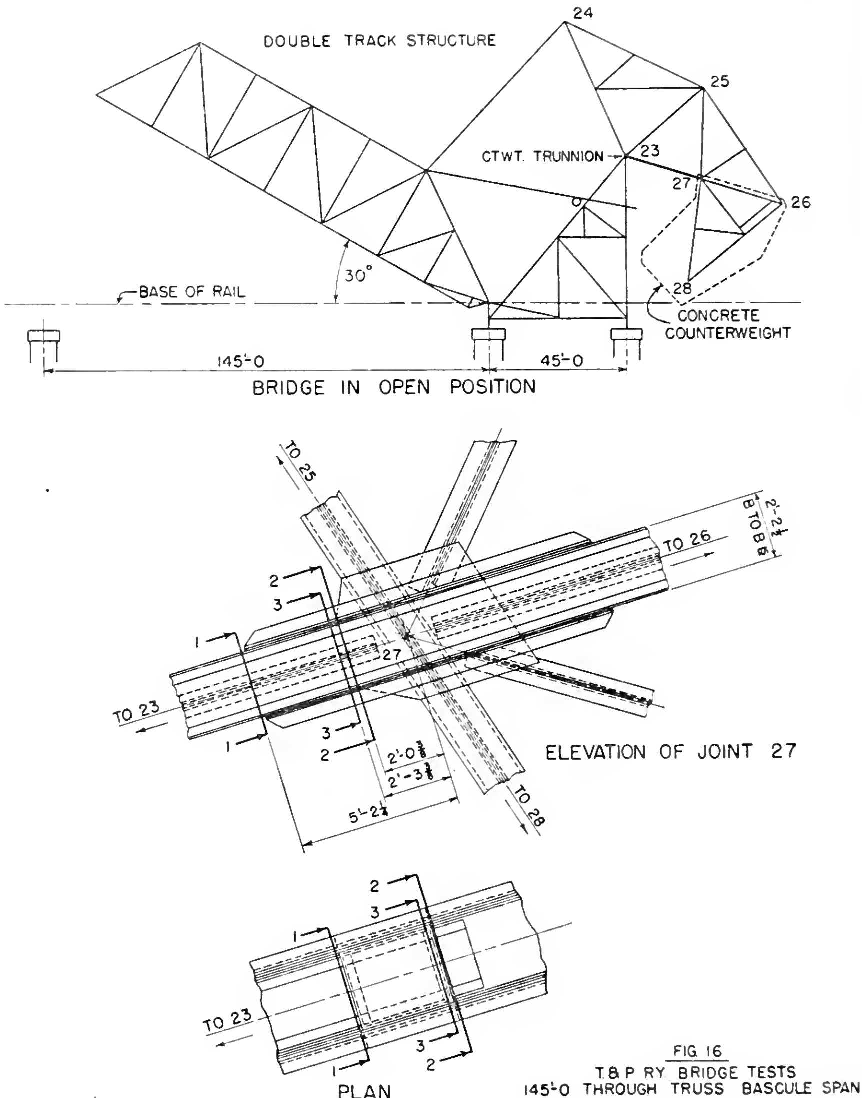
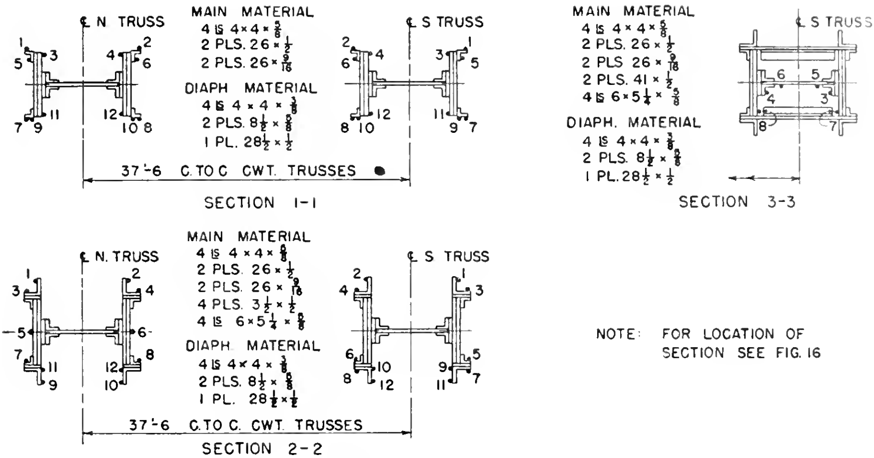


FIG. 16
T. & P. RY. BRIDGE TESTS
145'-0 THROUGH TRUSS BASCULE SPAN
OPEN TIMBER FLOOR
LOCATION OF TEST MEMBER



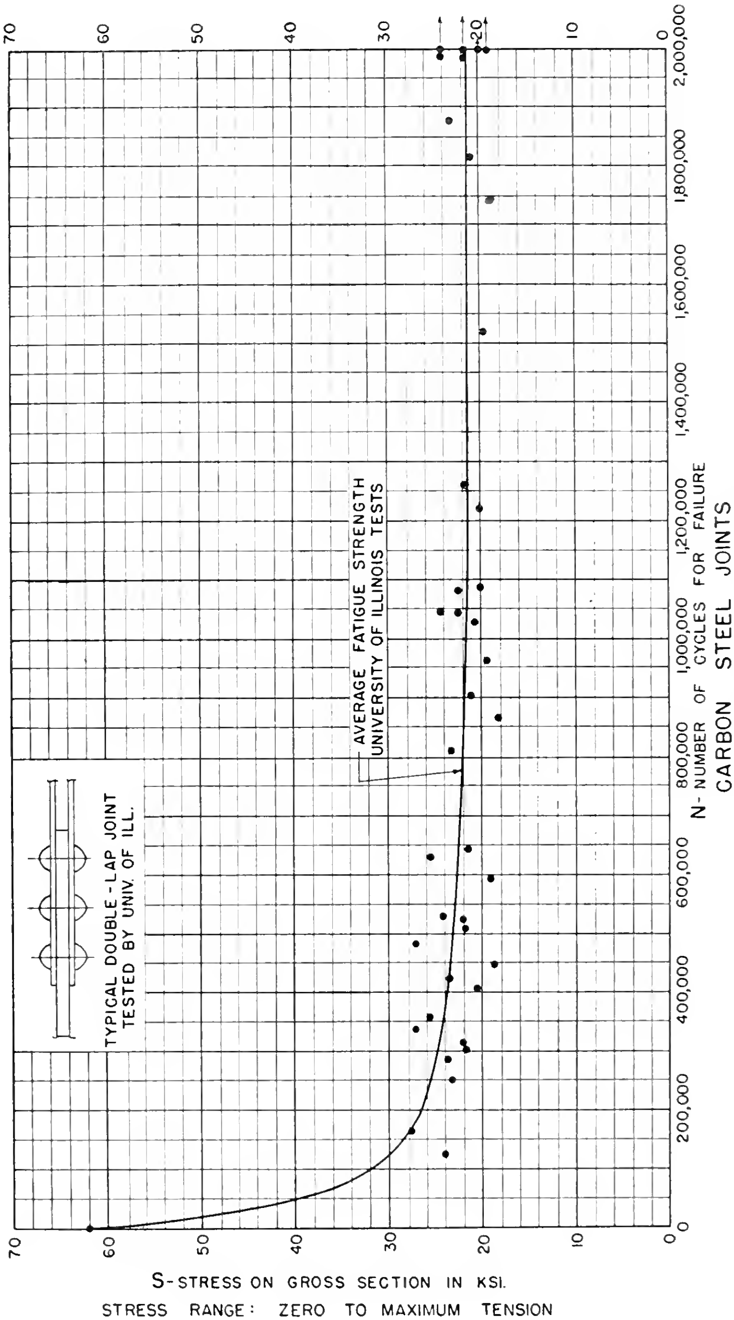
LOCATION OF GAGES

RECORDED STRESS RANGE

SECTION			SECTION 1-1			SECTION 2-2			SECTION 3-3		
ANGLE OF OPENING			45°	60°	75°	45°	60°	75°	45°	60°	75°
SOUTH TRUSS	GAGE NO.	1	+ 4,500	+ 6,400	+ 8,500	0					
		2	+ 5,700	+ 8,000	+10,300	0					
		3	+ 3,400	+ 4,500	+ 6,000	+ 2,000	+ 3,000	+ 3,700	+ 7,000	+ 8,300	+ 9,100
		4	+ 4,200	+ 4,600	+ 7,000	+ 2,700	+ 3,800	+ 4,700	+ 9,700	+12,300	+13,800
		5	+ 4,800	+ 6,500	+ 7,800	+10,200	+12,700	+14,900	+ 6,200	+ 7,700	+ 8,300
		6	+ 5,800	+ 7,600	+ 9,600	+13,000	+16,000	+18,500	+ 5,000	+ 6,100	+ 6,700
		7	+23,000	+27,800	+32,000	+ 9,100	+11,700	+13,700	+14,900	+18,500	+20,900
		8	+24,800	+29,000	+32,800	+11,500	+14,400	+16,700	+14,000	+17,100	+19,300
		9	+20,000	+23,900	+27,600	+13,800	+17,100	+19,600			
		10	+19,000	+22,900	+26,400	+13,400	+16,300	+18,500			
		11	+14,500	+15,800	+21,000	+12,400	+15,200	+17,600			
		12	+15,000	+18,300	+21,400	+12,300	+16,000	+17,200			
NORTH TRUSS	GAGE NO.	1	+ 5,700	+ 8,200	+10,300	− 500	0	+ 800			
		2	+ 5,800	+ 8,100	+10,100	− 200	+ 400	+ 800			
		3	+ 3,400	+ 4,100	+ 6,400	+ 2,800	+ 2,800	+ 3,800			
		4	+ 4,000	+ 5,700	+ 7,000	+ 2,100	+ 3,100	+ 4,200			
		5	+ 6,000	+ 7,800	+ 8,300	+ 7,000	+ 9,500	+11,900			
		6	+ 5,700	+ 7,800	+ 9,600	+ 6,600	+ 9,000	+11,000			
		7	+24,000	+29,400	+33,300	+ 9,400	+12,600	+15,000			
		8	+21,300	+25,700	+28,800	+ 9,000	+12,200	+14,200			
		9	+20,500	+25,000	+28,200	+12,100	+15,400	+18,000			
		10	+20,500	+25,300	+28,700	+12,300	+15,800	+18,300			
		11	+16,000	+20,000	+23,000	+14,100	+17,700	+20,400			
		12	+16,000	+20,000	+23,000	+13,000	+16,000	+18,700			

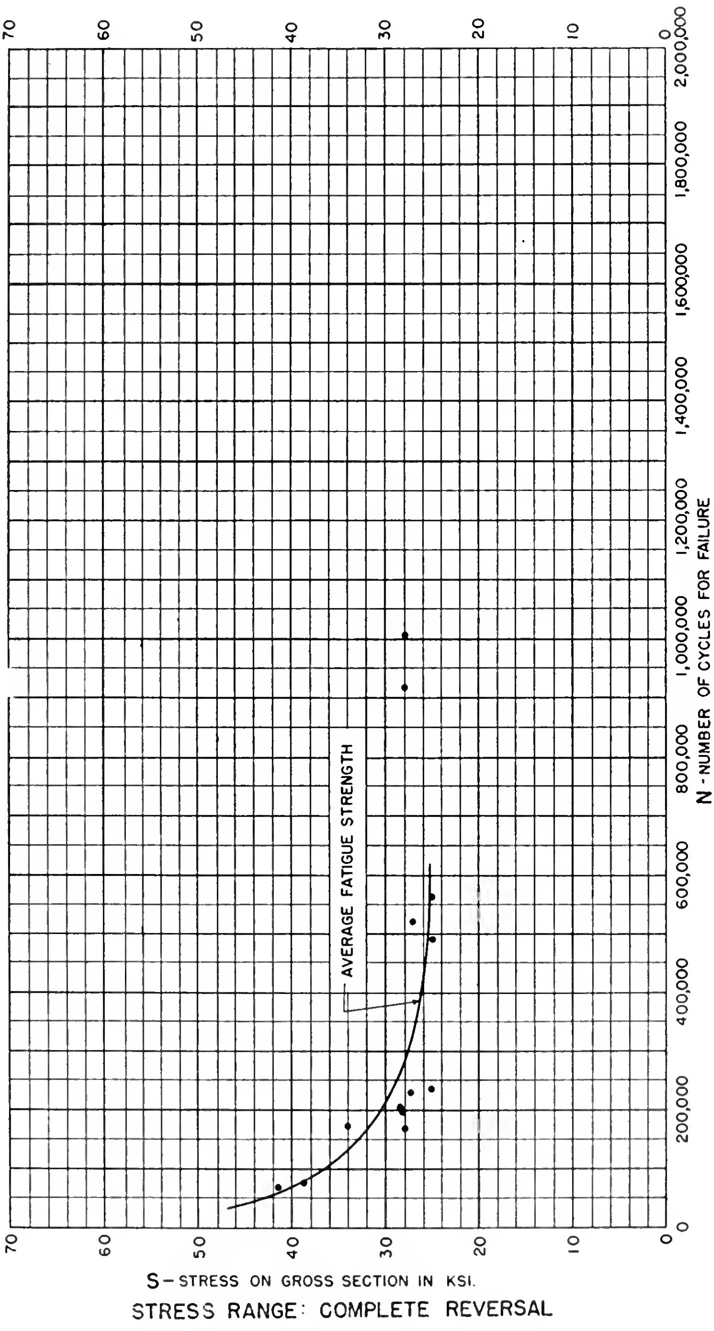
NOTE: STRESSES SHOWN ARE ON GROSS SECTION IN PSI
+ TENSION
− COMPRESSION

FIG 17
T. & P. RY. BRIDGE TESTS
145'-0 THROUGH TRUSS BASCULE SPAN
OPEN TIMBER FLOOR
COUNTERWEIGHT TRUSS MEMBER 23-27-26
RECORDED STRESS RANGE



NOTE: SEE BULLETIN NO. 302, UNIVERSITY OF ILLINOIS ENGINEERING EXPERIMENT STATION

FIG. 18
FATIGUE TESTS ON CARBON STEEL JOINTS
S-N CURVE
FOR STRESS RANGE: ZERO TO MAXIMUM TENSION



CARBON STEEL JOINTS

FIG. 19
FATIGUE TESTS
ON CARBON STEEL JOINTS
S-N CURVES
FOR STRESS RANGE:
MAXIMUM TENSION TO
MAXIMUM COMPRESSION

NOTE: SEE BULLETIN NO. 302, UNIVERSITY
OF ILLINOIS ENGINEERING
EXPERIMENT STATION.
AREA PROCEEDINGS, VOL. 51

Preliminary Report of Committee 3—Ties

P. D. Brentlinger, *Chairman*
J. E. Armstrong, Jr.
R. S. Belcher
C. S. Burt
W. J. Burton
R. F. Bush
G. B. Campbell
C. M. Coates
E. L. Collette
B. S. Converse
R. L. Cook
R. W. Cook
B. E. Crumpler
L. P. Drew
H. R. Duncan
W. F. Dunn, Sr.
T H. Friedlin
A. K. Frost
W. E. Fuhr
L. E. Gingerich
B. D. Howe
M. J. Hubbard
C. E. Jackman
G. R. Janosko
F. O. Johnson, Jr.
W. J. Kernan
L. W. Kistler
W. G. Lindeman
C. M. Long
L. C. Collister, *Vice-Chairman*
Roy Lumpkin
D. E. Patton
M. H. Priddy
W. C. Reichow
N. B. Roberts
H. S. Ross
T. D. Saunders
Stuart Shumate
P. V. Thelander
S. Thorvaldson
C. D. Turley
R. G. Wintrich
Committee

Report on Assignment 4

Tie Renewals and Costs Per Mile of Maintained Track

The Bureau of Railway Economics, AAR, annual statistics providing information regarding the number and costs of cross ties laid in maintenance during the year 1951 are shown in Tables A and B. It will be noted that there were approximately 1,400,000 fewer ties laid in replacement in the United States in 1951 than in 1950. However, average tie costs were up 20¢ each so that the renewal cost per mile of maintained track increased from $252 to $257. Special attention is called to the fact that for the first time in the history of the American Railroads, the 5-year average of tie renewals per mile of maintained track is below 100. This reflects an average service life of over 30 years and is due in great part to the use of treated ties.

The Committee on Ties,
P. D. Brentlinger, *Chairman*.

Table A

CROSS TIE STATISTICS (EXCLUDING SWITCH & BRIDGE) FOR CLASS I RAILROADS IN THE UNITED STATES AND LARGE CANADIAN RAILROADS

Table A

CROSS TIE STATISTICS (EXCLUDING SWITCH & BRIDGE) FOR CLASS I RAILROADS IN THE UNITED STATES AND LARGE CANADIAN RAILROADS

Calendar year ended December 31, 1951

Road	New wooden ties untreated (U): Number	New wooden ties untreated (U): Average cost	New wooden ties treated (T): Number	New wooden ties treated (T): Average cost	Total all new wooden ties laid: Number	Total all new wooden ties laid: Average cost	Ties other than wood (S) & second-hand (*) reapplied ties	Total ties applied
1	2	3	4	5	6	7	8	9
NEW ENGLAND REGION:								
Bangor & Aroostook	84 784	$1.65	31 094	$3.54	115 883	$2.15	-	115 883
Boston & Maine	-	-	143 388	3.47	143 388	3.47	-	143 388
Canadian Nat. Lines in New Eng.	-	-	12 463	2.[illegible]	12 4[illegible]	[illegible]	-	12 463
Canadian Pacific (lines in Me.)	-	-	18 606	2.42	18 60[illegible]	2.4[illegible]	-	18 606
Canadian Pacific (lines in Vt.)	-	-	14 952	2.42	14 95[illegible]	2.42	-	14 952
Central Vermont	-	-	28 541	2.74	28 541	[illegible]	* 1 922	[illegible] 463
Maine Central	12 917	1.71	61 193	4.[illegible]	7[illegible] 110	[illegible]	* 38 734	112 844
New York Connecting	-	-	734	4.14	734	4.14	-	734
New York, New Haven & Hartford	-	-	98 989	3.16	98 989	3.16	-	98 989
Rutland	-	-	9 731	3.17	9 731	3.17	* 11 [illegible]	[illegible]
Total	98 701	1.66	419 696	3.32	518 397	3.00	52 758	570 755
GREAT LAKES REGION:								
Ann Arbor	-	-	[illegible] 576	[illegible]	[illegible] 576	[illegible]	-	[illegible]
Cambria & Indiana	-	-	[illegible]	[illegible].61	[illegible]	[illegible]	* [illegible]	[illegible]
Delaware & Hudson	-	-	14[illegible] 019	[illegible]	14[illegible] 019	[illegible]	-	[illegible]
Delaware, Lackawanna & Western	-	-	14[illegible] 446	[illegible].57	14[illegible] 446	[illegible]	* [illegible]	[illegible]
Detroit & Mackinac	8 690	1.36	[illegible]	[illegible]	[illegible] 485	[illegible]	-	[illegible]
Detroit & Toledo Shore Line	-	-	1[illegible] 145	4.49	1[illegible] 145	4.49	* 104	[illegible]
Erie	-	-	[illegible] 624	[illegible]	[illegible]	[illegible]	-	[illegible]
Grand Trunk Western	-	-	[illegible]	[illegible]	[illegible]	[illegible]	-	[illegible]
Lehigh & Hudson River	-	-	[illegible]	[illegible]	[illegible]	[illegible]	* 1 [illegible]	[illegible]
Lehigh & New England	-	-	[illegible]	3.41	[illegible]	[illegible]	-	[illegible]
Lehigh Valley	-	-	[illegible]	[illegible]	[illegible]	[illegible]	-	[illegible]
Monongahela	-	-	[illegible]	[illegible]	[illegible]	[illegible]	-	[illegible]
Montour	-	-	[illegible] 784	[illegible]	[illegible] 784	[illegible]	-	[illegible]
New York Central	-	-	1 [illegible]	[illegible]	[illegible]	[illegible]	* [illegible]	[illegible]
New York, Chgo. & St. L. (Incl. W&LE)	-	-	[illegible] 165	[illegible]	[illegible] 165	[illegible]	-	[illegible]
New York, Ontario & Western	-	-	[illegible]	1.4[illegible]	[illegible]	1.4[illegible]	-	[illegible]
New York, Susquehanna & Western	-	-	[illegible] 157	[illegible]	[illegible]	[illegible]	-	[illegible]
Pittsburgh & Lake Erie	-	-	[illegible]	[illegible]	[illegible]	[illegible]	-	[illegible]
Pittsburg & Shawmut	-	-	11 [illegible]	4.15	11 [illegible]	[illegible]	* 714	17 [illegible]
Pittsburgh & West Virginia	-	-	[illegible] 44	[illegible]	[illegible] 44	[illegible]	* 11[illegible]	[illegible]
Wabash	-	-	270 3[illegible]7	[illegible]	[illegible] 107	[illegible]	-	[illegible]
Total	8 690	1.[illegible]	3 [illegible] 762	[illegible]	3 [illegible]	3.46	13 [illegible]	[illegible]
CENTRAL EASTERN REGION:								
Akron, Canton & Youngstown	24 748	3.21	-	-	24 748	[illegible]	* 14 1[illegible]9	[illegible] 427
Baltimore & Ohio	-	-	908 718	2.88	908 718	2.88	-	[illegible]
Bessemer & Lake Erie	-	-	29 710	4.16	29 710	4.16	-	29 710
Central R.R. of New Jersey	-	-	44 331	[illegible]	44 331	[illegible]	-	44 [illegible]
Central R.R. of Pennsylvania	-	-	21 9[illegible]0	[illegible].46	21 920	[illegible]	-	21 [illegible]
Chicago & Eastern Illinois	-	-	68 201	[illegible].56	68 201	[illegible]	-	68 [illegible]
Chicago & Illinois Midland	-	-	19 747	3.5[illegible]	19 747	[illegible]	-	19 747
Chicago, Indpls. & Louisville	-	-	158 389	2.90	158 389	2.90	-	158 389
Detroit, Toledo & Ironton	1 855	0.46	66 364	2.94	68 719	2.87	-	68 719
Elgin, Joliet & Eastern	-	-	56 115	2.90	[illegible]6 115	2.90	* 16 3[illegible]4	72 509
Illinois Terminal	-	-	46 411	[illegible].60	46 411	2.60	* [illegible] 210	4[illegible] 621
Long Island	-	-	80 [illegible]81	3.48	80 [illegible]81	3.48	-	80 [illegible]81
Missouri-Illinois	-	-	27 669	2.56	27 669	2.56	-	27 669
Pennsylvania	-	-	1 721 496	3.35	1 721 496	[illegible]	-	1 721 496
Penna.-Reading Seashore Lines	-	-	36 104	3.85	36 104	3.85	-	36 1[illegible]4
Reading Co.	-	-	246 107	3.11	246 107	[illegible]	-	246 107
Staten Island Rapid Transit	-	-	4 162	[illegible].75	4 162	.75	-	4 162
Western Maryland	233	2.38	86 5[illegible]2	1.47	86 755	3.47	-	86 [illegible]55
Total	26 836	3.01	3 62[illegible] 047	[illegible] 19	[illegible] 649 68[illegible]	3.19	[illegible] 70[illegible]	3 [illegible] 466
POCAHONTAS REGION:								
Atlantic & Danville	11 015	1.92	14 888	2.81	[illegible]	2.37	-	[illegible] 903
Chesapeake & Ohio	-	-	644 836	3.11	644 836	3.11	-	644 836
Norfolk & Western	-	-	563 822	2.95	563 822	2.95	* [illegible] 539	569 361
Richmond, Fred. & Potomac	-	-	33 489	3.32	33 489	[illegible]	* 1 740	[illegible]
Virginian	-	-	134 [illegible]48	2.80	134 [illegible]48	[illegible]	-	134 [illegible]48
Total	11 015	1.92	1 391 283	3.02	1 402 298	3.01	7 279	1 409 577
SOUTHERN REGION:								
Alabama Great Southern	-	-	4[illegible] 886	3.36	49 886	3.36	-	49 886
Atlanta & St Andrews Bay	-	-	16 580	3.82	16 580	3.82	-	16 580
Atlanta & West Point	-	-	23 290	3.27	23 290	3.27	-	23 290
Atlantic Coast Line	4 849	1.97	776 900	3.33	781 749	3.32	-	781 749
Central of Georgia	-	-	353 445	2.24	353 445	2.24	-	353 445
Charleston & Western Carolina	-	-	99 600	3.47	99 600	3.47	-	99 600
Cin., New Orleans & Tex. Pac.	-	-	105 931	3.39	105 931	3.39	-	105 931
Clinchfield	190	1.46	130 443	3.16	130 633	3.15	-	130 633
Columbus & Greenville	-	-	28 357	2.30	28 357	2.30	-	28 357
Florida East Coast	7 649	1.97	127 512	3.52	135 161	3.44	* 1 443	136 604
Georgia	2 490	2.95	68 307	3.02	70 797	3.00	-	70 797
Georgia & Florida	128 255	1.45	193	3.42	128 448	1.45	-	128 448
Georgia, Southern & Florida	51 059	2.23	48 240	[illegible].77	99 299	2.49	-	99 299
Gulf, Mobile & Ohio	-	-	371 414	2.76	371 414	2.76	* 4 713	376 127
Illinois Central	943	1.50	1 429 357	2.58	1 430 300	2.58	§ 137	1 430 437
Louisville & Nashville	-	-	795 154	2.71	795 154	2.71	-	795 154
Mississippi Central	-	-	23 468	2.54	23 468	2.54	* 120	23 588
Nashville, Chatt. & St. Louis	-	-	226 466	2.65	226 466	2.65	-	226 466
New Orleans & Northeastern	-	-	27 070	[illegible].36	27 070	3.36	-	27 070
Norfolk Southern	56 078	1.72	71 840	2.80	127 918	2.13	* 67 601	195 519
Seaboard Air Line	1 701	2.01	689 664	3.04	691 365	3.04	-	691 365
Southern Ry.	721	2.15	864 903	3.20	865 624	3.20	-	865 624
Tennessee Central	19 916	1.88	25 437	2.82	45 353	2.41	-	45 353
Western Ry. of Alabama	-	-	34 908	3.30	34 908	3.30	-	34 908
Total	273 851	1.72	6 390 365	2.90	6 664 216	2.85	74 014	6 738 230

Road	Miles of maintained tracks (item 3)	Estimated total cross ties in all maintained tracks (item 4)	Average number of cross ties per mile of maintained track	Number of equated cross tie-miles (thousands)	Number of equated cross tie-miles per mile of maintained track (thous.)	Per cent renewals to all ties in maintained track	New wooden ties in the replacement average: Number laid per mile of maintained track	Renewal cost per mile of maintained track	Renewal cost per M equated cross tie-miles
1	10	11	12	13	14	15	16	17	18
NEW ENGLAND REGION:									
Bangor & Aroostook	819.74	2 66 554	2 887	1 [illegible] 798	1 977	4.5	141	[illegible]	[illegible]
Boston & Maine	2 759.36	8 140 112	[illegible]	14 [illegible]	[illegible]	1.[illegible]	[illegible]	180	[illegible]
Canadian Nat. Lines in New Eng.	231.54	719 756	3 108	669 342	2 808	1.7	53	123	4.7[illegible]
Canadian Pacific (lines in Me.)	216.4[illegible]	[illegible]	[illegible] 400	1 051 845	[illegible]	[illegible]	86	200	[illegible]
Canadian Pacific (lines in Vt.)	125.41	76 7[illegible]	[illegible]	[illegible]	[illegible]	4.[illegible]	[illegible]	.89	[illegible]
Central Vermont	491.07	1 456 974	2 966	[illegible] 67 716	4 814	[illegible]	[illegible]	[illegible]	[illegible]
Maine Central	1 17[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	64	[illegible]	[illegible]
New York Connecting	[illegible].30	52 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
New York, New Haven & Hartford	[illegible].11	11 07[illegible] 017	3 11[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.4[illegible]
Rutland	[illegible]	[illegible]	3 11[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Total	9 877.[illegible]	29 [illegible] 469	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
GREAT LAKES REGION:									
Ann Arbor	[illegible]	[illegible]	[illegible]	[illegible]	4 14	[illegible]	[illegible]	[illegible]	[illegible]
Cambria & Indiana	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Delaware & Hudson	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Delaware, Lackawanna & Western	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Detroit & Mackinac	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Detroit & Toledo Shore Line	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Erie	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Grand Trunk Western	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Lehigh & Hudson River	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Lehigh & New England	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Lehigh Valley	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Monongahela	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Montour	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
New York Central	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
New York, Chgo. & St. L. (Incl. W&LE)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
New York, Ontario & Western	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
New York, Susquehanna & Western	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Pittsburgh & Lake Erie	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Pittsburg & Shawmut	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Pittsburgh & West Virginia	150.[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Wabash	[illegible]	[illegible]	114	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Total	4 279.[illegible]	[illegible] 754	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
CENTRAL EASTERN REGION:									
Akron, Canton & Youngstown	214.69	641 [illegible]19	[illegible]	[illegible]	4.[illegible]	[illegible]	11[illegible]	[illegible]	[illegible]
Baltimore & Ohio	10 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Bessemer & Lake Erie	487.11	1 14 046	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Central R.R. of New Jersey	858.74	[illegible] 498 4[illegible]	[illegible]	[illegible]	[illegible]	1.6	[illegible]	[illegible]	[illegible]
Central R.R. of Pennsylvania	459.[illegible]	1 [illegible]91 7[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible].46
Chicago & Eastern Illinois	1 [illegible]	9[illegible] 999	[illegible] 916	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Chicago & Illinois Midland	[illegible]	500 196	[illegible]	1 [illegible] 157	[illegible] 464	[illegible]	110	416	[illegible].22
Chicago, Indpls. & Louisville	[illegible]	[illegible] 254 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Detroit, Toledo & Ironton	601.11	1 7[illegible]1 197	[illegible]	[illegible]	[illegible]	4.[illegible]	[illegible]14	[illegible]	[illegible]
Elgin, Joliet & Eastern	859.[illegible]	[illegible]	[illegible]	4 086 7[illegible]	4 7[illegible]	[illegible].1	[illegible]	189	[illegible]
Illinois Terminal	646.44	[illegible] 00 964	3 100	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Long Island	700.06	[illegible] 4 469	[illegible] 579	85 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]8	[illegible]
Missouri-Illinois	[illegible]16.59	680 [illegible]10	3 141	[illegible]	[illegible]	[illegible]1	[illegible]	[illegible]	[illegible]
Pennsylvania	[illegible]1 4[illegible]7.49	61 265 [illegible]04	2 [illegible]58	[illegible]	9 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Penna.-Reading Seashore Lines	[illegible]2.14	1 604 810	2 719	1 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Reading Co.	2 789.89	7 721 [illegible]30	2 768	16 [illegible]	6 [illegible]	[illegible]	[illegible]	[illegible]	4.[illegible]
Staten Island Rapid Transit	[illegible].18	[illegible]	[illegible] 566	[illegible]	[illegible]	1.[illegible]	[illegible]	[illegible]	[illegible].46
Western Maryland	1 1[illegible].63	3 394 141	[illegible] 442	8 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Total	4[illegible] 854.[illegible]1	125 756 44	[illegible] 868	166 41[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
POCAHONTAS REGION:									
Atlantic & Danville	[illegible]	666 094	[illegible] 946	[illegible]	1 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Chesapeake & Ohio	8 029.[illegible]	24 351 85[illegible]	3 01[illegible]	[illegible]	11 [illegible]	[illegible]	[illegible]	[illegible]	[illegible].26
Norfolk & Western	4 341.[illegible]	13 4[illegible] 463	[illegible] 100	[illegible] 044 41[illegible]	1[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Richmond, Fred. & Potomac	[illegible]	1 [illegible]14 600	[illegible] 446	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Virginian	646.04	2 966 522	[illegible]07[illegible]	11 [illegible]	1[illegible]	4.[illegible]	1[illegible]	-	[illegible]
Total	13 954.[illegible]	4[illegible] 344 051	3 05[illegible]	1[illegible] 884	11 [illegible]	[illegible]	1[illegible]	[illegible]	[illegible].06
SOUTHERN REGION:									
Alabama Great Southern	496.80	1 5[illegible]7 [illegible]01	[illegible] 034	4 [illegible] 444	[illegible] 066	[illegible]	100	[illegible]	[illegible].64
Atlanta & St Andrews Bay	115.16	345 687	[illegible] 002	[illegible]16 18[illegible]	[illegible]	[illegible].4	161	[illegible]	11.65
Atlanta & West Point	147.82	441 266	[illegible] 985	[illegible]	[illegible]	[illegible].3	[illegible]	[illegible]	9.[illegible]1
Atlantic Coast Line	7 317.19	[illegible]2 333 886	3 05[illegible]	41 067 404	[illegible] 612	[illegible]	[illegible]	[illegible]	6.32
Central of Georgia	2 305.30	6 667 913	2 892	10 402 447	4 513	5.[illegible]	[illegible]	[illegible]	7.61
Charleston & Western Carolina	423.63	1 26[illegible] 671	2 988	1 169 8[illegible]4	[illegible] 762	7.4	[illegible]	[illegible]	[illegible]
Cin., New Orleans & Tex. Pac.	773.34	[illegible] 290 840	2 96[illegible]	9 [illegible]	1[illegible]	[illegible].6	1[illegible]7	465	[illegible].72
Clinchfield	421.31	1 3[illegible] 879	3 140	[illegible] 257	12 288	9.4	310	478	7.96
Columbus & Greenville	204.44	647 666	3 168	[illegible]81 685	1 7[illegible]	4.4	[illegible]	[illegible]19	[illegible].16
Florida East Coast	1 15[illegible]	3 [illegible]	[illegible] 908	6 [illegible]04 830	[illegible] 405	4.[illegible]	11[illegible]	403	6.[illegible]
Georgia	442.45	1 34[illegible] 435	3 041	[illegible]	4 607	5.3	160	48[illegible]	10.47
Georgia & Florida	409.[illegible]4	1 105 758	2 700	[illegible]	1 497	11.6	[illegible]14	[illegible]	10.45
Georgia, Southern & Florida	463.66	1 460 [illegible]05	3 148	[illegible] 674 187	4 48[illegible]	6.8	214	[illegible]	11.40
Gulf, Mobile & Ohio	[illegible] 500.15	11 088 473	3 166	1[illegible]	[illegible] 236	3.4	106	29[illegible]	[illegible]
Illinois Central	9 840.25	29 98[illegible]	3 047	66 [illegible]	7 006	4.8	145	[illegible]74	[illegible]
Louisville & Nashville	6 751.47	14 306 179	2 860	49 749 [illegible]36	7 [illegible]	4.1	113	314	[illegible]
Mississippi Central	173.93	552 481	3 176	37[illegible] 656	2 14[illegible]	4.2	13[illegible]	[illegible]	16.60
Nashville, Chatt. & St. Louis	1 426.68	3 403 944	[illegible] 736	8 066 [illegible]	[illegible] 653	5.8	15[illegible]	4.1	7.44
New Orleans & Northeastern	295.04	872 304	2 957	[illegible] 754 416	9 [illegible]	3.1	42	109	[illegible]
Norfolk Southern	769.[illegible]	2 260 [illegible]	[illegible] 936	1 94[illegible] 664	2 52[illegible]	.7	100	367	15.3[illegible]
Seaboard Air Line	5 429.87	16 406 156	3 021	35 [illegible]	6 577	4.[illegible]	[illegible]	387	[illegible].88
Southern Ry.	8 456.68	26 221 568	3 101	5[illegible] 401 [illegible]	6 [illegible]	3.[illegible]	10[illegible]	[illegible]8	[illegible].16
Tennessee Central	342.60	1 037 393	3 028	744 [illegible]	[illegible] 17[illegible]	4.[illegible]	1[illegible]	[illegible]19	14.68
Western Ry. of Alabama	186.34	[illegible] 745	2 993	96[illegible]	5 11[illegible]	6.2	16[illegible]	[illegible]	11.[illegible]
Total	51 840.38	156 [illegible]81 659	3 014	326 309 [illegible]43	6 295	4.[illegible]	129	367	[illegible]

Table A

CROSS TIE STATISTICS (EXCLUDING SWITCH & BRIDGE) FOR CLASS I RAILROADS IN THE UNITED STATES AND LARGE CANADIAN RAILROADS

Calendar year ended December 31, 1951

Road	Cross ties laid in replacement								Miles of maintained tracks (item 25)	Estimated total cross ties in all maintained tracks (item 24)	Average number of cross ties per mile of maintained track	Number of equated gross ton-miles e (thousands)	Number of equated gross ton-miles per mile of maintained track (thous.)	New wooden cross tie replacement averages			
	New wooden ties untreated (U)		New wooden ties treated (T)		Total all new wooden ties laid		Ties other than wood (S) & second-hand(*) reapplied ties	Total ties applied						Per cent renewal to all ties in maintained track	Number laid per mile of maintained track	Renewal cost per mile of maintained track	Renewal cost per 1000 equated gross ton-miles
	Number	Average cost	Number	Average cost	Number	Average cost											
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

Table 4

CROSS TIE STATISTICS (EXCLUDING SWITCH & BRIDGE) FOR CLASS I RAILROADS IN THE UNITED STATES AND LARGE CANADIAN RAILROADS

Calendar year ended December 31, 1951

Road	Cross ties laid in replacement: New wooden ties untreated (U): Number	Average cost	New wooden ties treated (T): Number	Average cost	Total all new wooden ties laid: Number	Average cost	Ties other than wood (S) & second-hand (•) reapplied ties	Total ties applied	Miles of maintained tracks (item 45)	Estimated total cross ties in all maintained tracks (item 44)	Average number of cross ties per mile of maintained track	Number of equated gross ton-miles a (thousands)	Number of equated gross ton-miles per mile of maintained track (thous.)	New wooden cross tie replacement averages: Per cent renewal to all ties in maintained track	Number laid per mile of maintained track	Renewal cost per mile of maintained track	Renewal cost per 100,000 equated gross ton-miles
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
NORTHWESTERN REGION:																	(cents)
Chicago & North Western	23 867	$1.26	949 375	$[illegible]	[illegible]	$2.59	-	964 [illegible]	10 970.60	32 [illegible] 077	2 963	43 [illegible] 364	4 421	3.0	[illegible]	$.28	.16
Chicago Great Western	369	2.06	120 376	3.53	120 745	3.53	-	120 745	1 786.4	[illegible] 330 5 5	2 484	8 [illegible]	4 930	2.3	68	238	4.84
Chicago, Milwaukee, St. Paul & Pac.	94 206	0.33	372 380	2.71	466 586	2.23	-	466 586	13 509.25	41 659 564	3 084	62 044 553	4 593	1.1	35	77	1.67
Chicago, St. Paul, Minple. & Omaha	-	-	180 080	2.99	180 080	2.99	-	180 080	2 145.54	[illegible] 361 317	2 965	8 131 153	[illegible]	2.8	4	.51	[illegible]
Duluth, Missabe & Iron Range	932	1.73	53 738	2.88	54 670	2.86	-	54 670	1 1[illegible]	[illegible] 890	2 7[illegible]	9 [illegible]	7 044	1.7	46	[illegible]	1.69
Duluth, South Shore & Atlantic	7 314	1.24	58 479	2.81	65 793	2.64	-	65 793	[illegible]	1 [illegible]	2 9[illegible]	[illegible] 374 177	4 315	4.1	[illegible]	[illegible]	7.43
Duluth, Winnipeg & Pacific	1 744	1.50	23 929	2.56	25 673	2.49	-	25 673	205.11	604 47[illegible]	2 947	1 109 32	[illegible] 408	4.2	125	312	5.76
Great Northern	589	0.75	1 104 562	3.05	1 105 151	3.05	• 8 532	1 113 683	10 [illegible]	31 800 791	3 096 •	59 [illegible]	5 79[illegible]	3.[illegible]	108 •	[illegible]	.00
Green Bay & Western	3 743	1.85	26 021	3.83	29 764	3.58	-	29 764	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	108	[illegible]	[illegible]
Lake Superior & Ishpeming	14 935	1.34	11 620	3.12	26 555	2.1[illegible]	-	26 555	[illegible]	[illegible]	3 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Minneapolis & St. Louis	41 208	1.45	194 204	2.79	235 412	2.55	-	235 41[illegible]	1 [illegible]	4 [illegible] 705	3 01[illegible]	4 111 1	[illegible] 667	5.1	15[illegible]	19[illegible]	14.[illegible]
Minple., St. Paul & S.S.M. (Inc WC)	12 830	1.13	45[illegible] 409	2.56	468 [illegible]	[illegible]	-	468 [illegible]	4 817.42	14 [illegible]	[illegible] 915	[illegible]	4 419	[illegible]	97	[illegible]	[illegible]
Northern Pacific	1 445	2.21	47[illegible] 268	2.71	476 71[illegible]	2.71	-	470 71[illegible]	9 [illegible]	[illegible] 786 939	2 901 •	[illegible]	4 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Spokane International	53 822	1.88	12 5[illegible]0	[illegible]	66 [illegible]	[illegible]	-	66 [illegible]	17 01	511 671	2 414	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Spokane, Portland & Seattle	23 486	0.21	47 347	[illegible]	7[illegible] 833	2.26	-	7[illegible] 833	1 1[illegible].45	[illegible] 62[illegible] 916	[illegible]	[illegible] 671	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Total	280 490	1.02	4 076 318	2.83	4 356 808	[illegible].71	[illegible]	4 365 14[illegible]	[illegible]	[illegible] 74 24[illegible]	[illegible]	[illegible]	4 [illegible]				
CENTRAL WESTERN REGION																	
Atchison, Topeka & Santa Fe	-	-	1 191 339	2.88	1 191 339	2.88	-	1 191 339	19 419.75	[illegible] 007 [illegible]	[illegible] 193	159 794 [illegible]	[illegible]				[illegible]
Chicago, Burlington & Quincy	-	-	690 708	2.70	690 708	2.70	• 63 900	754 608	11 8[illegible] 18	[illegible]	[illegible] 059 •	[illegible]	74				
Chicago, Rock Island & Pacific	-	-	811 085	2.51	811 085	2.51	-	811 08[illegible]	[illegible] 970.25	[illegible] 474	[illegible] 981	[illegible]	[illegible]				
Colorado & Southern	-	-	44 420	3.01	44 420	3.01	• [illegible] 479	47 399	[illegible]	[illegible]	3 00[illegible]	[illegible]	[illegible]				
Colorado & Wyoming	-	-	16 379	5.05	16 379	5.05	-	16 379	[illegible]	[illegible]	2 45[illegible]	[illegible]	[illegible]				
Denver & Rio Grande Western	-	-	198 096	3.54	198 096	3.54	• 120 458	315 554	3 319.96	[illegible] 000	[illegible] 114	[illegible] 41	[illegible]				[illegible]
Fort Worth & Denver	-	-	60 145	3.13	60 145	3.13	• 604	60 749	957 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]				[illegible]
Northwestern Pacific	10 836	2.74	72 199	3.12	83 035	3.07	-	83 035	42[illegible]	1 [illegible]	[illegible]	[illegible]	[illegible]				
Sacramento Northern	[illegible] 082	2.44	17 495	2.96	19 577	2.90	-	19 577	315 [illegible]	944 212	3 000	[illegible] 30	[illegible]	[illegible]			
Southern Pacific Co.– Pac. Lines	[illegible] 786	2.44	865 712	3.[illegible]	872 498	3.20	• [illegible] 446	674 [illegible]	12 [illegible]	[illegible] 76 17[illegible]	[illegible] 972	1[illegible]	10 [illegible]	[illegible]	[illegible]	[illegible]	[illegible] 13
Toledo, Peoria & Western	-	-	17 994	3.24	17 994	3.24	-	17 994	279.66	[illegible]	[illegible] 162	[illegible] 21	86[illegible]	[illegible]	4		
Union Pacific	2 320	2.09	526 406	3.04	528 726	3.03	-	[illegible] 28 726	13 [illegible] 76.22	37 796 [illegible]	[illegible]	14[illegible] 14	1[illegible]	1.4	4		
Utah	401	1.94	914	4.51	1 315	3.74	• 1 717	3 03[illegible]	76 64	[illegible] 94	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
Western Pacific	13 214	2.80	175 758	3.05	188 972	3.03	• 927	189 899	1 5[illegible].40	[illegible] 364	[illegible]	12 [illegible]	[illegible]	4.1	1[illegible]		[illegible]
Total	35 639	2.64	4 688 700	2.93	4 724 339	2.92	19[illegible] 931	4 417 27[illegible]	74 [illegible] 78	225 4[illegible]	[illegible] 031	[illegible]	[illegible]				
SOUTHWESTERN REGION																	
Beaumont, Sour Lake & Western	-	-	20 495	2.97	20 495	2.97	-	20 495	144.90	446 [illegible]	[illegible] 977	1 441 [illegible]	[illegible]	4			[illegible]
International-Great Northern	-	-	270 739	2.84	270 739	2.84	-	270 739	1 346.21	4 [illegible]	3 16[illegible]	8 744 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
Kansas City Southern	68	1.41	199 405	2.83	199 473	2.[illegible]	-	199 473	1 299.42	4 112 [illegible]	3 165	10 06[illegible]	[illegible] 64	4.[illegible]	[illegible]	[illegible]	[illegible]
Kansas, Oklahoma & Gulf	-	-	37 043	3.40	37 043	3.40	-	37 043	35[illegible].56	1 047 634	[illegible]	1 7[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
Louisiana & Arkansas	-	-	115 301	2.82	115 301	2.82	-	115 301	884.[illegible]	2 879 501	3 [illegible]	4 [illegible]	[illegible]	4.[illegible]	[illegible]	167	7.04
Midland Valley	147	0.25	27 450	3.14	27 597	3.12	-	27 597	352.05	1 042 067	2 960	[illegible] 44[illegible]	1 07[illegible]	2.6	76	[illegible]	[illegible]
Missouri-Kansas-Texas Lines	-	-	297 873	2.85	297 873	2.85	-	297 873	3 923.[illegible]	1[illegible] 3[illegible] 200	[illegible]	16 705 [illegible]	4 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Missouri Pacific	1 746	1.12	1 25[illegible] 153	2.79	1 253 899	2.79	-	1 253 899	8 830.[illegible]	27 2[illegible] 295	[illegible] 064	5[illegible] 464	[illegible] 740	4.6	14[illegible]	[illegible]	[illegible]
New Orleans, Texas & Mexico	-	-	50 263	2.98	50 263	2.98	-	50 263	227 81	696 400	3 059	1 61[illegible]	7 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Oklahoma City-Ada-Atoka	1 915	0.63	15 864	3.72	17 779	3.39	-	17 779	1[illegible].70	393 868	2 880	[illegible] 476	[illegible] 91	4.[illegible]	1[illegible]0	[illegible]	[illegible]
St. Louis, Brownsville & Mexico	-	-	91 324	2.82	91 324	2.82	-	91 324	776 57	2 149 100	[illegible]	[illegible] 862 [illegible]	[illegible]	[illegible]	118	[illegible]	[illegible]
St. Louis-San Francisco	188	1.92	525 484	2.67	525 672	2.67	-	525 672	5 779.63	16 188 893	3 [illegible]	[illegible] 494	[illegible]	[illegible].9	91	[illegible]	[illegible]
St. Louis, San Fran. & Texas	-	-	12 754	2.81	12 754	2.81	-	12 754	153.66	466 410	[illegible] 130	771 47[illegible]	[illegible]	[illegible].7	[illegible]	[illegible]	[illegible]
St. Louis Southwestern Lines	-	-	256 196	2.68	256 196	2.68	• 1 796	257 99[illegible]	1 836.08	5 7[illegible] 014	[illegible] 118	1[illegible] 145 54[illegible]	8 [illegible]	4.[illegible]	140	74	[illegible]
San Antonio, Uvalde & Gulf	-	-	43 129	2.80	43 129	2.80	-	43 129	355.[illegible]	1 026 400	2 884	776 574	2 18[illegible]	4.[illegible]	1[illegible]	4	[illegible]
Texas & New Orleans	-	-	[illegible] 16	2.46	[illegible]	2.46	• 79	5[illegible]8 595	5 574 97	15 [illegible] 711	2 7[illegible]	34 [illegible]	6 2[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Texas & Northern	-	-	2 377	2.65	2 377	2.65	-	2 377	12.41	47 50[illegible]	[illegible] 8[illegible]	3[illegible] 618	[illegible] 19[illegible]	[illegible]	19[illegible]	[illegible]	[illegible]
Texas & Pacific	-	-	326 255	2.77	326 255	2.77	-	326 255	2 25[illegible]	6 584 920	2 924	18 989 083	8 [illegible]	[illegible]	[illegible]	401	4.70
Texas Mexican	-	-	43 069	3.41	43 069	3.41	-	43 069	214 49	74[illegible] 864	3 168	244 464	1 [illegible]	[illegible]	1[illegible]	[illegible]	[illegible]
Total	4 064	0.90	4 115 690	2.76	4 119 754	2.7	1 875	4 121 629	34 478.72	104 970 557	[illegible] 045	211 254 529	6 1[illegible]7	3.9	119	32[illegible]	[illegible]
Grand total – United States	739 286	1.53	27 938 661	2.99	28 677 947	2.9[illegible]	263 380	29 061 327	329 705.37	991 859 107	3 009	[illegible] 319 980 409	7 036	2.9	87	251	[illegible]
CANADIAN ROADS.																	
Canadian National	372 759	1.37	3 283 226	2.41	3 655 985	2.30	-	655 985	27 874 00	81 [illegible] 130	[illegible] 919	b	[illegible]	4.[illegible]	1[illegible]	[illegible]	
Canadian Pacific	98 431	1.82	2 694 821	2.31	2 793 252	2.29	-	2 793 252	21 249.60	60 976 687	2 870	108 328 255	5 098	4.6	131	301	5.91
Ontario Northland	122 817	1.64	79 266	2.83	202 083	2.11	-	202 083	679.70	1 971 130	[illegible] 842	1 748 304	[illegible]	10.3	[illegible]	[illegible]	[illegible]

a Gross ton-miles of cars and contents, plus two times gross ton-miles of locomotives and tenders in freight service, plus three times gross ton-miles of locomotives and tenders in passenger service.
b Not reported.

Note "Average cost" as shown in Columns 3, 5 and 7, represents storekeepers average cost of ties charged out and used. They are not the actual costs or the prices paid for the ties purchased during the period.

Compiled by
Association of American Railroads. Bureau of Railway Economics, Washington, D.C.
from Annual Reports of Class I Railways to the Interstate Commerce Commission.
June 3, 1952

Table B

NUMBER AND AGGREGATE COST OF NEW WOOD CROSS TIE RENEWALS PER MILE OF MAINTAINED TRACK AND RATIO OF NEW WOOD CROSS TIE RENEWALS TO TOTAL CROSS TIES IN MAINTAINED TRACK

Table B

NUMBER AND AGGREGATE COST OF NEW WOOD CROSS TIE RENEWALS PER MILE OF MAINTAINED TRACK AND RATIO OF NEW WOOD CROSS TIE RENEWALS TO TOTAL CROSS TIES IN MAINTAINED TRACK

Class I roads in the United States and large Canadian roads, by years, and for the average of five years 1947 to 1951, inclusive

Note: All figures are exclusive of bridge and switch ties

Road	Number of new wood cross tie renewals per mile of maintained track						Aggregate cost of new wood cross tie renewals per mile of maintained track						Per cent new wood cross tie renewals to all ties in tracks					
	1947	1948	1949	1950	1951	5 year average	1947	1948	1949	1950	1951	5 year average	1947	1948	1949	1950	1951	5 year average
NEW ENGLAND REGION:																		
Bangor & Aroostook	163	187	223	167	141	176	$365	$297	$359	$304	$305	$326	5.7	6.5	7.8	5.8	4.9	6.1
Boston & Maine	62	61	49	64	52	58	185	181	156	215	180	183	2.1	2.1	1.7	2.2	1.8	2.0
Canadian Nat. Lines in New England	108	109	78	75	53	85	208	229	175	168	123	181	3.4	3.5	2.5	2.4	1.7	2.7
Canadian Pacific (lines in Me.)	100	10[illegible]	100	91	86	97	214	242	244	206	208	223	3.2	3.6	3.5	3.1	3.0	3.3
Canadian Pacific (lines in Vt.)	68	55	58	104	119	81	145	110	128	211	289	177	2.3	1.8	1.9	3.5	4.0	2.7
Central Vermont	52	49	49	49	58	51	126	139	147	134	165	142	1.8	1.7	1.6	1.7	2.0	1.8
Maine Central	123	135	108	105	64	107	324	353	306	276	230	298	4.1	4.5	3.6	3.5	2.1	3.6
New York Connecting	125	117	93	91	26	91	441	470	369	377	116	353	4.0	3.7	2.9	2.9	0.9	2.9
New York, New Haven & Hartford	83	81	44	60	28	59	225	240	146	189	88	178	2.6	2.6	1.4	1.9	0.9	1.9
Rutland	39	45	57	32	21	39	97	117	172	135	65	111	1.2	1.4	1.8	1.0	0.7	1.2
Total	86	88	71	76	52	75	22[illegible]	240	190	210	158	203	2.8	2.9	2.3	2.5	1.7	2.4
GREAT LAKES REGION:																		
Ann Arbor	100	103	119	117	123	112	275	29[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3.2	3.4	3.9	3.9	4.1	3.7
Cambria & Indiana	82	34	26	21	12	35	235	[illegible]	[illegible]	68	43	117	[illegible]	1.2	1.0	0.7	.4	1.2
Delaware & Hudson	123	123	115	107	106	115	366	354	374	354	350	366	[illegible]	3.3	3.6	3.4	3.3	3.6
Delaware, Lackawanna & Western	86	100	91	79	[illegible]	[illegible]	241	[illegible]	313	[illegible]	247	275	[illegible]	3.5	[illegible]	2.6	2.2	2.9
Detroit & Mackinac	131	175	136	113	231	157	249	[illegible]	284	[illegible]	[illegible]	[illegible]	4.4	[illegible]	4.5	3.7	[illegible]	[illegible]
Detroit & Toledo Shore Line	66	[illegible]	[illegible]	119	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	251	2.2	[illegible]	[illegible]	3.9	2.2	2.4
Erie	62	77	79	74	80	74	176	[illegible]	[illegible]	242	[illegible]	239	2.1	2.6	2.7	[illegible]	2.7	[illegible]
Grand Trunk Western	116	113	[illegible]	105	107	[illegible]	[illegible]	[illegible]	276	241	314	259	3.6	3.6	[illegible]	[illegible]	3.4	3.4
Lehigh & Hudson River	[illegible]	93	54	55	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	242	[illegible]	3.4	[illegible]	2.0	2.2	2.7
Lehigh & New England	75	97	111	120	[illegible]	[illegible]	[illegible]	322	354	[illegible]	432	359	[illegible]	3.2	[illegible]	[illegible]	[illegible]	3.4
Lehigh Valley	93	99	[illegible]	75	[illegible]	[illegible]	[illegible]	334	[illegible]	[illegible]	244	[illegible]	3.1	[illegible]	2.9	[illegible]	[illegible]	2.9
Monongahela	76	70	46	40	[illegible]	[illegible]	[illegible]	211	[illegible]	[illegible]	[illegible]	167	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Montour	87	11	68	86	94	[illegible]	[illegible]	[illegible]	264	342	[illegible]	276	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
New York Central	73	99	58	69	63	72	[illegible]	[illegible]	190	275	[illegible]	[illegible]	2.4	3.2	2.0	[illegible]	[illegible]	[illegible]
New York, Chgo. & St. Louis (incl. W&LE)	126	107	117	101	[illegible]	108	351	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
New York, Ontario & Western	-	-	-	53	49	20	-	-	-	[illegible]	71	29	-	-	-	[illegible]	1.7	.7
New York, Susquehanna & Western	41	57	66	26	43	47	[illegible]	[illegible]	228	[illegible]	[illegible]	157	1.4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Pittsburgh & Lake Erie	99	112	107	95	77	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	254	[illegible]	3.4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Pittsburg & Shawmut	153	223	106	52	97	[illegible]	[illegible]	[illegible]	343	173	[illegible]	413	5.4	8.0	[illegible]	[illegible]	[illegible]	[illegible]
Pittsburgh & West Virginia	[illegible]	[illegible]	78	103	113	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Wabash	100	96	94	92	86	[illegible]	[illegible]	286	[illegible]	296	[illegible]	[illegible]	[illegible]	3.1	[illegible]	[illegible]	2.7	[illegible]
Total	83	97	76	78	[illegible]	82	232	[illegible]	241	[illegible]	[illegible]	[illegible]	2.7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
CENTRAL EASTERN REGION:																		
Akron, Canton & Youngstown	182	176	150	56	113	135	411	[illegible]	424	165	[illegible]	[illegible]	[illegible]	5.8	[illegible]	[illegible]	[illegible]	[illegible]
Baltimore & Ohio	100	106	44	104	81	[illegible]	255	[illegible]	115	[illegible]	[illegible]	[illegible]	3.5	3.7	[illegible]	[illegible]	3.1	3.1
Bessemer & Lake Erie	28	27	28	[illegible]	61	40	97	95	109	[illegible]	[illegible]	155	[illegible]	.9	[illegible]	1.7	[illegible]	1.3
Central R.R. of New Jersey	82	69	[illegible]	[illegible]	50	72	212	[illegible]	201	235	167	213	2.9	1.2	2.3	[illegible]	1.0	[illegible]
Central R.R. of Pennsylvania	111	101	77	[illegible]	48	81	343	436	275	244	165	273	4.0	[illegible]	2.7	[illegible]	1.7	[illegible]
Chicago & Eastern Illinois	60	84	47	38	50	56	145	[illegible]	134	137	179	161	[illegible]	2.8	[illegible]	1.2	1.7	1.8
Chicago & Illinois Midland	114	180	98	80	118	118	357	[illegible]	327	[illegible]	[illegible]	[illegible]	3.9	6.0	[illegible]	[illegible]	[illegible]	3.9
Chicago, Indianapolis & Louisville	124	169	141	175	218	165	[illegible]	[illegible]	378	470	632	447	4.0	5.4	[illegible]	5.6	7.0	5.3
Detroit, Toledo & Ironton	72	76	103	90	114	91	178	200	250	241	326	239	2.5	2.7	[illegible]	3.1	[illegible]	3.2
Elgin, Joliet & Eastern	61	82	70	51	65	66	146	202	197	149	189	177	2.0	2.7	[illegible]	1.7	2.1	2.2
Illinois Terminal	73	89	91	90	72	83	159	217	225	223	187	[illegible]	2.4	3.0	3.0	2.9	[illegible]	2.7
Long Island	116	139	87	115	103	112	401	535	340	348	356	396	4.1	4.9	3.0	4.0	3.6	3.9
Missouri-Illinois	219	261	173	194	128	195	496	562	392	448	327	443	7.0	8.3	[illegible]	[illegible]	4.1	6.2
Pennsylvania	89	97	86	89	80	88	256	293	271	278	269	[illegible]	3.1	3.4	[illegible]	3.1	[illegible]	3.1
Penna.-Reading Seashore Lines	108	113	77	[illegible]	61	85	379	385	282	248	235	306	4.0	4.1	2.8	[illegible]	[illegible]	3.1
Reading Company	128	116	65	86	88	97	350	346	216	290	274	295	4.6	4.1	2.3	3.2	3.2	3.5
Staten Island Rapid Transit	75	65	63	59	45	61	[illegible]	197	217	208	167	199	2.9	2.6	[illegible]	2.3	1.7	2.4
Western Maryland	77	57	61	72	75	68	213	172	191	213	261	214	2.7	2.0	2.1	2.5	2.6	2.4
Total	94	101	73	91	83	88	258	292	224	275	265	263	3.3	3.5	2.6	3.2	2.9	3.1
POCAHONTAS REGION:																		
Atlantic & Danville a	-	-	20	118	115	*	-	-	45	276	278	*	-	-	0.7	4.0	4.9	*
Chesapeake & Ohio (Incl. Pere M.)	88	94	77	81	80	84	233	289	224	217	250	243	2.9	3.1	2.5	2.7	2.6	2.8
Norfolk & Western	114	134	125	137	130	128	273	361	351	373	483	348	3.7	4.3	4.0	4.4	4.2	4.1
Richmond, Fred'burg & Potomac	52	46	44	47	81	[illegible]	132	129	130	148	270	160	1.8	1.6	1.5	1.6	[illegible]	1.9
Virginian	100	121	121	114	142	12[illegible]	205	295	310	301	397	302	3.2	3.9	3.9	3.7	4.6	3.9
Total	96	107	93	101	100	99	241	308	264	270	302	277	3.1	3.5	[illegible]	[illegible]	[illegible]	[illegible]
SOUTHERN REGION:																		
Alabama Great Southern	219	191	177	147	100	167	608	580	569	470	338	513	7.2	6.3	5.8	4.8	3.3	5.5
Atlanta & St. Andrews Bay	103	131	146	172	161	143	303	353	440	584	624	461	3.4	4.3	4.8	5.7	5.4	4.7
Atlanta & West Point	132	152	153	160	158	151	340	403	441	489	515	438	4.3	5.1	5.1	5.3	5.3	5.0
Atlantic Coast Line (incl. AB&C)	254	207	141	99	107	162	617	551	377	261	354	432	5.4	6.8	4.6	3.2	3.5	5.3
Central of Georgia	149	131	138	132	153	141	305	296	399	293	343	327	5.3	4.5	4.4	4.6	5.3	4.8
Charleston & Western Carolina	187	167	157	208	235	191	430	453	468	553	817	544	6.5	5.8	5.4	7.2	7.9	6.6
Cincinnati, New Orleans & Tex. Pac.	96	144	178	161	137	143	265	458	570	513	465	454	3.3	4.9	6.0	5.4	4.6	4.8
Clinchfield	212	227	284	266	310	264	433	526	693	800	978	687	7.0	7.5	9.3	9.4	9.9	8.6
Columbus & Greenville	181	183	163	143	139	162	414	442	364	311	319	370	5.4	5.8	5.2	4.5	4.4	5.1
Florida East Coast	195	132	136	133	117	143	503	343	389	391	403	406	6.7	4.5	4.7	4.6	4.0	4.9
Georgia R.R.	112	130	128	145	160	135	275	320	349	390	482	363	3.7	4.3	4.2	4.8	5.3	4.5
Georgia & Florida	201	221	223	248	314	241	307	312	331	340	456	349	7.5	6.2	6.2	9.2	11.6	6.9
Georgia, Southern & Florida	209	211	204	211	214	210	393	452	463	487	534	466	6.7	6.7	6.5	6.7	6.8	6.7
Gulf, Mobile & Ohio (incl. Alton)	234	187	135	122	106	157	359	451	344	318	293	393	7.5	6.4	4.3	3.9	3.4	5.1
Illinois Central (incl. G&SI and Y&MV)	198	193	157	144	145	167	471	469	420	389	374	425	6.5	6.3	5.2	4.7	4.8	5.5
Louisville & Nashville	134	127	104	100	118	117	334	326	273	259	319	302	4.7	4.4	3.6	3.5	4.1	4.1
Mississippi Central	161	153	168	103	135	144	424	326	308	245	344	329	5.1	4.8	5.3	3.2	4.2	4.5
Nashville, Chattanooga & St. Louis	85	77	99	136	159	111	182	186	248	333	421	274	3.1	2.8	3.6	5.0	5.8	4.1
New Orleans & Northeastern	234	226	198	141	92	178	710	680	661	470	409	566	8.2	7.9	6.7	4.8	3.1	6.1
Norfolk Southern	229	244	201	210	166	210	471	498	409	444	387	442	7.8	8.3	6.9	7.2	5.7	7.2
Seaboard Air Line	171	168	161	148	127	155	417	426	427	378	387	407	5.7	5.6	5.3	4.9	4.2	5.1
Southern Ry.	129	122	89	111	102	111	379	367	268	338	328	336	4.2	3.9	2.9	3.6	3.3	3.6
Tennessee Central	152	157	120	136	132	139	298	295	194	315	319	284	5.0	5.2	4.0	4.5	4.4	4.6
Western Ry. of Alabama	174	135	127	162	185	147	321	358	367	495	611	430	4.1	4.5	4.2	5.4	6.2	4.9
Total	178	164	136	129	129	147	437	419	361	343	367	385	5.9	5.5	4.5	4.3	4.3	4.9

Table B

NUMBER AND AGGREGATE COST OF NEW WOOD CROSS TIE RENEWALS PER MILE OF MAINTAINED TRACK AND RATIO OF NEW WOOD CROSS TIE RENEWALS TO TOTAL CROSS TIES IN MAINTAINED TRACK

Class I roads in the United States and large Canadian roads, by years, and for the average of the five years 1947 to 1951, inclusive

Note: All figures are exclusive of bridge and switch ties

Road	Number of new wood cross tie renewals per mile of maintained track						Aggregate cost of new wood cross tie renewals per mile of maintained track						Per cent new wood cross tie renewals to all ties in tracks					
	1947	1948	1949	1950	1951	5 year average	1947	1948	1949	1950	1951	5 year average	1947	1948	1949	1950	1951	5 year average
NORTHWESTERN REGION:																		
Chicago & North Western	106	110	73	90	88	93	$235	$268	$184	$229	$228	$229	3.6	3.7	2.5	3.0	3.0	3.2
Chicago Great Western	134	181	204	217	68	161	329	495	690	744	238	499	4.5	6.1	6.9	7.3	2.3	5.4

Table B

NUMBER AND AGGREGATE COST OF NEW WOOD CROSS TIE RENEWALS PER MILE OF MAINTAINED TRACK AND RATIO OF NEW WOOD CROSS TIE RENEWALS TO TOTAL CROSS TIES IN MAINTAINED TRACK

Class I roads in the United States and large Canadian roads, by years, and for the average of the five years 1947 to 1951, inclusive

Note: All figures are exclusive of bridge and switch ties

Road	Number of new wood cross tie renewals per mile of maintained track						Aggregate cost of new wood cross tie renewals per mile of maintained track						Per cent new wood cross tie renewals to all ties in tracks					
	1947	1948	1949	1950	1951	5 year average	1947	1948	1949	1950	1951	5 year average	1947	1948	1949	1950	1951	5 year average
NORTHWESTERN REGION:																		
Chicago & North Western	106	110	73	90	88	93	$236	$268	$164	$229	$22[illegible]	$229	3.6	3.7	2.5	3.0	3.0	3.2
Chicago Great Western	[illegible]	161	204	217	68	161	429	495	690	744	238	499	4.5	6.1	6.9	7.3	2.3	5.4
Chicago, Milwaukee, St. Paul & Pacific	145	102	64	23	35	74	323	248	169	55	77	174	4.7	3.3	2.1	0.7	1.1	2.4
Chicago, St. Paul, Minpls. & Omaha	116	115	50	89	84	97	281	309	228	253	251	264	3.9	3.9	2.7	3.0	2.8	3.3
Duluth, Missabe & Iron Range	56	70	94	60	46	65	120	172	243	170	133	168	1.9	2.4	3.2	2.0	1.7	2.2
Duluth, South Shore & Atlantic	130	150	162	156	122	146	293	338	408	384	321	349	4.7	5.1	5.4	5.2	4.1	4.9
Duluth, Winnipeg & Pacific	265	251	222	173	125	207	523	582	513	420	312	470	9.0	8.5	7.5	5.9	4.2	7.0
Great Northern	124	123	118	96	108	114	249	284	314	252	328	295	4.0	4.0	3.8	3.1	3.5	3.7
Green Bay & Western	110	141	120	109	108	118	240	278	375	316	386	339	3.6	4.4	4.2	3.8	3.8	4.0
Lake Superior & Ishpeming	149	170	137	112	1[illegible]7	135	271	346	284	22[illegible]	22[illegible]	270	5.0	5.7	4.6	3.7	3.6	4.5
Minneapolis & St. Louis	151	189	196	191	1[illegible]4	170	338	447	476	4[illegible]5	39[illegible]	424	5.0	[illegible]	[illegible]	6.3	5.1	5.8
Minpls., St. Paul & S. Ste. Marie (incl. Wis. C.)	111	110	97	98	97	103	234	254	274	[illegible]	24[illegible]	241	3.7	3.7	3.2	3.3	3.3	3.4
Northern Pacific	64	69	62	49	52	[illegible]	121	151	153	131	140	141	2.3	2.4	2.1	1.7	1.6	2.1
Spokane International	3[illegible]8	305	310	313	170	[illegible]	456	433	481	436	804	522	10.6	10.5	10.7	13.7	13.0	11.1
Spokane, Portland & Seattle	164	111	76	67	[illegible]	97	430	294	270	173	142	248	5.6	3.6	2.5	2.2	2.0	3.2
Total	117	110	[illegible]	77	75	94	257	262	235	207	[illegible]	233	3.9	3.6	3.0	2.6	2.5	3.1
CENTRAL WESTERN REGION:																		
Atchison, Topeka & Santa Fe	86	89	[illegible]	[illegible]	61	74	172	210	185	167	177	1[illegible]	[illegible]	2.9	[illegible]	1.9	1.9	2.2
Chicago, Burlington & Quincy	[illegible]	80	64	63	[illegible]	[illegible]	161	184	166	170	161	16[illegible]	[illegible]	[illegible]	[illegible]	2.1	1.9	[illegible]
Chicago, Rock Island & Pacific	72	108	94	86	92	87	159	234	199	202	[illegible]	[illegible]	[illegible]	[illegible]	2.8	[illegible]	2.2	[illegible]
Colorado & Southern	94	56	[illegible]	50	[illegible]	[illegible]	210	220	202	[illegible]	[illegible]	19[illegible]	3.1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Colorado & Wyoming	28	38	40	[illegible]	[illegible]	[illegible]	[illegible]	139	127	78	77[illegible]	239	[illegible]	1.3	1.8	[illegible]	[illegible]	[illegible]
Denver & Rio Grande West. (incl. D&SL)	[illegible]	40	56	[illegible]	[illegible]	[illegible]	[illegible]	112	19[illegible]	199	211	[illegible]	[illegible]	1.2	1.8	1.9	1.9	1.6
Fort Worth & Denver	[illegible]	[illegible]	[illegible]	64	63	[illegible]	280	264	273	154	197	226	4.1	[illegible]	[illegible]	2.1	2.1	2.9
Northwestern Pacific	115	137	145	175	196	[illegible]	[illegible]	359	273	431	[illegible]	428	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Sacramento Northern b	-	[illegible]	[illegible]	8	[illegible]	*	-	424	274	[illegible]	[illegible]	*	-	[illegible]	[illegible]	[illegible]	2.1	*
Southern Pacific Co.- Pac. Lines	[illegible]	72	[illegible]	72	77	76	237	194	277	[illegible]	241	212	[illegible]	2.4	[illegible]	2.4	2.4	2.5
Toledo, Peoria & Western	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.7	[illegible]	2.9	[illegible]	1.8
Union Pacific	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	174	[illegible]	[illegible]	[illegible]	2.7	[illegible]	[illegible]	2.5	1.4	2.1
Utah Ry.	162	154	139	52	19	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.8
Western Pacific	[illegible]	[illegible]	[illegible]	133	[illegible]	[illegible]	777	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	11.6	[illegible]	[illegible]	4.9	4.1	[illegible]
Total	[illegible]	81	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SOUTHWESTERN REGION:																		
Beaumont, Sour Lake & Western	161	224	[illegible]	[illegible]	137	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
International-Great Northern	138	[illegible]	[illegible]	178	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	411	[illegible]	[illegible]	[illegible]	4.5	[illegible]	[illegible]	[illegible]	[illegible]
Kansas City Southern	70	65	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	434	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.7
Kansas, Oklahoma & Gulf	71	74	[illegible]	44	[illegible]	[illegible]	[illegible]	154	[illegible]	245	457	[illegible]	[illegible]	2.5	3.4	[illegible]	[illegible]	[illegible]
Louisiana & Arkansas	130	46	45	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	347	227	4.0	1.4	1.4	[illegible]	[illegible]	[illegible]
Midland Valley	64	77	79	[illegible]	[illegible]	[illegible]	[illegible]	171	149	[illegible]	[illegible]	196	[illegible]	2.6	[illegible]	2.9	[illegible]	2.6
Missouri-Kansas-Texas Lines	109	93	79	[illegible]	[illegible]	91	[illegible]	[illegible]	214	[illegible]	217	[illegible]	[illegible]	3.0	[illegible]	3.1	2.4	2.9
Missouri Pacific	159	164	107	[illegible]	142	141	371	[illegible]	[illegible]	[illegible]	396	[illegible]	5.1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
New Orleans, Texas & Mexico	142	154	144	[illegible]	[illegible]	[illegible]	[illegible]	344	[illegible]	[illegible]	658	[illegible]	4.6	5.0	4.7	6.1	[illegible]	[illegible]
Oklahoma City-Ada-Atoka	190	198	[illegible]	189	[illegible]	[illegible]	[illegible]	511	465	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
St. Louis, Brownsville & Mexico	147	130	105	113	118	123	424	[illegible]	294	272	331	[illegible]	4.8	4.3	[illegible]	3.7	3.9	[illegible]
St. Louis-San Francisco	129	119	127	127	91	119	270	270	290	314	243	[illegible]	4.1	3.8	4.0	[illegible]	[illegible]	[illegible]
St. Louis, San Francisco & Texas	117	125	118	111	[illegible]	111	287	[illegible]	254	[illegible]	243	[illegible]	[illegible]	4.0	3.8	[illegible]	2.7	[illegible]
St. Louis Southwestern Lines	164	164	143	134	140	[illegible]	423	[illegible]	377	339	374	[illegible]	[illegible]	5.3	4.5	4.3	[illegible]	4.4
San Antonio, Uvalde & Gulf	124	101	108	112	[illegible]	113	285	241	269	[illegible]	[illegible]	[illegible]	[illegible]	3.2	3.7	[illegible]	4.2	3.9
Texas & New Orleans	112	114	108	110	[illegible]	[illegible]	235	279	271	269	234	[illegible]	4.0	4.2	3.9	[illegible]	3.4	3.9
Texas & Northern c	-	-	124	[illegible]	192	*	-	-	217	113	[illegible]	*	-	-	3.1	1.6	[illegible]	*
Texas & Pacific	172	171	146	139	[illegible]	[illegible]	357	332	394	[illegible]	[illegible]	[illegible]	5.9	[illegible]	[illegible]	3.6	[illegible]	[illegible]
Texas Mexican	81	165	75	100	184	121	174	391	178	[illegible]	627	312	[illegible]	5.2	[illegible]	[illegible]	[illegible]	3.8
Total	135	130	108	124	119	123	[illegible]	310	273	[illegible]	324	[illegible]	4.4	4.3	[illegible]	4.1	3.9	4.1
Grand Total, United States	112	111	91	92	97	99	270	266	249	252	257	263	3.7	3.7	[illegible]	[illegible]	[illegible]	3.3
CANADIAN ROADS:																		
Canadian National	143	135	142	145	141	149	247	257	295	[illegible]	[illegible]	251	4.9	[illegible]	4.8	[illegible]	[illegible]	4.8
Canadian Pacific	146	144	143	134	131	140	267	291	329	313	301	300	5.1	5.0	5.0	4.7	4.6	4.9
Ontario Northland	167	263	273	272	297	254	226	459	524	588	626	[illegible]	5.7	9.1	9.6	9.6	10.3	6.9

* Not reported.

a The Atlantic & Danville became a Class I road August 1, 1949; figures shown for 1949 are for the last five months of year.

b The Sacramento Northern became a Class I road January 1, 1948; formerly a Class I Electric road.

c The Texas & Northern became a Class I road November 30, 1948.

Compiled by
Association of American Railroads, Bureau of Railway Economics, Washington, D. C.,
from annual reports of Class I railways to the Interstate Commerce Commission.
June 3, 1952.

The Effect of Grip on the Fatigue Strength of Riveted and Bolted Joints

Submitted by Committee 15—Iron and Steel Structures, as an Advance Part of Its 1953 Report

By Frank Baron[1] and Edward W. Larson, Jr.[2]

SYNOPSIS

An investigation was made to determine the effect of clamping force and length of grip on the fatigue strength of riveted and bolted structural joints. Double butt joints having a tension-shear-bearing ratio of about 1.00:0.75:1.50 were subjected to zero to tension cycles of loading or to fully reversed cycles of loading. The fasteners consisted of hot-driven rivets, cold-formed cold-driven rivets, hot-formed cold-driven rivets, and high-strength bolts. Three lengths of grip were considered for each type of fastener.

Static tension tests were conducted of joints similar to those tested in fatigue to determine the effects of the fasteners on the efficiencies and the load-slip characteristics of the joints. As a result of difficulties encountered during the fatigue tests of the joints with cold-driven rivets, a survey was made to determine the degree of hole-filling to be expected with cold driving practice.

The investigation showed that the clamping force of a fastener was one of the most important factors affecting the fatigue strength of a joint. The fatigue strength of a joint increased with an increase in the clamping force of a fastener. The fatigue strengths of the bolted joints were greater than those of the riveted joints. The fatigue strengths of the joints with hot-driven rivets were usually greater than those of the joints with cold-driven rivets. The degree of hole-filling for the cold-driven rivets was in general not sufficient to prevent serious slippages from occurring during the fatigue and static tension tests. The experimental efficiencies of the joints tested in static tension were about the same irrespective of the kind of fastener. The tests showed that experimental efficiencies of 80 percent or over can be obtained.

INTRODUCTION

This investigation was conducted in the Department of Civil Engineering at Northwestern University with the cooperation of the Research Council on Riveted and Bolted Structural Joints. Messrs. Raymond Archibald, Jonathan Jones, J. J. Kelley, K. H. Lenzen, N. M. Newmark, E. J. Ruble, C. E. Webb, W. M. Wilson, and the writers served as members of a Project Committee assigned the task of determining the effect of grip upon the fatigue strength of riveted and bolted joints. The support of the sponsors of the Research Council is gratefully acknowledged.

At the time the program was defined, little was known concerning the fatigue characteristics of joints fastened with either high-strength bolts or with cold-driven

[1] Professor of Civil Engineering, Northwestern University, Evanston, Ill.
[2] Research Associate in Civil Engineering, Northwestern University, Evanston, Ill

rivets. In 1938, W. M. Wilson and F. P. Thomas[3] reported the results of an extensive series of fatigue tests of joints fastened with hot-driven rivets. In 1949, K. H. Lenzen[4] reported the results of tests dealing with the effects of various fasteners on the fatigue strength of structural joints. The latter tests were restricted to joints having small lengths of grip. The program reported herein was defined to investigate more fully the effect of clamping force, degree of hole-filling, and length of grip on the fatigue strength of riveted and bolted structural joints.

SPECIMENS TESTED IN STATIC TENSION AND IN FATIGUE

The dimensions and details of the specimens tested in static tension and in fatigue are shown in Fig. 1. Two large fabricators, henceforth referred to as A and B, provided the specimens for this investigation. Each length of grip and each type of fastener indicated in the figure was included in the group of specimens fabricated by A. The group fabricated by B included specimens fastened only with hot-formed, cold-driven rivets.

The specimens consisted of double butt joints having a tension-shear-bearing ratio of about 1.00:0.75:1.50. Each joint had two rows with three fasteners in each row. The lengths of grip considered were $1\frac{3}{16}$ in, $2\frac{1}{16}$ in, and $3\frac{1}{16}$ in. All plates had milled edges and were of ASTM A7 steel. The surfaces were smooth and had the mill scale left intact. The main plates of each group of specimens were obtained from the same heat and rolling.

The rivets used were of ASTM A141 rivet steel and were shop-driven in accordance with standard shop practice. The bolted joints were assembled in the laboratory with high-tensile bolts meeting the requirements of ASTM specification A325. The assembly was made in accordance with a tentative specification which was later modified and approved[5] by the Research Council on Riveted and Bolted Structural Joints. In general, the bolts were torqued to a value of 280 ft-lb as compared to the value of 320 ft-lb now recommended in the specification.

TESTS OF MAIN PLATE MATERIALS AND FASTENERS

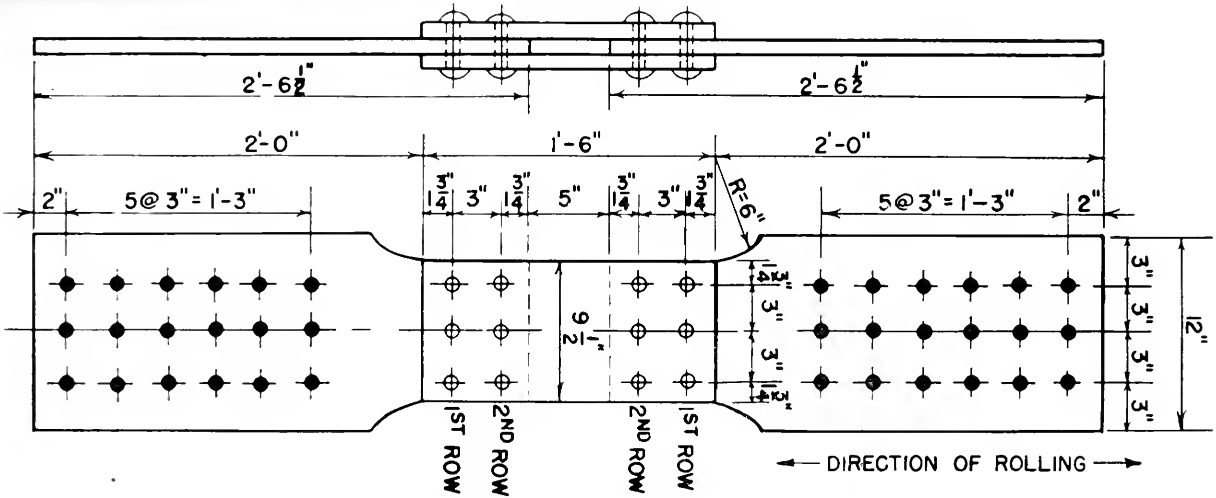
Static and Related Tests

Various tests were made to determine the properties of the main plate materials and of the fasteners. The average physical properties and the Rockwell hardnesses of the main plate materials are given in Table 1. The average clamping characteristics for the various lengths of grip of the hot-driven and of the cold-driven rivets are given in Table 2. The clamping characteristics were obtained by measuring the changes in the lengths of grip caused by removing the plate materials from between the rivet heads. For the hot-driven rivets the average clamping stress increased with the length of grip. For the cold-driven rivets the clamping stress decreased with length of grip.

[3] "Fatigue Tests of Riveted Joints", by W. M. Wilson and F. P. Thomas, University of Illinois, Engineering Experiment Station, Bulletin 302.

[4] "The Effect of Various Fasteners on the Fatigue Strength of a Structural Joint", by K. H. Lenzen, American Railway Engineering Association, Bulletin 480, June–July, 1949.

[5] Specifications for Assembly of Structural Joints Using High-Tensile Bolts, approved by Research Council on Riveted and Bolted Structural Joints of the Engineering Foundation, January 31, 1951. The specification was published by the American Railway Engineering Association, Bulletin 499, Vol. 53, 1952, and was endorsed by the American Institute of Steel Construction and by the Industrial Fasteners Institute.



NOMINAL DIAMETER OF ALL FASTENERS: 3/4"

DIAMETER OF HOLES: FABRICATOR A 13/16", FABRICATOR B 25/32"

LENGTH OF GRIP, IN.	1 3/16	2 1/16	3 1/16
THICKNESS OF MAIN PLATE, IN.	9/16	9/16	9/16
THICKNESS OF 2 SIDE PLATES, IN.	10/16	1 1/2	2 1/2

AREAS, IN.^{2}:	FABRICATOR A	FABRICATOR B
TENSION:	3.97	4.03
SHEAR:	5.30	5.30
BEARING:	2.53	2.53

	FABRICATOR A	FABRICATOR B
TENSION : SHEAR : BEARING RATIO :	1.00:0.75:1.57	1.00 : 0.76 : 1.59

FIGURE 1. DIMENSIONS AND DETAILS OF SPECIMENS TESTED IN STATIC TENSION AND IN FATIGUE

TABLE 1: PHYSICAL PROPERTIES OF THE MAIN-PLATE MATERIALS OF THE DOUBLE BUTT JOINTS

Fabricator	Yield Point (psi)	Ultimate Stress (psi)	Elongation 8 in. %	Elongation 2 in. %	Reduction in Area %	Rockwell Hardness*
A	37,900	65,900	29.9	54.0	60.2	74.5
B	36,400	63,200	27.6	50.8	57.6	65.6

*Rockwell "B" Scale, 100 kg. load, 1/16 in. steel ball.

TABLE 2: AVERAGE CLAMPING STRESS OF RIVETS

Fabricator	Type of Rivet	Length of Grip in.	Recovery in. x 10^{-5}	Clamping Stress psi	Aver. Diam. in.	Clamping Force Actual Area lb.	Clamping Force Nominal Area lb.
A	Hot-driven	1 3/16	71	18,000	.819	9,500	8,000
		2 1/16	187	27,100	.820	14,400	12,000
		3 1/16	321	31,500	.797	15,700	13,900
A	Cold-Formed Cold-Driven	1 3/16	50	12,600	.838	6,960	5,570
		2 1/16	45	6,490	.808	3,340	2,860
		3 1/16	38	3,720	.802	1,880	1,640
A	Hot-Formed Cold-Driven	1 3/16	37	9,430	.833	5,140	4,170
		2 1/16	49	7,070	.817	3,710	3,120
		3 1/16	26	2,540	.808	1,300	1,120
B	Hot-Formed Cold-Driven	1 3/16	82	20,700	.819	10,900	9,150
		2 1/16	54	7,860	.789	3,800	3,480
		3 1/16	79	7,760	.785	3,750	3,430

In general, the clamping stresses for the same lengths of grip were greater for the cold-driven rivets of B than for those of A.

Load-elongation relationships were obtained for the ¾-in diameter high-strength bolts. The bolt moduli decreased with length of grip and were 5,040,000 lb per in for the $1\frac{3}{16}$-in grip, 4,040,000 lb per in for the $2\frac{1}{16}$-in grip, and 3,030,000 lb per in for the $3\frac{1}{16}$-in grip. These moduli were based on total elongations of bolts.

Hole-Filling With Cold-Driven Rivets

A survey was made to determine the degree of hole-filling that may exist in joints fabricated with cold-driven rivets. The survey resulted from difficulties encountered in conducting the fatigue tests of the cold-driven specimens fabricated by A. For several of these specimens the slippage was so large that it was not possible to adjust the machine for the desired load. The survey was made of the butt joints prepared by A and of sample specimens prepared by A and three other fabricators. In the succeeding discussion, the various fabricators are designated as A, B, C, and D.

The holes of all specimens prepared by fabricator A were drilled $\frac{1}{16}$ in larger than the nominal diameter of the rivet. The practice of fabricator B was to drill the holes with $\frac{1}{32}$-in clearance. The specimens of C were sub-drilled and reamed to $\frac{1}{32}$ in over nominal rivet size. No information was received from fabricator D concerning the operations used in fabricating the specimens of D.

The specimens submitted by each fabricator were prepared for visual examination by sawing sections containing the longitudinal axes of rivets. These sections were ground and polished and all burrs were removed. The worst examples of hole-filling for specimens having about a 3-in grip are shown in Fig. 2. The numbers appearing on each specimen indicate in thousandths of an inch the width of the gap between a rivet and plate. The arrows indicate the location at which the gap was measured.

The average widths and sizes of gaps for the various specimens are given in Table 3. In general, the worst gaps appeared along the central portion of a rivet and were greatest for the specimens with the longest grips. The gaps in the immediate vicinity of a manufactured head were at times as large as those along the central portion of a rivet. The rivets usually filled the holes in the immediate vicinity of the driven head.

As a result of the survey to determine the degree of hole-filling, it was concluded that the butt joints fabricated by A were representative of usual cold-driving practice. The hole-filling obtained with usual cold-driving practice was not sufficient to prevent appreciable slippage from occurring in joints fabricated with cold-driven rivets. However, since a greater degree of hole-filling was obtained for the sample specimens of B, a group of butt joints was also furnished by B for testing in fatigue. The latter group of joints was included to determine if the degree of hole-filling had an effect on the fatigue strength of joints with cold-driven rivets.

FATIGUE TESTS

The fatigue tests were conducted in two 250,000-lb capacity machines, each having an operating speed of 180 rpm.[6] The slippages between a main plate and the side plates of a joint were measured by means of Ames dial gages attached to the edges of a specimen. The gages for each joint were located midway between the two rows of fasteners. The results of the fatigue tests are summarized in Table 4. A specimen designation has been used which needs clarification. The first letter of the designation indicates the fabricator. The number after the first letter indicates the approximate length of grip, and the succeeding letters indicate the kind of fastener. For example, A2CH refers to a specimen fabricated by A with hot-formed, cold-driven rivets having a $2\frac{1}{16}$-in length of grip.

In testing each specimen a procedure had been selected of welding the joint that failed first and continuing the test with additional cycles of load. The procedure was modified for several joints and consisted of removing six fasteners and replacing the broken main plate with a substitute plate fastened with bolts. The substitute plate was used for several specimens and did not fail after being subjected to more than 10,000,000 cycles of loading. For this plate the bolts were tightened beyond their yield strengths.

The Bolted Specimens

Several ranges of zero to tension cycles of loading and a fully reversed cycle of loading were considered for the bolted specimens. In general, all bolts were tightened with a torque of 280 ft-lb as compared to the torque of 320 ft-lb now recommended in the specification approved by the Research Council. The bolt tension accompanying the latter torque is approximately 90 percent of the specified elastic proof load of the bolt. For several of the bolted joints torques of 320 ft-lb and of 400 ft-lb were used. The

[6] The machines were described in the report, "The Effect of Various Fasteners on the Fatigue Strength of a Structural Joint", by K. H. Lenzen, American Railway Engineering Association, Bulletin 480, June–July, 1949.

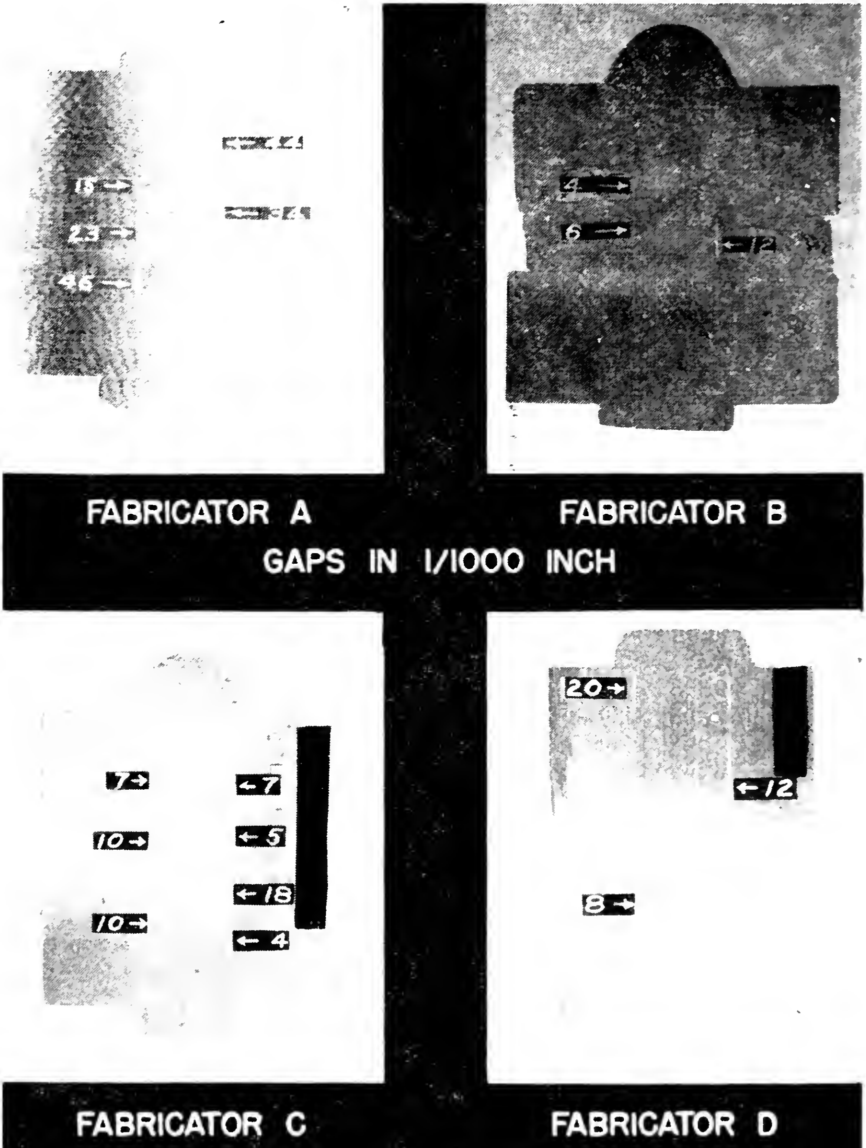


FIGURE 2: WORST EXAMPLES OF COLD-DRIVEN SPECIMENS HAVING ABOUT A 3 INCH GRIP

TABLE 3: AVERAGE WIDTHS OF GAPS FOR SAMPLE SPECIMENS WITH COLD-DRIVEN RIVETS.

Description of Specimens	Nominal Diam. of Rivet in.	Average Width of Gap*		
		Minimum of one Specimen	Maximum of one Specimen	Average Determined From (n) Specimens
Fabricator A				
3-1/8 in. grip	3/4	0.0009	0.0073	0.0033 (18)
2-1/16 in. grip**	3/4	0.0031	0.0082	0.0050 (4)
3-1/16 in. grip**	3/4	0.0020	0.0178	0.0073 (3)
Fabricator B				
3 in. grip	3/4	0.0006	0.0014	0.0008 (5)
3-1/16 in. grip	3/4	0.0004	0.0014	0.0008 (4)
4 in. grip	3/4	0.0004	0.0028	0.0015 (5)
5 in. grip	3/4	0.0000	0.0013	0.0009 (5)
6 in. grip	3/4	0.0008	0.0024	0.0016 (2)
Fabricator C				
3 in. grip	3/4	0.0034	0.0063	0.0045 (4)
4 in. grip	7/8	0.0045	0.0138	0.0077 (4)
5 in. grip	7/8	0.0022	0.0129	0.0083 (4)
Fabricator D				
3-1/8 in. grip	3/4	0.0017	0.0034	0.0024 (4)
4-1/8 in. grip	3/4	0.0005	0.0035	0.0026 (4)

* Average width of gap was determined by estimating total area of gap on both sides of a rivet and dividing by twice the length of grip.

** Fatigue specimens

bolt tension accompanying the torque of 400 ft-lb exceeded the yield strength of the bolts.

The average clamping force per bolt in general decreased during a fatigue test. The loss in clamping force appeared to decrease with an increase in grip. The loss was evidently not caused by the turning of a nut as no turning of a nut was observed. The loss may have been caused by the adjustment of the pillowing between the plates and the wearing of the plate surfaces during a fatigue cycle of loading.

For all riveted and bolted joints the slippages during a cycle of loading were measured at the start of each test and at regular intervals during each test. For several bolted joints measurements were also made of the slippages during the first application of load and of the cumulative slippages for repeated applications of load. The slippages for the first application of load were approximately equal to the specified clearances of the bolt holes. During assembly of each joint the bolts were concentrically alined with the holes of the plates. The bolts were in bearing before failure occurred as was indicated by an inspection of the sides of the holes after failure occurred. The sides of the holes were scored by the threads of the bolts. The cyclical slippages of the bolted joints were negligible and did not exceed 0.002 in.

TABLE 4: RESULTS OF FATIGUE TESTS FOR ZERO TO TENSION CYCLES OF STRESS (T) AND COMPLETE REVERSALS OF STRESS (R)

Type of Fastener	Spec. No.	Maximum Stress	Average Number of Cycles	Maximum Cyclical Slip of a Spec.		Number of Main-Plate Failures In Joints	Number of Joints Tested
				Initial	Final		
Bolt	A1B	21,500(T)	12,275,000(a)	0.001	0.001	None	2
		24,000(T)	3,123,662(b)	0.001	0.001	None	4
		28,000(T)	2,361,921	0.001	0.001	None	4
		30,000(T)	2,036,978	0.001	0.001	One	4
	A2B	24,000(T)	3,092,094	0.001	0.002	None	4
		28,000(T)	2,870,785	0.001	0.001	None	4
		30,000(T)	1,214,258	0.002	0.002	Three	4
		16,000(R)	1,754,738	0.002	0.001	Three	4
	A3B	24,000(T)	2,298,120	0.001	0.001	One	4
		28,000(T)	1,867,491	0.002	0.001	Two	4
		30,000(T)	855,326	0.001	0.001	Three	4
		16,000(R)	573,642	0.002	0.002	Three	4
Hot-Driven Rivet	A1H	21,000(T)	923,627	0.002	0.003	Two	4
		22,500(T)	931,823	0.002	0.004	Two	4
		24,000(T)	443,446	0.002	0.003	Two	4
		16,000(R)	1,216,610	0.010	0.022	Two	4
	A2H	22,500(T)	2,125,795	0.001	0.002	Two	4
		24,000(T)	913,613	0.001	0.001	Three	4
		28,000(T)	559,289	0.002	0.002	Two	4
		16,000(R)	722,918	0.002	0.006	Two	4
	A3H	22,500(T)	1,392,130	0.002	0.003	Four	4
		24,000(T)	1,075,932	0.002	0.002	Three	4
		28,000(T)	343,349	0.002	0.002	Two	4
		16,000(R)	345,481	0.002	0.002	Two	2
Cold-Formed Cold-Driven Rivet	A1CC	22,500(T)	1,155,546	0.002	0.002	Two	4
		24,000(T)	589,819	0.002	0.002	Three	4
	A2CC	24,000(T)	927,528	0.006	0.019	Three	4
	A3CC	24,000(T)	590,148	0.017	0.040	Rivets Failed	4
Hot-Formed Cold-Driven Rivet	A1CH	21,000(T)	4,000,000	0.002	0.002	None	2
		22,500(T)	1,292,797	0.002	0.002	One	2
		24,000(T)	1,465,678	0.002	0.006	Four	4
		28,000(T)	530,991	0.002	0.002	Three	4
	A2CH	22,500(T)	737,531	0.002	0.004	Three	4
		24,000(T)	533,824	0.004	0.010	Four	4
	A3CH	24,000(T)	908,238	0.015	0.034	Rivets Failed	4
Hot-Formed Cold-Driven Rivet	B1CH	24,000(T)	979,411	0.002	0.003	Three	4
	B2CH	22,500(T)	1,480,342	0.002	0.002	One	2
		24,000(T)	954,239	0.002	0.003	Two	2
	B3CH	20,000(T)	1,799,900	0.004	0.010	Rivets Failed	2
		22,500(T)	780,490	0.005	0.009	Rivets Failed	2
		24,000(T)	483,472	0.004	0.009	Rivets Failed	4

(a). Bolts torqued to a value of 320 ft. lb. (b). Bolts torqued to a value of 400 ft. lb. All other bolts torqued to a value of 280 ft. lb.

The fatigue strengths of the bolted joints were considerably greater than those of the riveted joints. Only 1 of the 12 bolted joints tested at a zero to +24,000 psi range of stress failed before 3,000,000 cycles were applied. An average of more than 2,000,000 cycles was applied to each of 12 bolted joints tested at a zero to +28,000 psi range of stress. Three of the latter joints failed at the grip end of a specimen and two failed across a gross section of a joint, as shown in Fig. 3. The fatigue lives of the bolted joints tested at a zero to +30,000 psi range of stress were approximately the same as those of the bolted joints tested at a ±16,000 psi range of stress. For each of the latter ranges of stress the average fatigue lives of the bolted joints decreased with an increase in length of grip. The fatigue fractures of these joints occurred in the main plates and were usually across the net section of a joint. The fatigue lives of the joints tested at the higher ranges of stress might have been increased if the bolts had been torqued to a greater value than 280-ft-lb.

Several fatigue tests were made of bolted joints for which the bolts were tightened with a torque greater than 280 ft-lb. Two joints, for which the bolts were tightened with a torque of 320 ft-lb, were tested at a zero to +21,500 psi range of stress and neither joint failed after 12,275,000 cycles of loading. Four joints, for which the bolt tensions exceeded the yield strengths of the bolts, were tested at a zero to +24,000 psi range of stress and none of these joints failed after 3,000,000 cycles of loading. During the fatigue tests the percentage decrease in the clamping stresses for the bolts of the latter joints was about the same as for the bolts of the other joints.

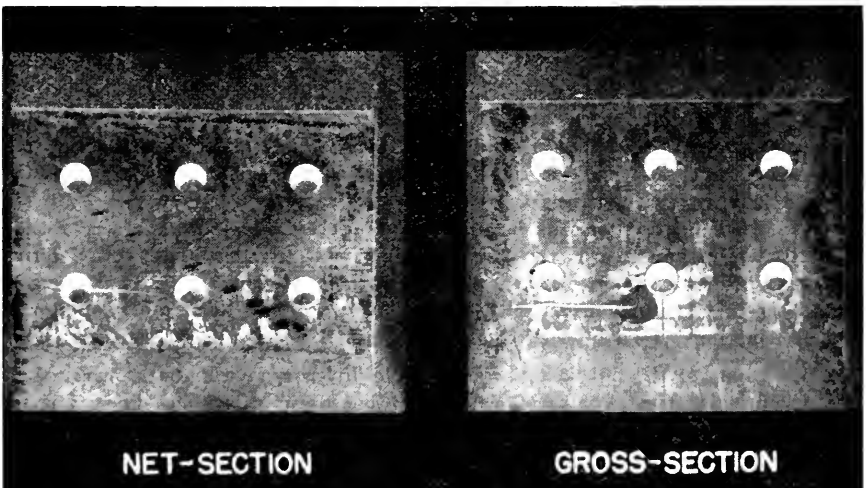


FIGURE 3: TYPICAL FATIGUE FRACTURES ACROSS A NET-SECTION AND A GROSS-SECTION

Specimens With Hot-Driven Rivets

Several ranges of zero to tension cycles of loading and a fully reversed cycle of loading were considered for the specimens with hot-driven rivets. No difficulty was encountered in testing the joints with hot-driven rivets. For the zero to tension cycles of loading the final cyclical slippages were equal to or less than 0.004 in. The slippages at the reversed cycles of loading decreased with an increase in grip. All failures of the riveted joints occurred in the main plates at the first row of rivets. In several cases, the second failure of a specimen occurred in the reinforcing weld of the joint that had failed in the main plate. The fatigue fracture, shown in Fig. 3, across the net section of a specimen was typical of the fractures for the riveted joints.

The results of the fatigue tests for the specimens with hot-driven rivets are plotted in Fig. 4 in the form of S–N diagrams. For the zero to tension cycles of loading the average fatigue strengths of the joints with hot-driven rivets were appreciably greater at the longer grips than at the $1\frac{3}{16}$-in grip. The results at the zero to tension cycles of loading were in general agreement with the values of the clamping stresses obtained for the various lengths of grip. For the fully reversed cycles of loading the average fatigue strengths of the joints with hot-driven rivets decreased with an increase in length of grip. This indicates that the type of loading and length of grip, as well as clamping force, affects the fatigue strength of joints.

Specimens With Cold-Driven Rivets

Difficulties were encountered in conducting the fatigue tests of the cold-driven specimens having a $3\frac{1}{16}$-in length of grip. At this length of grip rivet failures were obtained and the slippages were so large that it was not possible to adjust the machine for the desired load. The rivets failed in flexural fatigue for each of the ranges of loading considered. The lowest range of loading considered was a zero to +20,000 psi range of stress on the net section. In many cases the broken rivets could not be detected until the specimens were cut apart. For several tests, indications of rivet failures were obtained by measuring the separations of side plates and observing the increases in the cyclical and the cumulative slippages of the joints. The slippages for the cold-driven specimens having a $3\frac{1}{16}$-in grip were appreciably greater than those for the corresponding specimens with hot-driven rivets. The fatigue strengths of the cold-driven specimens having a $3\frac{1}{16}$-in grip were appreciably less than those of the corresponding specimens with hot-driven rivets. For the cold-driven specimens having a $3\frac{1}{16}$-in grip the differences in the degree of hole-filling for the specimens of fabricator A and of fabricator B had little effect on the fatigue characteristics of the joints.

The results of the fatigue tests for the cold-driven specimens are summarized in Fig. 5 for the different lengths of grip. All of the specimens with cold-driven rivets having a $1\frac{3}{16}$-in or a $2\frac{1}{16}$-in grip failed in fatigue of the main plates. The average fatigue strengths for the specimens with cold-driven rivets having a $1\frac{3}{16}$-in grip were greater than those for the specimens with hot-driven rivets at the same length of grip. At the $2\frac{1}{16}$-in grip the average fatigue strengths for the specimens with cold-driven rivets were dependent upon the degree of hole-filling. At this grip the average fatigue strengths for the specimens of fabricator B were greater than for the cold-driven specimens of fabricator A, and were almost the same as for the corresponding specimens with hot-driven rivets.

The slippages for the specimens with cold-driven rivets increased with length of grip and with the number of applied cycles. The slippages for the cold-driven specimens

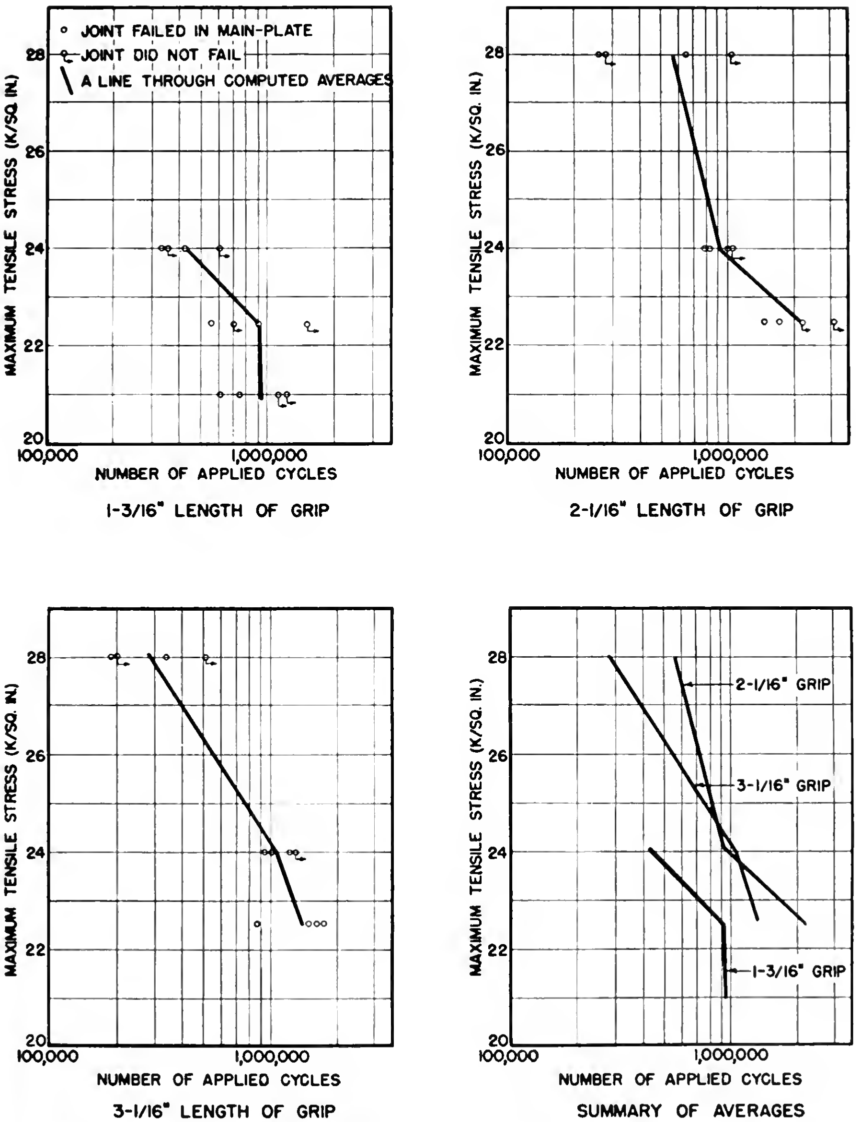


FIGURE 4: RESULTS OF FATIGUE TESTS FOR JOINTS WITH HOT-DRIVEN RIVETS

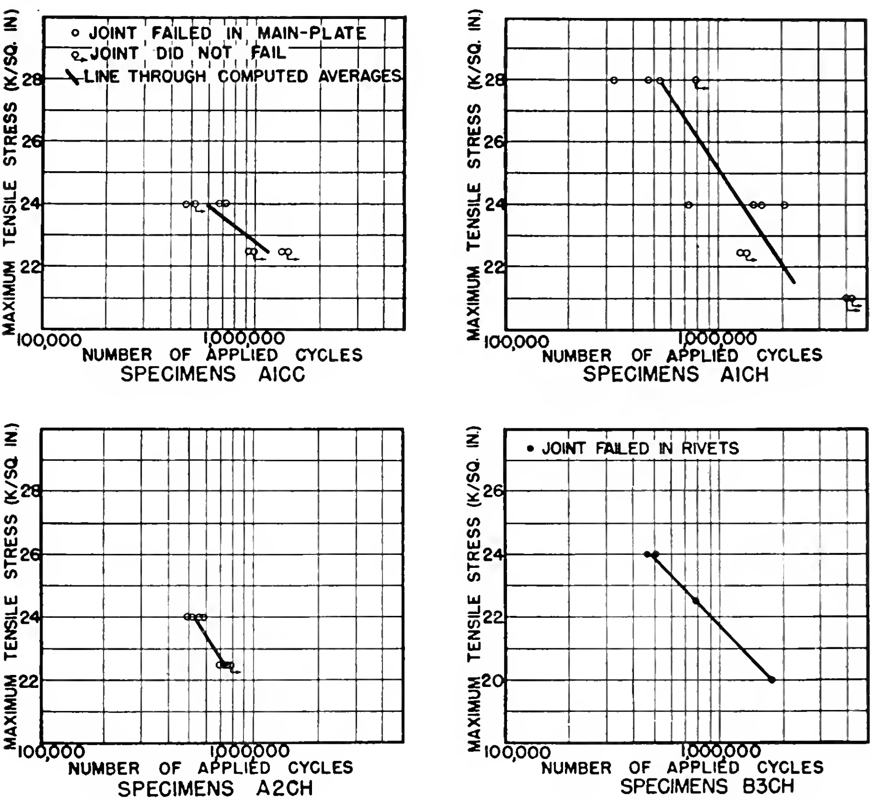


FIGURE 5: RESULTS OF FATIGUE TESTS FOR JOINTS WITH COLD-DRIVEN RIVETS

having a $1\frac{3}{16}$-in grip were about the same as for the specimens with hot-driven rivets. At the $2\frac{1}{16}$-in grip the slippages for the specimens with cold-driven rivets were greater than for the specimens with hot-driven rivets.

STATIC TENSION TESTS OF THE JOINTS

Static tension tests were made of each type of joint to determine the efficiencies, characters of fracture, load-slip characteristics, and coefficients of friction. The tests were made in a 1,000,000-lb capacity Baldwin–Southwark testing machine. Each specimen was bolted in special grips designed for minimizing the possible eccentricity of load on the specimen. The load on a specimen was applied in increments until failure occurred. If the failure occurred in a main plate no further tests were made of the specimen. For the riveted joints, failure frequently occurred in the rivets. The broken rivets were removed and were replaced with high-tensile bolts. The specimen was reloaded until failure occurred in the main plate of a joint. For each increment of load the slippages between the center and side plates of a joint were measured by means of Federal dial gages reading in ten-thousandths of an inch. Two gages, one on each edge of a joint, were located at a section mid-way between the rows of fasteners of a joint. Curves are shown in Fig. 6 relating the average shear stresses to the measured slips for the various joints. The plotted values of slip are the averages of the slip indicated by two dial gages.

Davis, Woodruff, and Davis,[7] in a report of tension tests of large riveted joints, described the behavior of each joint for four ranges of loading. For range 1 the slippage was small and was due principally to the differences in strain of the side plates and the main plates of a joint. At this stage the load was resisted by friction between the plates. In range 2 the friction was overcome and a sudden slip occurred until the rivets came into bearing. In range 3 the rivets and plates seemed to deform elastically, and the load-slip relationship was approximately linear. In range 4 yielding of the rivets and plates occurred until the joint failed.

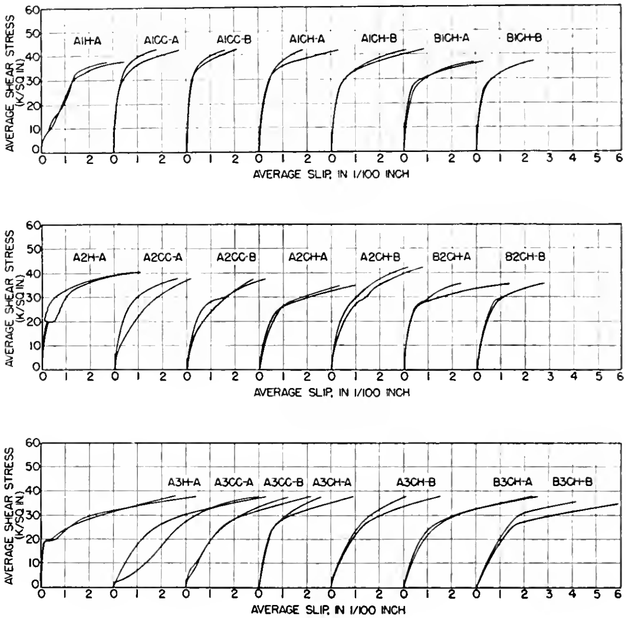
The above classification is useful in interpreting the results of the present series of tests. For the joints with hot-driven rivets, all four ranges were observed. The shear stress at which the first major slip occurred depended on the length of grip and clamping force of the hot-driven rivets. The value of this shear stress was about 6600 psi for the joints with a $1\frac{3}{16}$-in grip, and was about 19,500 psi for the joints with longer grips. Ranges 1 and 2 were practically non-existent for the specimens with cold-driven rivets. In general, the cold-driven rivets were in bearing from the beginning of a test. All four ranges of behavior were observed for the bolted joints. For the bolted joints tested in static tension and in fatigue the shear stress at which the first major slip occurred ranged between 9000 psi and 16,000 psi. The values of these stresses might have been greater if the bolts had been tightened with a greater torque than 280 ft-lb. The major slips for the bolted joints were of a different degree than those obtained for the riveted joints. This was due to the differences in the clearances for the driven rivets and for the bolts.

Ratios of the shear stress at first major slip to the initial clamping stress were obtained for the joints with hot-driven rivets and for the bolted joints. The ratios were obtained for several joints tested in static tension and in fatigue. The average ratio for the joints with hot-driven rivets was 0.27 at the $1\frac{3}{16}$-in grip, and about 0.57 at the longer grips. The average ratio for the bolted joints was about 0.20.

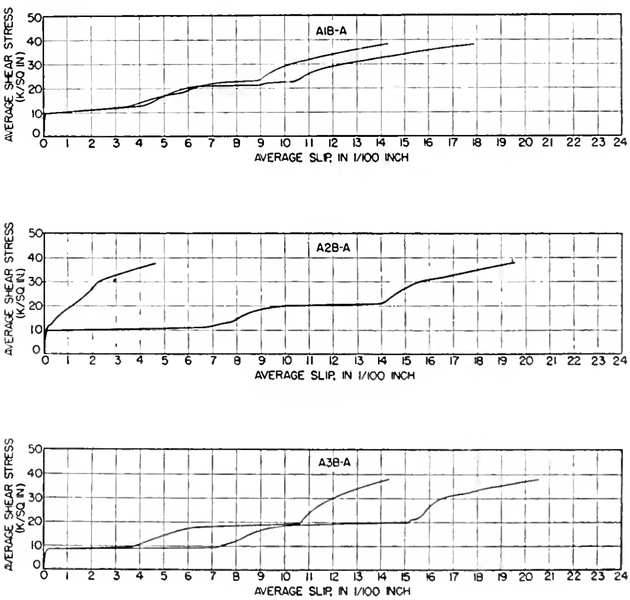
The ultimate loads and the experimental efficiencies of the joints tested in static tension are given in Table 5. The efficiencies were about the same for all joints, irrespective of the kind of fastener and length of grip. In those cases for which bolts were used to replace broken rivets, the plate efficiencies apparently were not influenced by this procedure of testing. For all joints, except one, the experimental efficiencies were 80 percent or over. The static tension failures of the main plates occurred at the first row of fasteners and were of the ductile type.

[7] "Tension Tests of Large Riveted Joints", by R. E. Davis, G. B. Woodruff, and H. E. Davis, Transactions of the American Society of Civil Engineers, Vol. 105, 1940, pp. 1193–1245.

(Text continued on page 190)



RIVETED JOINTS



BOLTED JOINTS

FIGURE 6 SHEAR STRESS VERSUS SLIP FOR JOINTS TESTED IN STATIC TENSION

TABLE 5: RESULTS OF STATIC TENSION TESTS OF JOINTS

Type of Fastener	Spec. No.	Number of Specimens Tested	Failure in Rivets		Failure in Main-Plate		Plate Efficiency
			Average Max. Load lb.	Average Max. Shear Stress psi	Average Max. Load lb.	Average Max. Stress on Net-Sect. psi.	
Bolt	A1B	1			287,000	72,300	81.7
	A2B	1			290,000	73,000	82.5
	A3B	1			296,000	74,500	84.4
	Overall Average				291,000	73,300	82.9
Hot-Driven Rivet	A1H	1			281,500	70,800	80.1
	A2H	1			284,000	71,500	80.8
	A3H	1	281,000	52,900	294,000	74,000	83.7
	Overall Average				287,000	72,100	81.5
Cold-Formed Cold-Driven Rivet	A1CC	2			279,000	70,300	79.4
	A2CC	2	278,000	52,400	288,000	72,400	81.8
	A3CC	2	275,000	51,900	291,000	73,300	82.8
	Overall Average				286,000	72,000	81.3
Hot-Formed Cold-Driven Rivet	A1CH	2			285,000	71,600	81.0
	A2CH	2			284,000	71,500	80.9
	A3CH	2			288,000	72,400	81.9
	Overall Average				286,000	71,800	81.2
Hot-Formed Cold-Driven Rivet	B1CH	2	269,000	50,800	277,000	68,600	81.8
	B2CH	2	265,000	50,000	276,000	68,400	81.4
	B3CH	2	262,000	49,500	277,000	68,600	81.7
	Overall Average				277,000	68,600	81.5

CONCLUSIONS

On the basis of these tests, the following conclusions can be made:

1. One of the most important factors affecting the fatigue strength of a riveted or a bolted joint is the clamping force of a fastener. An increase in the clamping force of the fastener results in an increase in the fatigue strength of the joint.

2. The fatigue strengths of joints with high-tensile bolts are considerably greater than those of joints with hot-driven or cold-driven rivets. For the bolted joints tightened with a torque of 280 ft-lb the average fatigue strength at 2,000,000 cycles of a zero to tension loading was 28,000 psi.

3. At zero to tension cycles of loading the fatigue strengths of joints with hot-driven rivets increase with an increase in grip. The average clamping stress for hot-driven rivets increases with length of grip and, at a $3\frac{1}{16}$-in grip approaches the yield stress of the undriven rivet material.

4. The fatigue strength of a joint with cold-driven rivets having a short grip can be as great as that of a similar joint with hot-driven rivets but is dependent on the cold-driving procedure. The fatigue strength of a joint with cold-driven rivets having a long grip, such as $3\frac{1}{16}$ in, is considerably less than that of a similar joint with hot-driven rivets. At the latter grip, rivet failures will occur in joints with cold-driven rivets.

5. The hole-filling and clamping stresses obtained with usual cold-driving procedures are not sufficient to prevent appreciable slippage from occurring in joints fabricated with cold-driven rivets. A good degree of hole-filling with cold-driven rivets can be obtained at short lengths of grip but is dependent on the cold-driving procedure.

6. The experimental plate efficiencies of riveted and bolted joints are the same irrespective of the kind of fastener. Experimental efficiencies of at least 80 percent can be realized for riveted and bolted joints having a tension-shear-bearing ratio of 1.00:0.75:1.50.

7. The major slips for bolted joints tested in static tension are of a different degree than those obtained for riveted joints. The shear stress at which the first major slip of a joint occurs is dependent on the kind of fastener.

Tests on Waterproofing Coatings for Concrete Surfaces
Final Report

By J. B. Blackburn

Research Engineer, Engineering Experiment Station

Purdue University

for

Committee 29—Waterproofing

American Railway Engineering Association

TABLE OF CONTENTS

Tests on Waterproofing Coatings for Concrete Surfaces Final Report

Submitted by Committee 29—Waterproofing, as an Advance Part of Its 1953 Report

By J. B. Blackburn
Research Engineer, Engineering Experiment Station
Purdue University

FOREWORD

This report, the final one, contains in summary form the results of 2½ years of research on the effects of waterproofing coatings on the durability of concrete. The work was begun in March 1949, and completed in October 1951. Three progress reports were written during the time the tests were in progress. These were issued in October 1949; April 1951; and October 1951. These three reports contained all the detailed test data that are summarized in this report; however, the emphasis has been shifted from results of tests on individual coatings to a broader comparison of the results of the tests on permeable versus impermeable coatings. Copies of the three progress reports, of which this is a summation, are available at the Central Research Laboratory, Association of American Railroads, Chicago.

The research project on waterproofing coatings was conducted at the Purdue University Engineering Experiment Station under the general direction of Professor K. B. Woods, associate director, Joint Highway Research Project, and professor of highway engineering, with Professor D. W. Lewis, and J. B. Blackburn, research engineer, in direct charge. Administration was by Dr. A. A. Potter, director of the Engineering Experiment Station and dean of engineering, and by Professor R. B. Wiley, head of the School of Civil Engineering and Engineering Mechanics. The program was sponsored financially by the Association of American Railroads. It was initiated upon the recommendation of AREA Committee 29-Waterproofing, and was supervised by that committee. This was a cooperative project, and the research staff of the Association of American Railroads, under the general direction of G. M. Magee, director engineering research, and P. D. Miesenhelder, concrete engineer, assisted in and advised regarding the work.

SYNOPSIS

This investigation was undertaken to determine the relative merits of various waterproofing coatings when used on concrete that is subject to outdoor weathering. One hundred and three coatings were applied on small concrete specimens which were subjected to a series of weathering tests, the effects of which were evaluated by immersion tests in which the permeability rates of the coatings were determined by increases in the weights of the specimens. Comparisons were made with the increases in the weights of uncoated "control" specimens.

The results of the tests on all impermeable coatings indicated that good results could be expected so long as the permeability rate did not increase due to weathering. However, only a few of the 103 coatings were impermeable.

Sixteen of the coatings were subjected to additional tests to determine the relative severity of the first series of tests and to determine the merits of using impermeable

coatings rather than permeable coatings. The latter include materials commonly used for decorative purposes where surfaces are protected from severe weather, as in the case of building interiors.

The results of the second series of tests on the 16 coatings showed that an impermeable coating was superior to a permeable coating for preventing the deterioration of concrete surfaces when all the surfaces that are subject to moisture absorption are waterproofed. The following results of individual tests were obtained:

1. In an outdoor absorption test, where changes in the weights of the specimens were due to rainfall and humidity changes, 4 of the coatings which had been practically impermeable in laboratory immersion tests changed weight only slightly for a period of 166 days. In the same test four of the coatings which had been highly permeable in laboratory immersion tests were very nearly ineffective, since the specimens on which these coatings were used changed weight in almost the same amounts as the unpainted control specimens.

2. In freezing and thawing tests the impermeable coatings prevented the deterioration of the concrete specimens on which they were used while the permeable coatings caused a more rapid rate of deterioration than was experienced with uncoated control specimens.

3. Outdoor weathering of 9-sq ft test panels on the south-facing wing walls of an overpass structure has resulted in damage of some sort to all but 2 of 11 permeable-type coatings after 1½ years. No damage has occurred to two of three impermeable-type coatings, while the third, linseed oil, has chalked off the surface. The results of laboratory weathering and immersion tests show that the linseed oil was undoubtedly still effective.

Only two of the commercial coatings that were tested retained their high degree of impermeability and durability during the weathering tests. These were both basically pigmented linseed oil coatings. In addition to these, raw linseed oil applied at a temperature of 140–160 deg F, and 9 brands of white house paints gave excellent results.

It appears that the volume of data on the wide variety of types of waterproofing coatings that were tested and the conclusions that may be drawn from these data are adequate to form the basis of a performance-type specification for waterproofing coatings.

INTRODUCTION

For many years people who have had the responsibility of maintaining concrete structures have been concerned with the problem of surface scaling on exposed concrete surfaces, and the additional problem of disintegration of hand rails, pier caps, and other thin structural members that are fully exposed to the actions of the weather. These problems exist because of defects in design or construction, or because of the poor quality of construction materials, coupled with severe weathering conditions, such as freezing and thawing in a nearly saturated condition and, to a lesser extent, with wetting and drying, or heating and cooling.

The problem involved, as in nearly all cases of concrete disintegration, is the elimination of moisture from the concrete mass. If moisture can be effectively sealed out of concrete, even poorly constructed concrete, or that containing materials of inferior quality, will give satisfactory performance for many years. On the other hand, the life of such a structure is shortened many years by becoming saturated with moisture, as is evidenced by the results of concrete durability investigations that have been carried out by a number of research laboratories. To prevent moisture from entering the structure, then, is an important problem, and it appears that the evaluation of various methods of waterproofing would prove fruitful in extending the structural service life of exposed concrete.

The opportunities for making a concrete structure waterproof begin with the design of the structure, where the elimination of possible water traps and careful attention to structural shape will reduce the opportunities for local deterioration which may spread and become a serious maintenance problem. The constant control of aggregate gradation will assure a high degree of impermeability of the concrete mass when used with the proper cement factor and water-cement ratio. The use of air-entraining admixtures or air-entraining cements will effectively reduce the permeability of the concrete mass. Finally, the use of surface coatings offers a means of protecting existing structures, provided the coatings are properly applied and their use is understood. The refinements of structural design and of concrete mix design and placing are well known and generally practiced. In contrast, the preservation of existing structures that were built before our present knowledge of concrete technology often becomes an important economic problem. It has been estimated that the railroad industry spends approximately $1,000,000 annually on the rehabilitation of concrete structures. Because of this expenditure it was appropriate that, upon the suggestion of the Waterproofing committee, AREA, the AAR undertook the study of the effectiveness of surface coatings in preventing the deterioration of concrete.

There are two methods of waterproofing currently being used and the choice of method generally depends upon the exposure conditions and whether or not moisture can enter the structure from some source other than the surfaces to be coated. Probably the most generally used method, because of its application to basement waterproofing and to the waterproofing of other surfaces that are not subjected to freezing, is the application of a coating which is highly permeable to water in the vapor form and presumably impermeable to water in the liquid form. This method of waterproofing is more properly called dampproofing since the protected concrete will readily absorb water in the vapor phase through the coating. The reason for the permeability of the coating is not to permit the absorption of water vapor by the concrete however, but rather to allow the escape of water in the vapor form that has entered the concrete from some unprotected surface. If the coating is impermeable water may accumulate immediately under the surface and cause a loss of bond between the concrete and the coating that would result in the failure of the coating.

If freezing weather enters the picture, as in the case of abutments and wing walls of bridges, the use of a waterproof coating on a concrete surface which must allow the escape of moisture may result in earlier surface disintegration than if the structure had been left uncoated, because of the danger of partially blocking the escape of moisture from the surface. This damming effect could create a highly saturated condition in the concrete which, in turn, would expand excessively because of the formation of ice, and thus cause disintegration of the concrete beneath the coating.

The method of waterproofing which is most applicable to structures that are located in cold climates is the application of an impermeable coating which does not allow the passage of moisture as a liquid and has a very slow rate of permeability to water vapor. As stated in the preceding paragraph, disintegration will proceed at a *slower* rate if the exposed surface is left unpainted when moisture enters the concrete through an uncoated surface and must escape through the exposed surface. The application of an impermeable or waterproof coating then is limited to those structures that are free from moisture ingress from surfaces that cannot be coated. Examples include handrails and bannisters, piers above ground, thin-wall sections and outside building walls above ground, and the exposed surfaces of earth retaining structures provided (1) that the surface next to the earth fill was satisfactorily waterproofed previous to backfilling or, (2) that the concrete is of such quality that it is impermeable. In these and similar instances, the disintegration of exposed surfaces can be reduced materially by the use of an impermeable coating.

With the thought in mind that impermeability was a desirable characteristic of a waterproof coating for concrete exposed to freezing weather, a series of tests were devised to develop the data which are reported on the following pages of this report.

MATERIALS

Waterproofing Coatings

A total of 103 coatings were tested for impermeability and durability. Of these coatings 85 were obtained from manufacturers of commercial waterproofing materials. The remaining 18 coatings were of an experimental nature.

As a means of summary and illustration the 103 coatings have been grouped, according to their basic constituents, into 13 categories. Four of these 13 categories are further grouped into pigmented and non-pigmented categories, making a total of 17 distinctly different types of waterproofing coatings that were tested. The manufacturers of 13 of the coatings would not release information pertaining to the categories into which their products belonged so these products were placed into 3 categories of unidentified coatings.

The following listing contains all the coatings. Those that are marked with an asterisk are the experimental coatings.

Cement Base Coatings

*ACI Com. 616 cement-base paint
Agraseal brush coat
Armor Coat, white
Armor Coat, light cream
Aquella
*Cement-water paste
*Cement-sand mortar, 1:1 by wt.
Century Cement Sealer
Luxstar
Mastertex
Quartz coat
Seal Rite
Sika Kote, gray
Thoroseal, white
Venetian Cement Paint

Resin Solutions, Pigmented†

Acidseal #1040
Aluminum Mastic
Cocoon Vinyl Plastic
Para Stonetex
Penetryn D–2
Permalume
Plastinium, aluminum
Plastinium, gray
Prufcoat Buff #1045
Ramuc Masonry Paint
Ramuc Utility Enamel
Vikote

† Two of these resin solutions applied over 2 percent ZnCl–3 percent H_3PO_4 pretreatment.

Resin Solutions, Non-pigmented

All-Protect
Hayproc #640
Penetryn D–1
Pruftite Transparent #1
Prufcoat Clear BX
Sika Vinyl Coating, clear
Zoco Diamond Seal

Pigment in Oil†

Glastic
Glastic (Fire Proof)
Outside White House Paint
Perm-O-Morotex
Southport Concrete Paint
Surfa-Sele and Brine proof navy gray

† One of these coatings applied over 2 percent ZnCl–3 percent H_3PO_4 pretreatment.

Pigment in Oil—Outside White House Paint

(Outside white house paints from these eight manufacturers were purchased locally and tested to extend the data that was previously obtained from one house paint.)

*Armstrong
*Du Pont
*Dutch Boy
*Benjamin Moore
*O'Brien
*Pittsburgh
*Sears Roebuck
*Smith–Alsop

Wax Solutions

Clear Brick Wtpfg.
Clear Cement Wtpfg.
Dehydratine #2
Minwax, clear
Minwax, colored clear

Wax Emulsions

Sika Wax Emulsion
Ceremul–W

Resin Emulsions

Bakelite BKS 92 (Styrene)
Bakelite EF 1645 (Styrene)
Bakelite EF 1646 (Styrene)
Bakelite EF 1472
Monsanto Latex X–600
Monsanto Latex X–620
Monsanto Latex X–640–07
Monsanto Latex X–641–05

Silicone Solutions

Crystal
Horn Silicone waterproofing
Dow Silicone XR–760
Dow Silicone XR–763

Stearates in Hydrocarbons

Cresolac
Dehydratine #2A
Hydrocide, colorless D
Hydrocide, colorless G
Preservatex EE

Finely Ground Iron

Embeco #5
Ironite-regular
Ironite-fine
Metallic Waterproofing

Silicate of Soda

One

Linseed Oil

*Raw linseed oil was applied at 160 deg F

Bituminous Emulsions

Laykold Fibrecoat, black
Laykold Fibrecoat, green
Laykold Fibrecoat, red
Laykold Weathercoat
Liquinoleum

Bituminous Solutions

Binderseal
Sika-Seal

Colorless Solutions, Unidentified

Por-Lox
Super-Por-Seal
Stonhard Colorless Wall Coating
Stonhide
Waterlox, transparent (tung oil base)
Waterlox, water repellent
#505 Waterproofing
#525 Waterproofing

Water Emulsions, Unidentified

Aquaphane
Cerepel
Monstanto Latex X–601 plus Lustrex 820 and HB–40

Amber Solutions, Unidentified

Anhydrosol
Toxloxpore

Colorless Concrete Hardener

One containing zinc and magnesium fluosilicates

Caulking Mastic

One

Concrete Specimens, 1 In by 3 In by 8 In

The 1-in by 3-in by 8-in concrete specimens that were used in the early tests were made as nearly alike as possible (see Illustration 1). Each concrete mix was designed for a cement factor of 1.5 bbl/cu yd and a water-cement ratio of 0.6 by weight. The quality of the fine and coarse aggregates was known to be good from the results of field studies and previous laboratory tests. The aggregates were equally proportioned between sand and crushed lime-stone passing the ⅜-in sieve and retained on the No. 4 sieve. The cement was obtained in a single shipment and was produced from a single batch of clinker.

Concrete Specimens, 3 In by 4 In by 16 In

Specimens measuring 3 in by 4 in by 16 in were fabricated from 6 batches of concrete of 12 specimens each. These specimens were used in some of the later tests to determine the effect of several types of coatings on the durability of concrete specimens when subjected to freezing and thawing. Each mix was designed for a cement factor of 1.5 bbl/cu yd and a water-cement ratio of 0.5 by weight. The specimens from two of the mixes contained a coarse aggregate of poor quality, while the specimens from the remaining four mixes contained a coarse aggregate of good quality. The aggregate was divided in the ratio 54:46 by volume between a well-graded crushed limestone coarse aggregate and natural sand fine aggregate taken from a river terrace. The slump averaged 4½ in for the 2 mixes containing the coarse aggregate of poor quality and 2 in for the 4 mixes containing the coarse aggregate of good quality.

PROCEDURE

Concrete Specimens—Fabrication, Curing, and Preparation for Painting

The concrete for all the test specimens was mixed for 3 min in a revolving-drum mixer having a capacity of 1½ cu ft. The concrete was dumped and formed into specimens and left covered for 24 hr with damp cloths to prevent evaporation until the specimens had hardened enough that they could be removed from the molds (see Illustration 1). The specimens were immediately weighed and this weight was used as the base weight and is designated the zero percent value for all the change-in-weight calculations which are presented later.

The 1-in by 3-in by 8-in specimens were cured for 6 days in water followed by 7 days of drying at 90 deg F in a controlled-temperature oven. At this stage the specimens were etched in a 10–15 percent solution of muriatic acid to clean the surfaces, rinsed, and dried an additional 24 hr, at which time they were weighed in order that the weight of the paint coating could be determined later. They were then ready for painting.

The 3-in by 4-in by 16-in specimens were cured in water for 13 days, followed by 14 days of drying in the 90 deg F oven. They were then etched in a 15 percent muriatic acid solution, rinsed, and dried an additional 24 hr, and then weighed and painted.

Applying and Curing the Coatings

All the coatings were applied according to the manufacturers' instructions. Exceptions to this procedure were those coatings for which no instructions for application were supplied. In these instances the coatings were applied according to the instructions which had been previously followed for a coating of the same type. Each coating was applied on a group of three concrete specimens and the average results for the three coated specimens are reported rather than results from a single specimen, (see Illustration 2).

The coated specimens were placed in the 90-deg F oven for 5 days to cure the coatings, except where instructions outlined specific procedures, as in the case of cement-base coatings. It was necessary to keep the cement-base coatings damp for the first two or three days of the five-day curing period.

The Initial Immersion Test

The waterproofing ability of the newly applied coatings was determined by immersing the coated specimens in water for 72 hr along with 4 unpainted control specimens from the same concrete mix and comparing the rates of absorption of the painted and unpainted specimens. The specimens were weighed after 6, 24, 48, and 72 hr to establish the rates of absorption. The control specimens were also weighed after 1 hr of immersion because of their rapid rates of absorption.

The First Series of Weathering Tests

The durability and waterproofing ability of each of the 103 coatings was further tested by subjecting 1-in by 3-in by 8-in coated specimens to 2 rather mild laboratory weathering tests. The first test was 150 hr of exposure in the weatherometer (see Illustration 3) to carbon-arc light filtered through Corex D glass, accompanied by a stationary water spray which was used to wash away the coating that had chalked and thus present a new surface for exposure with each rotation of the specimen drum. The second weathering test was exposure to 50 cycles of freezing at — 18 deg F in air and thawing at 130 deg F in water. After the exposure to the carbon-arc light the coated specimens were placed in a second 72-hr immersion test in order to evaluate the effects of the carbon-arc light on the permeability of the coatings. At the same time a visual inspection was made of the condition of the coating on each specimen. A third 72-hr immersion test followed the freezing and thawing cycles so that the weathering effects of the freezing and thawing on the permeability of the coatings could be determined by comparing the absorption data thus obtained with similar data from the second 72-hr immersion test.

At the end of the third immersion test the specimens were exposed outdoors for 90 days, after which they were brought back to the laboratory and subjected to a fourth 72-hr immersion test. No further mention of this short period of outdoor exposure will be made because no significant changes in the permeability or the durability of any of the coatings were observed.

The Second Series of Weathering Tests

When 65 of the coatings had been subjected to the first series of weathering tests described above, 10 of these were chosen as the best coatings from the standpoint of impermeability from data obtained in the initial immersion test. These ten coatings were supplemented by six additional coatings so that there were three cement-base coatings, three pigmented resin solutions, two pigment-in-oil coatings, two wax solutions, one iron coating, the linseed oil coating, a colorless solution, an amber solution, a styrene emulsion, and the caulking mastic.

The 16 coatings were subjected to 5 weathering tests that were more severe than the first series of tests. The purpose of these tests was to determine the relative severity of the first series and to develop more data concerning the use of the impermeable type of waterproofing coating. The individual tests will be discussed later. They include:

1. 1000 hr of exposure of 1-in by 3-in by 8-in newly coated specimens to carbon-arc light.
2. 300 cycles of freezing and thawing on 1-in by 3-in by 8-in newly coated specimens.
3. An outdoor change-in-weight test on 1-in by 3-in by 8-in newly coated specimens where changes in weight were caused by moisture absorbed from rainfall and humidity changes rather than by immersion in water as in the case of the laboratory immersion tests (see Illustration 4).
4. Outdoor weathering test using 1-in by 3-in by 8-in and 3-in by 4-in by 16-in newly coated specimens half buried in the ground in an upright position (see Illustrations 5 and 6).
5. Laboratory freezing and thawing on the 3-in by 4-in by 16-in coated specimens (reported in 4 above) to determine whether or not the coated specimens could withstand more cycles of freezing and thawing than the uncoated control specimens for the same loss in strength as measured by changes in the dynamic modulus of elasticity (see Illustration 7).
6. Exposure of test panels measuring 9 sq ft on the south-facing wing walls of a railroad structure (see Illustrations 8, 9 and 10).

(Text continued on page 206)

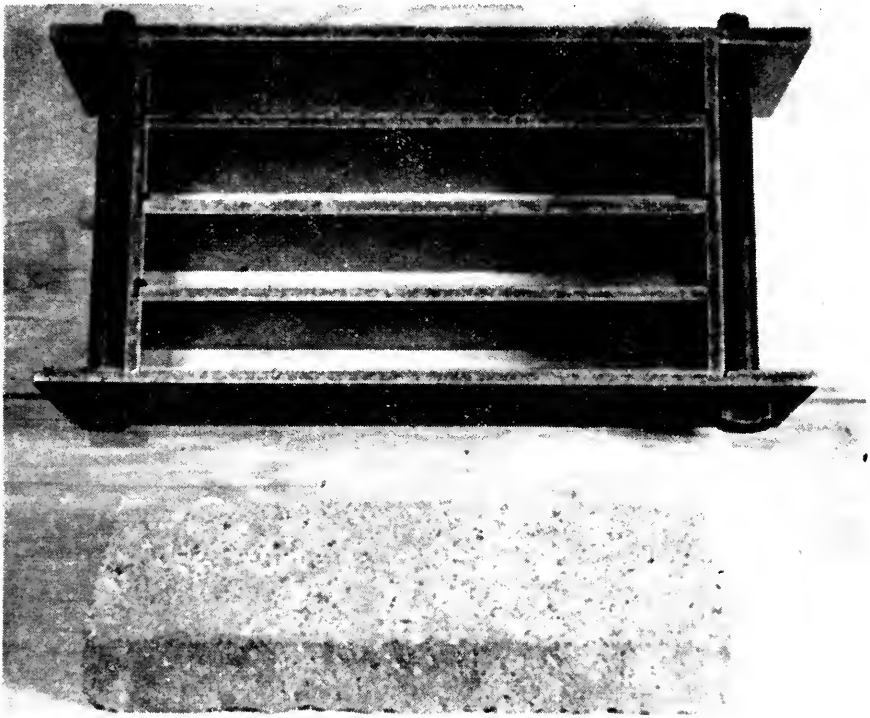


Illustration 1—Mold assembly used to fabricate 1-in by 3-in by 8-in specimens and typical specimen.

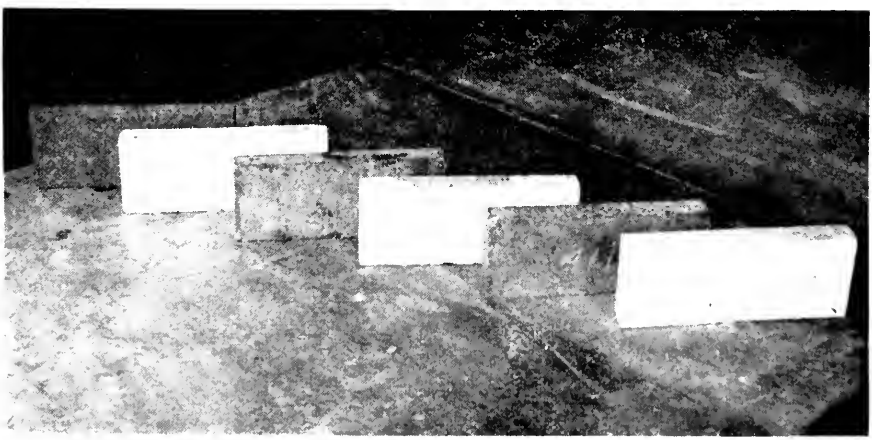


Illustration 2—Six specimens picked at random to show range in appearance and surface texture of coated specimens.

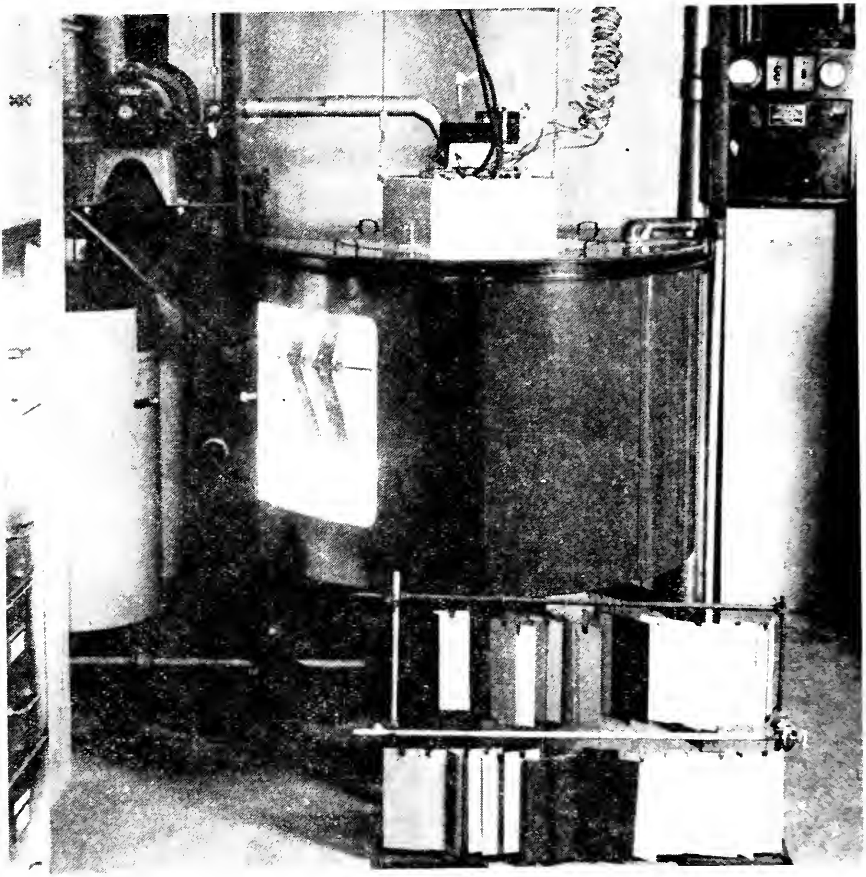


Illustration 3—View of the carbon-arc weathering machine in operation. Inspection door of exposure drum is open to show intensity of the light rays that are emitted from the arc between the carbon rods.

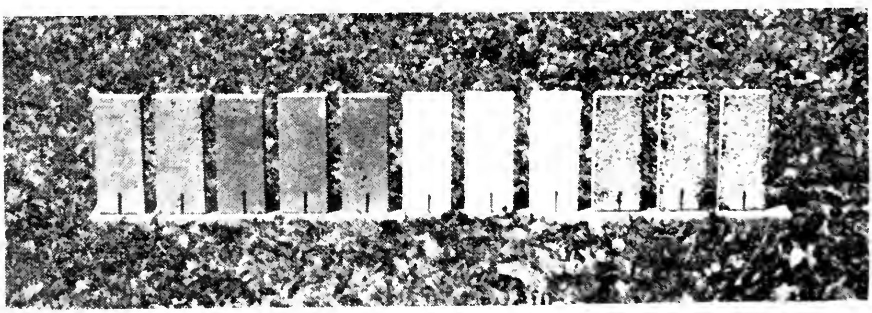


Illustration 4—A view of the rack on which 1-in by 3-in by 8-in coated specimens were subjected to outdoor change-in-weight tests where changes in weight were due to rainfall and humidity changes.

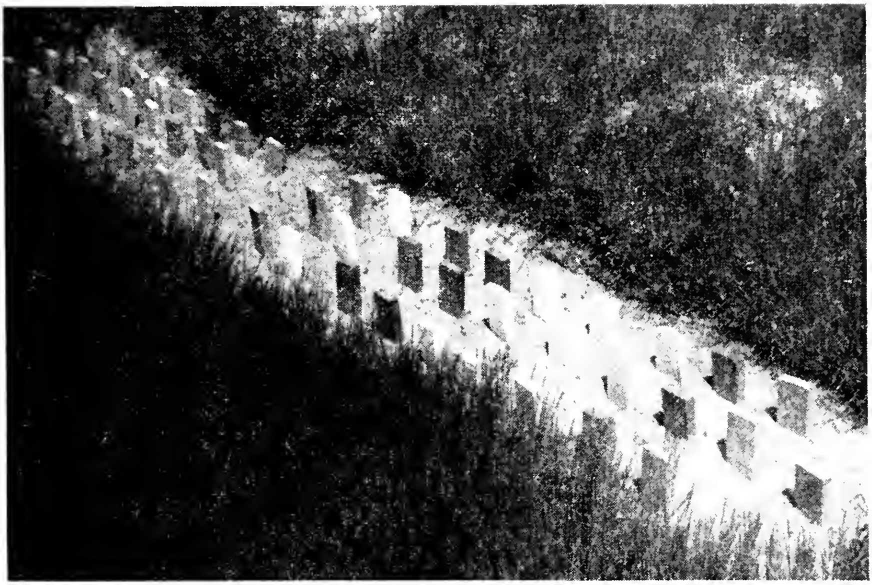


Illustration 5—Field weathering test on 1-in by 3-in by 8-in coated specimens half buried in an upright position. This test was followed by a similar test using 3-in by 4-in by 16-in specimens shown in Illustration 6.

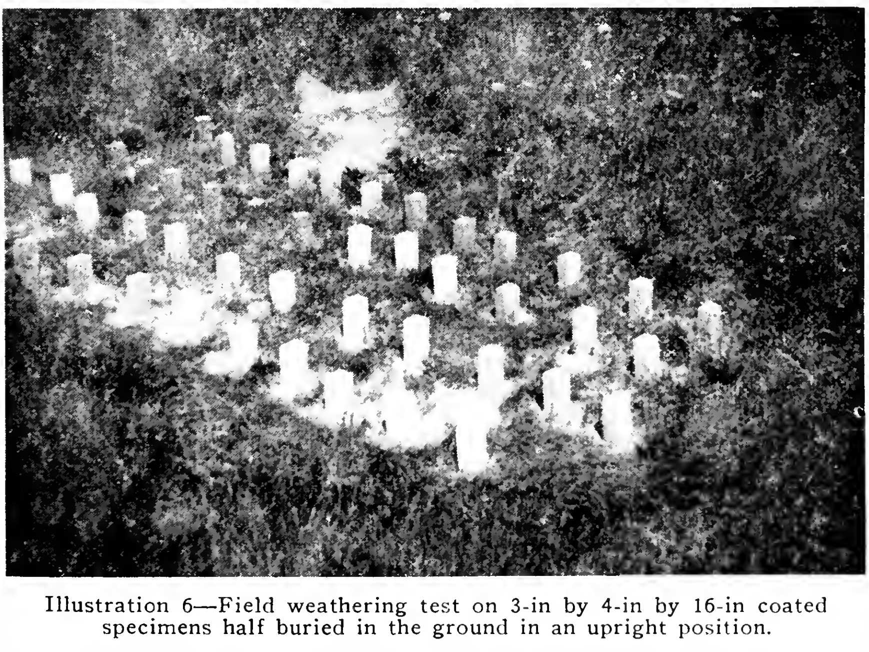


Illustration 6—Field weathering test on 3-in by 4-in by 16-in coated specimens half buried in the ground in an upright position.

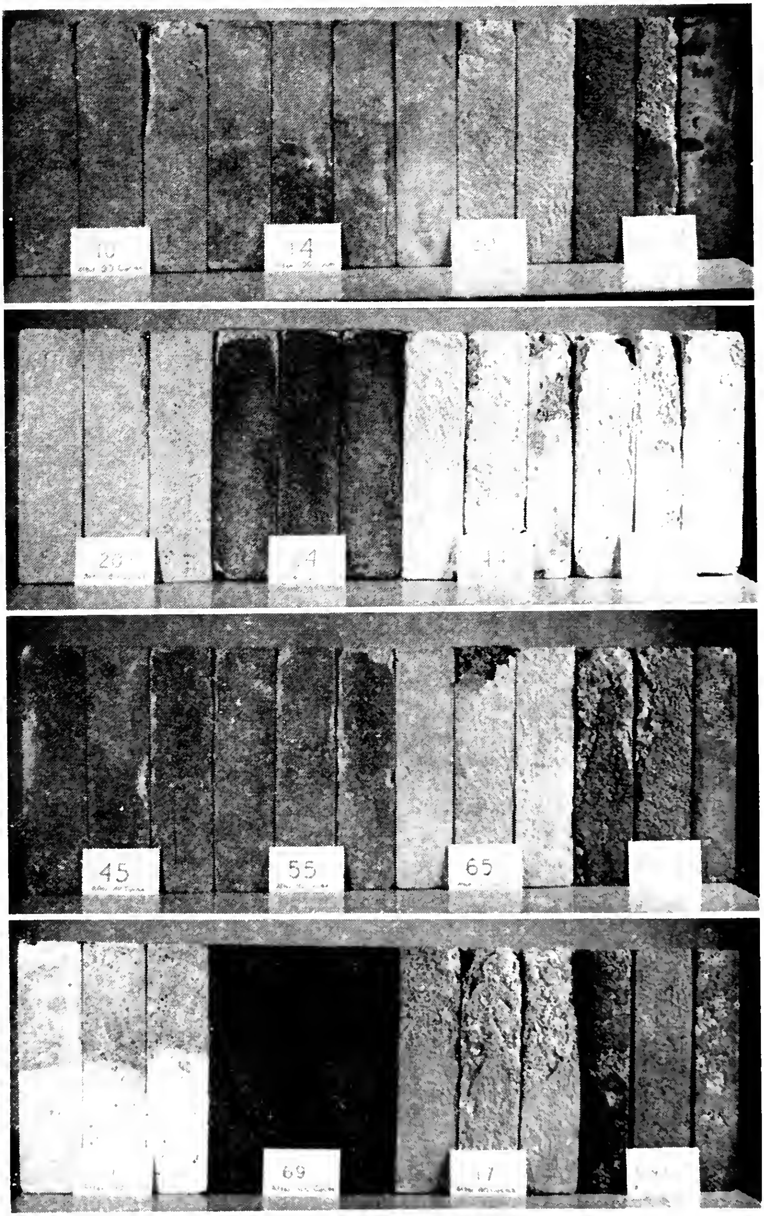


Illustration 7—Visible deterioration that occurred during freezing and thawing cycles on 3-in by 4-in by 16-in coated specimens. Cards identify the coating that was used on each set of three specimens and the number of cycles of freezing and thawing at the time they were removed from test.

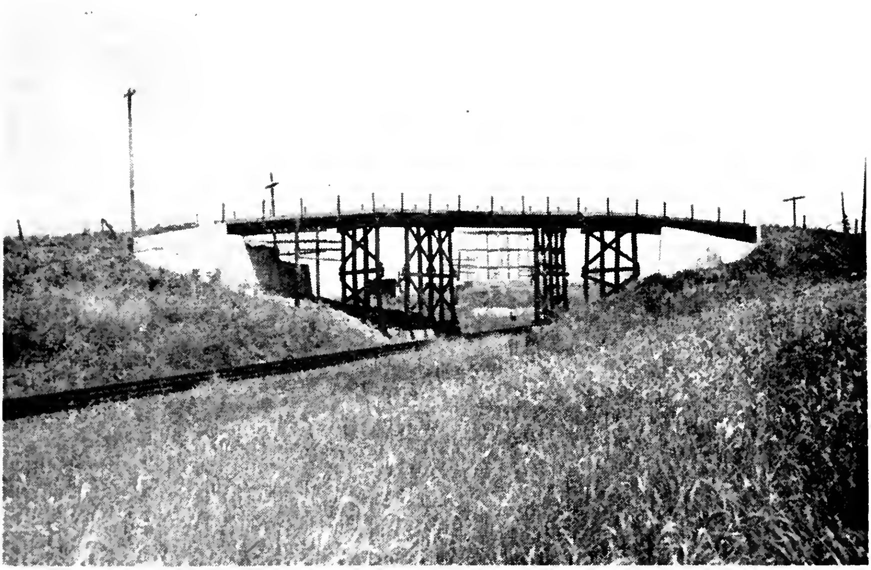


Illustration 8—View of the railroad structure where the 9-sq ft experimental panels were applied in July 1950. Wing walls of abutments shown have southerly exposure.

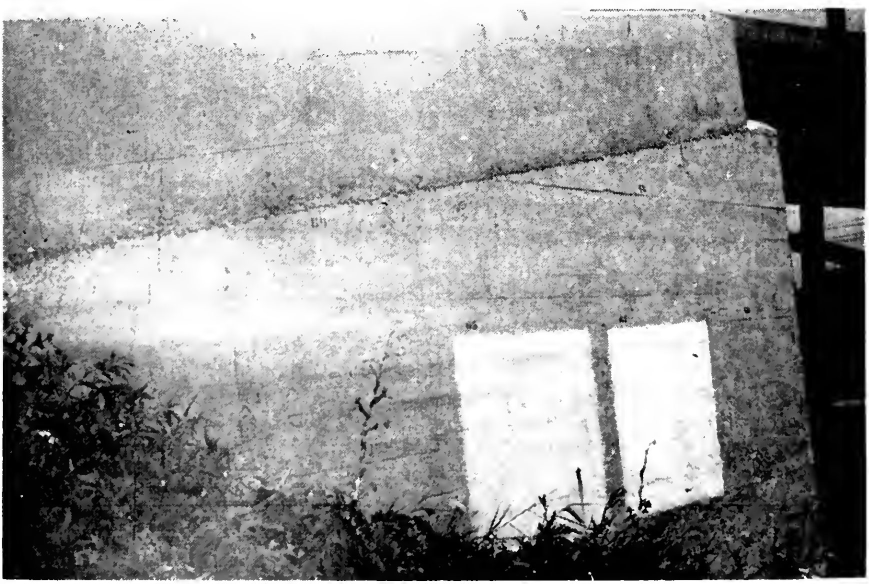


Illustration 9—Wing wall on west side of track on which 5 coatings were applied in panels measuring 9 sq ft. The coatings on three of the panels have chalked away after two years of weathering and the surface has returned to its original appearance.

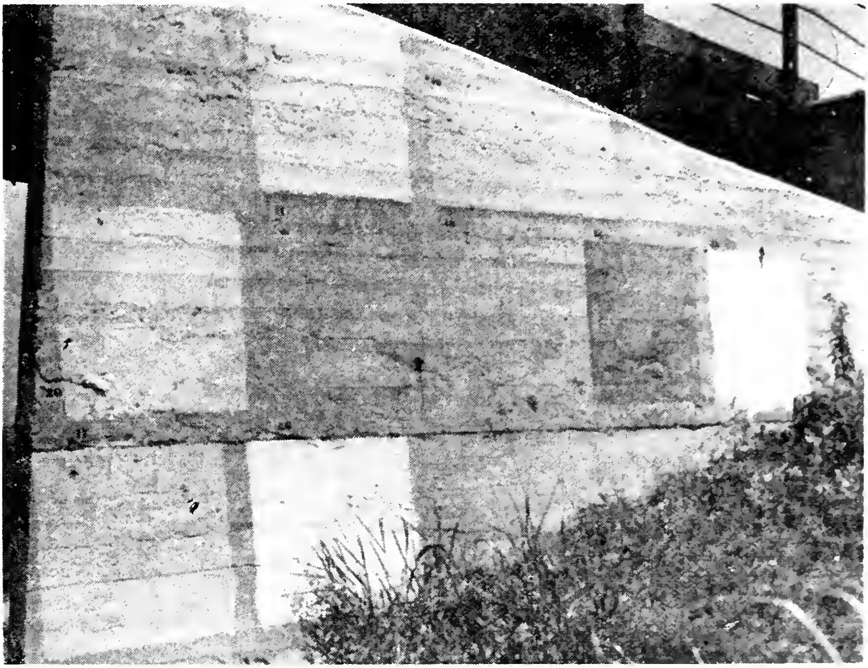


Illustration 10—Wing wall on east side of track on which nine coatings were applied in panels measuring 9 sq ft. The coatings on two of the panels have chalked away after two years of weathering.

PRESENTATION OF DATA

The test data are presented either whole or in part in Tables 1 through 5 according to the nature of the test. In each case the averages that are recorded were derived from the weights that were taken during the immersion tests, with the exception of Tables 4 and 5 in which the weight data were derived from successive weighings during the weathering tests. In addition, Table 5 shows the losses in dynamic modulus of elasticity for the 3-in by 4-in by 16-in specimens that were subjected to the freezing and thawing test.

The data that are shown in Table 1 represent approximately 85 percent of all the data taken and it was necessary to summarize them in some manner to present them in a reasonable amount of space. The summary of this data in Table 1 is based on showing the average and range values for all the coatings within a particular category; thus the data for the cement-base paint category are for the immersion test results for 15 coatings; for the pigmented resin solutions, 14 coatings; etc.

The data shown in Tables 2 through 5 are original data and are complete as shown. The range values shown in Tables 4 and 5 are for the data from the three individual specimens for which each average value was obtained.

In addition to the tables the data are summarized in graphical form for the purpose of facilitating discussion. These graphical summaries are presented in Figures 1 through 7 and will be discussed in the following section.

(Text continued on page 215)

Table I. Average and Range of Results for the 72-hr. Immersion Tests from the First Series of Weathering Tests for Each Category of Coating.

The values shown are absorption less than complete saturation and were computed as a percentage of the original weight of the specimens. These data supplement those shown in Figure 1-A thru 1-D.

Category	No. of Coatings in Category	Value Recorded	Immer. Test Before Weathering 0 hrs.	6 hrs.	24 hrs.	48 hrs.	72 hrs.	Immer. Test After 150-hrs. Weathero. 0 hrs.	6 hrs.	24 hrs.	48 hrs.	72 hrs.	Immer. Test After 50 Cy. f. & t. 0 hrs.	6 hrs.	24 hrs.	48 hrs.	72 hrs.
Cement-Base	15	Average	-3.90	-1.75	-1.10	-0.85	-0.65	-3.25	-1.15	-0.45	-0.35	-0.35	-3.10	-2.15	-1.25	-0.85	-0.60
		Range	2.45	4.10	3.45	3.45	3.45	3.05	3.00	3.15	2.00	2.65	1.80	2.65	2.90	3.05	3.25
Resin Solution-Pigmented	14	Average	-3.95	-3.00	-2.15	-1.75	-1.50	-3.55	-2.70	-1.85	-1.55	-1.40	-2.50	-1.80	-1.10	-0.80	-0.65
		Range	2.15	5.20	4.95	4.90	4.70	3.40	4.45	4.35	4.25	3.90	3.00	3.00	2.75	2.85	2.75
Resin Solution-Non-Pigmented	7	Average	-4.05	-2.45	1.45	-1.00	-0.70	-3.35	-1.95	-1.20	-1.00	-0.90	-2.65	-1.50	-0.70	-0.45	-0.30
		Range	2.15	4.00	2.55	1.95	1.50	2.90	3.65	2.70	2.45	2.30	2.20	2.40	1.75	1.50	1.35
Pigment in Oil	7	Average	-4.30	-3.95	-3.75	-3.40	-3.10	-4.65	-4.40	-4.10	-3.95	-3.75	-3.70	-3.30	-3.10	-2.85	-2.75
		Range	2.05	2.95	3.25	3.60	3.50	2.70	2.55	2.35	2.45	2.50	1.95	2.10	2.50	3.00	3.25
Pigment in Oil House Paint	8	Average	-5.65	-5.55	-5.40	-5.05	-5.00	-6.10	-5.90	-5.80	-5.75	-5.75	-5.70	-5.55	-5.25	-5.30	-5.30
		Range	1.35	1.30	1.20	1.25	1.15	1.15	1.10	0.95	0.95	0.90	1.00	1.05	1.00	0.85	0.80
Wax Solutions	5	Average	-3.95	-3.50	-2.80	-2.30	-2.05	-4.30	-3.15	-1.85	-1.40	-1.20	-3.55	-2.60	-1.60	-1.15	-0.85
		Range	1.10	1.25	1.35	1.80	2.00	1.20	2.40	3.30	3.30	3.45	1.20	1.15	1.35	1.55	1.55
Wax Emulsions	2	Average	-3.45	-1.50	-0.45	-0.15	-0.15	-3.25	-0.45	-0.30	-0.30	-0.25	-3.15	-1.30	-0.20	-0.15	-0.15
		Range	0.85	1.05	0.15	0.30	0.30	1.00	0.30	0.40	0.00	0.20	0.40	0.90	0.60	0.50	0.50
Resin Emulsions	8	Average	-2.60	-1.20	-0.70	-0.15	-0.05	-2.95	-1.30	-0.60	-0.30	-0.05	-2.70	-0.20	+0.10	+0.20	+0.30
		Range	0.65	2.35	2.10	2.10	2.10	0.75	2.00	2.15	1.70	1.40	0.60	0.70	1.10	1.30	1.45
Silicone Solutions	4	Average	-4.45	-3.80	-3.00	-2.35	-1.95	-4.60	-3.80	-2.80	-2.10	-1.60	-3.60	-1.90	-0.65	-0.25	-0.15
		Range	1.20	0.55	0.55	0.75	0.55	1.10	0.50	1.05	1.25	1.25	1.65	2.50	1.75	1.40	1.40
Stearates in Hydrocarbons	5	Average	-4.25	-2.45	-1.25	-0.95	-0.75	-3.90	-1.00	-0.60	-0.60	-0.55	-3.55	-1.70	-0.70	-0.50	-0.45
		Range	1.20	2.75	2.70	2.00	1.50	1.60	1.50	1.10	1.25	1.15	2.40	1.85	1.10	0.95	0.90
Finely Ground Iron	4	Average	-3.60	+0.10	+0.35	+0.40	+0.45	-2.60	+0.30	+0.50	+0.65	+0.75	-2.50	-0.30	+0.40	+0.55	+0.60
		Range	0.75	1.50	1.25	1.40	1.35	0.65	1.45	1.45	1.55	1.70	2.30	2.20	2.00	2.10	2.20
Silicate of Soda	1	Average	-3.85	-0.60	-0.55	-0.40	-0.25	-3.50	-1.05	-0.45	-0.45	-0.45	-3.20	-1.45	-0.80	-0.50	-0.45
		Range	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Linseed Oil	1	Average	-3.50	-3.35	-2.75	-2.35	-2.20	-3.05	-2.95	-2.95	-2.50	-2.50	-2.80	-2.55	-2.40	-2.40	-2.30
		Range	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Bituminous Emulsions	5	Average	-3.45	-2.45	-1.60	-1.15	-0.90	-3.75	-2.70	-1.60	-1.05	-0.85	-2.50	-0.70	-0.65	-0.35	-0.20
		Range	0.60	1.20	1.75	1.65	1.60	1.10	1.35	1.50	2.05	1.90	1.25	1.00	1.60	1.55	1.10
Bituminous Solutions	2	Average	-3.40	-2.55	-1.35	-0.75	-0.50	-2.05	-1.75	-1.20	-1.20	-1.20	-1.80	-1.40	-1.00	-0.90	-0.85
		Range	0.25	0.00	0.35	0.40	0.20	1.10	1.30	1.65	1.50	1.15	1.00	1.00	0.85	1.20	1.40
Colorless Solutions, Unidentified	8	Average	-4.05	-2.80	-1.95	-1.55	-1.20	-4.05	-2.45	-1.95	-1.70	-1.50	-3.45	-2.30	-1.35	-1.05	-0.95
		Range	2.10	3.35	4.70	3.60	3.05	3.05	5.30	5.05	4.70	4.30	1.25	2.15	3.25	2.95	2.90
Water Emulsions, Unidentified	3	Average	-4.20	-2.10	-0.85	-0.55	-0.40	-3.65	-1.55	-0.80	-0.70	-0.65	-3.75	-1.70	-0.90	-0.70	-0.65
		Range	2.50	1.85	1.10	0.75	0.55	0.85	0.50	0.85	0.95	1.05	1.45	0.65	0.65	0.75	0.85
Amber Solutions Unidentified	2	Average	-4.10	-2.70	-2.05	-1.85	-1.40	-3.95	-1.75	-1.05	-0.95	-0.95	-3.75	-2.45	-1.15	-0.95	-0.80
		Range	0.10	1.35	1.90	1.70	1.55	0.70	1.95	0.50	0.40	0.45	0.00	0.85	0.65	0.35	0.30
Concrete Hardener	1	Average	-3.75	-1.05	-1.05	-1.05	-1.00	-3.25	-1.05	-1.05	-1.05	-1.05	-3.70	-1.95	-1.15	-1.10	-0.95
		Range	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Caulking Mastic	1	Average	-3.75	-3.65	-3.15	-2.95	-2.90	-4.15	-4.05	-3.95	-3.95	-3.90	-3.75	-3.70	-3.55	-3.40	-3.35
		Range	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Table 2: Original Data from 1000-HRS. Exposure to Carbon-Arc Light in the Weatherometer on Sixteen Coatings Used on 1x3x8-in. Specimens

The curves shown in the left hand portion of Fig. 3-A thru 3-E summarize the data shown in this table.

Category	Specimens Weighed After	Before	100 hrs	200 hrs	300 hrs	400 hrs	500 hrs	600 hrs	700 hrs	800 hrs	900 hrs	1000 hrs
		Absorption Less Than Complete Saturation Expressed As A Percentage of Original Wet Weight of Specimens *										
Cement Base	0 hrs	-4.02	-3.54	-3.29	-3.23	-3.29	-3.47	-3.54	-3.19	-3.02	-3.33	-3.06
	6 hrs	-3.16	-2.10	-1.13	-1.37	-1.75	-1.24	-1.93	-1.82	-2.51	-2.40	-2.44
	24 hrs	-2.71	-0.79	-0.20	-0.31	-0.24	-0.34	-0.41	-0.34	-1.92	-0.73	-1.79
	48 hrs	-2.16	-0.34	-0.10	+0.00	-0.04	+0.00	+0.21	+0.10	-1.09	-0.21	------
	72 hrs	-1.96	+0.03	-0.03	+0.10	+0.14	+0.07	+0.21	+0.14	-0.75	+0.03	+0.70
Cement Base	0 hrs	-5.82	-5.04	-5.09	-4.74	-5.02	-4.85	-4.67	-4.71	-4.70	-4.01	-4.56
	6 hrs	-2.40	-3.10	-3.07	-2.96	-2.99	-2.69	-----	-2.89	-2.36	-2.96	-2.34
	24 hrs	-1.57	-1.70	-1.53	-1.47	-1.35	-1.42	-----	-1.53	-1.33	-1.36	-1.29
	48 hrs	-1.50	-1.32	-1.46	-1.39	-1.31	-1.38	-1.18	-1.43	-1.22	-1.01	-1.18
	72 hrs	-1.50	-1.47	-----	-1.28	-1.26	-1.39	-1.18	-1.22	-1.05	-1.29	-1.18
Cement Base	0 hrs	-5.62	-5.11	-5.11	-4.77	-5.08	-4.84	-4.66	-4.59	-4.66	-4.42	-4.49
	6 hrs	-4.56	-4.21	-3.77	-3.91	-3.97	-3.56	-----	-3.76	-3.38	-3.87	-3.52
	24 hrs	-3.69	-3.56	-2.45	-2.18	-2.04	-1.90	-----	-2.87	-2.14	-2.76	-1.86
	48 hrs	-3.01	-3.97	-1.74	-1.49	-1.38	-1.17	-1.62	-1.97	-1.45	-2.08	-1.00
	72 hrs	-2.42	-2.73	-1.21	-1.03	-1.03	-1.14	-1.48	-0.97	-1.66	-1.66	-1.00
Resin Solution Pigmented	0 hrs	-4.28	-2.16	-2.37	-2.54	-2.61	-2.81	-3.15	-3.25	-3.32	-3.35	-3.49
	6 hrs	-3.19	-1.82	-2.37	-2.43	-2.61	-2.88	-2.98	-3.15	-3.02	-3.35	-3.39
	24 hrs	-2.98	-1.78	-2.12	-2.40	-2.54	-2.61	-2.78	-3.15	-2.91	-3.29	-3.32
	48 hrs	-2.06	-1.78	-1.95	-2.30	-2.47	-2.57	-2.74	-2.81	-2.91	-3.05	-3.05
	72 hrs	-1.61	-1.75	-1.95	-2.19	-2.33	-2.50	-2.64	-2.81	-2.88	-2.88	-3.05
Resin Solution Pigmented	0 hrs	-4.44	-4.38	-4.75	-4.75	-4.48	-4.47	-4.47	-3.78	-4.20	-4.10	-4.27
	6 hrs	-3.83	-3.80	-4.37	-3.96	-3.86	-3.72	-3.45	-2.99	-3.14	-3.42	-3.25
	24 hrs	-3.45	-3.66	-3.69	-2.94	-2.56	-2.32	-2.05	-2.35	-1.51	-2.36	-1.61
	48 hrs	-3.08	-3.14	-3.38	-2.05	-1.88	-1.84	-1.54	-1.37	-1.41	-1.34	-0.92
	72 hrs	-2.87	-2.87	-2.87	-1.64	-1.60	-1.44	-1.09	-1.23	-1.16	-1.03	-0.79
Resin Solution Pigmented	0 hrs	-3.97	-2.84	-3.08	-3.52	-3.07	-3.32	-3.52	-3.93	-3.55	-3.35	-3.59
	6 hrs	-0.89	-1.67	-2.19	-2.15	-2.19	-2.22	-2.15	-2.66	-2.08	-2.29	-2.32
	24 hrs	-0.34	-1.23	-1.13	-1.23	-0.89	-1.12	-1.12	-1.61	-1.02	-1.36	-1.09
	48 hrs	-0.31	-0.75	-0.78	-0.78	-0.41	-0.72	-0.68	-0.55	-0.65	-0.61	-0.62
	72 hrs	-0.31	-0.54	-0.41	-0.48	-0.38	-0.48	-0.38	-0.41	-0.51	-0.41	-0.58
Pigment in Oil	0 hrs	-6.08	-5.47	-6.08	-5.85	-6.12	-6.15	-6.15	-6.05	-6.05	-5.88	-5.92
	6 hrs	-4.82	-4.89	-5.64	-5.74	-5.67	-5.61	-5.81(3 hrs)	-5.53	-5.20	-5.47	-5.58
	24 hrs	-2.42	-4.79	-5.23	-5.30	-5.30	-5.20	-5.50(20hrs)	-5.40	-5.06	-4.96	-5.13
	48 hrs	-1.66	-4.28	-4.89	-4.99	-4.89	-4.84	-4.93	-4.85	-4.69	-4.35	-4.62
	72 hrs	-1.22	-4.15	-4.25(96hrs)	-4.72	-4.48	-4.56	-4.76	-4.62	-4.08	-4.42	-4.45
Pigment in Oil	0 hrs	-5.08	-4.53	-4.74	-4.46	-4.71	-4.71	-4.71	-4.64	-4.60	-4.42	-4.56
	6 hrs	-4.53	-4.18	-4.42	-4.46	-4.43	-4.56	-4.53	-4.29	-3.91	-4.25	-4.22
	24 hrs	-3.91	-4.12	-4.29	-4.29	-4.12	-4.16	-4.32	-4.15	-3.88	-3.98	-3.88
	48 hrs	-3.67	-3.98	-4.12	-4.05	-4.02	-4.01	-3.98	-3.91	-3.70	-3.43	-3.40
	72 hrs	-3.19	-3.91	-3.81	-3.95	-3.81	-3.88	-3.81	-3.64	-3.39	-3.51	-3.26

* Each value in an average for three specimens.

Table 2: (Cont'd) Original Data from 1000-HRS. Exposure to Carbon-Arc Light in the Weatherometer on Sixteen Coatings Used on 1x3x8-in. Specimens

Category	Specimens Weighed After	Absorption Less Than Complete Saturation Expressed as a Percentage of Original Wet Weight of Specimen *										
		Before	100 hrs	200 hrs	300 hrs	400 hrs	500 hrs	600 hrs	700 hrs	800 hrs	900 hrs	1000 hr
	0 hrs	-4.42	-4.33	-4.63	-4.76	-4.94	-4.94	-4.93	-4.66	-4.91	-4.70	-4.87
	6 hrs	-3.58	-4.12	———	-4.42	-4.66	-4.60	-4.75	-4.42	-4.53	-4.67	-4.69
Wax Solution	24 hrs	-3.39	-3.70	-4.15	-4.08	-4.01	-4.29	-4.22	-4.15	-4.08	-4.33	-4.05
	48 hrs	-2.99	-3.46	-3.87	-3.70	-3.64	-3.94	-3.84	-3.65	-3.95	-3.71	-3.80
	72 hrs	-2.01	-3.23	-3.46	-3.36	-3.23	-3.67	-3.46	-3.40	-3.71	-3.39	-3.46
	0 hrs	-4.46	-3.70	-3.77	-3.83	-4.08	-4.01	-4.05	-4.15	-3.77	-3.43	-3.63
	6 hrs	-3.02	-2.43	———	-2.16	-2.61	-3.01	-2.84	-3.15	-2.84	-2.98	-2.95
Wax Solution	24 hrs	-2.26	-1.57	-1.30	-1.03	-1.10	-1.37	-1.10	-1.81	-1.37	-1.95	-1.13
	48 hrs	-1.64	-1.13	-0.89	-0.76	-0.72	-0.83	-0.79	-0.55	-0.65	-0.83	-0.75
	72 hrs	-1.30	-0.75	-0.48	-0.62	-0.48	-0.55	-0.45	-0.52	-0.48	-0.41	-0.48
	0 hrs	-3.99	-2.19	-2.97	-2.63	-2.53	-2.49	-2.64	-3.42	-2.63	-2.53	-2.73
	6 hrs	-0.48	-1.30	———	-1.30	-1.60	-1.74	-1.75	-2.16	-1.60	-1.84	-2.08
Resin	24 hrs	-0.20	-1.06	-1.05	-0.85	-0.72	-0.75	-0.72	-1.03	-0.55	-1.09	-0.85
Emulsion	48 hrs	-0.17	-0.55	-0.72	-0.48	-0.38	-0.51	-0.38	-0.21	-0.41	-0.41	-0.34
	72 hrs	-0.07	-0.34	-0.20	-0.31	-0.27	-0.27	-0.24	-0.17	-0.37	-0.20	-0.31
	0 hrs	-6.09	-4.55	-4.34	-4.51	-4.90	-4.76	-4.38	-3.79	-4.23	-4.13	-4.20
Finely	6 hrs	-2.10	-1.93	-2.07	-2.79	-2.86	-2.76	-3.52(3hrs)	-2.73	-2.45	-3.00	-2.96
Ground	24 hrs	-1.93	-1.93	-1.76	-1.86	-1.96	-2.00	-2.10(20hrs)	-2.31	-2.03	-2.10	-2.17
Iron	48 hrs	-1.96	-1.62	-1.76	-1.72	-1.72	-1.76	-1.65	-1.83	-1.83	-1.62	-1.86
	72 hrs	-1.93	-1.75	-1.62(96hrs)	-1.65	-1.72	-1.76	-1.58	-1.58	-1.51	-1.62	-1.80
	0 hrs	-5.30	-3.94	-4.44	-4.42	-4.92	-5.20	-5.12	-5.13	-5.13	-5.20	-5.13
	6 hrs	-3.73	-3.25	-3.73	-4.21	-4.35	-4.68	-4.75(3hrs)	-4.72	-4.31	-4.89	-4.82
Linseed Oil	24 hrs	-2.15	-3.25	-3.62	-4.07	-4.18	-4.34	-4.55(20hrs)	-4.56	-4.31	-4.48	-4.61
	48 hrs	-1.81	-3.01	-3.42	-3.90	-3.97	-4.38	-4.28	-4.41	-4.27	-4.00	-4.37
	72 hrs	-1.64	-2.97	-3.18(96hrs)	-3.76	-3.86	-4.34	-4.24	-4.18	-4.17	-4.38	-4.37
	0 hrs	-5.44	-4.85	-3.61	-3.26	-3.81	-3.82	-3.71	-4.13	-3.85	-3.78	-3.78
	6 hrs	-5.10	-3.74	-2.27	-2.44	-2.64	-2.46	-3.02(3hrs)	-2.37	-2.03	-2.43	-2.34
Colorless	24 hrs	-4.65	-2.58	-1.55	-1.58	-1.51	-1.54	-1.65(20hrs)	-1.55	-1.44	-1.31	-1.27
Solution	48 hrs	-4.42	-1.65	-1.13	-1.27	-1.17	-1.31	-1.07	-1.20	-1.14	-0.83	-1.00
	72 hrs	-3.94	-1.31	-0.89(96hrs)	-1.10	-1.07	-1.24	-1.07	-0.97	-0.93	-1.03	-1.00
	0 hrs	-5.59	-5.18	-4.09	-3.63	-4.15	-4.22	-3.98	-3.74	-3.91	-3.64	-4.02
	6 hrs	-5.18	-4.05	-2.68	-2.81	-2.88	-2.47	-3.29(3hrs)	-2.33	-1.96	-2.37	-2.41
Amber Solution	24 hrs	-4.77	-2.88	-1.75	-1.82	-1.65	-1.65	-1.65(20hrs)	-1.54	-1.51	-1.37	-1.41
	48 hrs	-4.22	-2.02	-1.48	-1.51	-1.41	-1.54	-1.34	-1.44	-1.34	-1.07	-1.30
	72 hrs	-3.74	-1.79	-1.24(96hrs)	-1.37	-1.34	-1.54	-1.34	-1.30	-1.17	-1.34	-1.30
	0 hrs	-4.16	-4.00	-4.03	-4.20	-4.37	-4.60	-4.53	-4.70	-4.77	-4.94	-4.90
	6 hrs	-3.96	-----	-3.96	-4.13	-4.37	-4.46	-4.53	-4.60	-4.77	-4.77	-4.63
Caulking	24 hrs	-3.72	-3.75	-3.96	-4.13	-4.23	-4.36	-4.43	-4.46	-4.70	-4.74	-4.60
Mastic	48 hrs	-3.52	-3.59	-3.96	-4.06	-4.23	-4.33	-4.26	-4.43	-4.46	-4.47	----
	72 hrs	-3.35	-3.52	-3.82	-3.96	-4.10	-4.13	-4.23	-4.40	-4.30	-4.47	-4.23

* Each value is an average for three specimens.

Table 3. Original Data from 300 Cycles of Freezing and Thawing on Sixteen Coatings Used on 1x3x8-in. Specimens.

The curves shown in the right hand portion of Fig. 3-A thru 3-E summarize the data shown in this table.

Category	Specimens Weighed After	Absorption Less Than Complete Saturation Expressed as a Percentage of Original Wet Weight of Specimen * Before Avg.	Before Range	50 Cycles Avg.	50 Cycles Range	100 Cycles Avg.	100 Cycles Range	150 Cycles Avg.	150 Cycles Range	200 Cycles Avg.	200 Cycles Range	250 Cycles Avg.	250 Cycles Range	300 Cycles Avg.	300 Cycles Range
	0 hrs	-5.51	0.10	-6.16	0.10	-5.07	0.21	-5.34	0.32	-4.86	0.41	-5.75	0.41	-4.19	0.41
	6 hrs	-4.11	0.65	-5.52	0.21	-5.00	0.22	-5.24	0.31	-4.56	0.42	-4.00	2.70	-3.29	1.80
Cement Base	24 hrs	-3.03	0.60	-5.11	0.21	-4.46	0.65	-4.76	0.33	-4.21	0.64	-3.15	3.02	-2.29	2.24
	48 hrs	-2.55	0.61	-4.70	0.51	-4.15	0.97	-4.56	0.51	-3.84	0.65	-2.87	2.92	-1.89	1.94
	72 hrs	-2.25	0.31	-4.22	0.52	-4.01	0.93	-4.42	0.44	-3.73	0.86	-2.22	2.64	-1.86	1.84
	0 hrs	-3.73	0.29	-2.19	0.31	-1.82	0.32	-1.89	0.43	-2.18	0.41	-2.42	0.53	-2.05	0.61
	6 hrs	-0.71	0.81	-1.59	0.31	-1.18	0.40	-1.21	0.40	-1.31	0.62	-1.55	0.41	-1.45	0.41
Cement Base	24 hrs	+0.24	0.20	-0.84	0.30	-----	----	-0.34	0.61	-0.94	0.41	-0.88	0.41	-0.81	0.41
	48 hrs	+0.34	[illegible]	-0.40	0.51	-0.34	0.61	-0.34	0.61	-0.51	0.48	-0.31	0.29	-0.33	0.30
	72 hrs	+0.40	0.30	-0.20	0.50	+0.13	0.70	+0.21	0.70	-0.20	0.51	+0.14	0.31	-0.10	0.40
	0 hrs	-3.76	0.04	-2.16	0.58	-1.94	0.27	-2.01	0.25	-2.15	0.34	-2.32	0.45	-1.98	0.26
	6 hrs	-1.30	0.08	-1.81	0.56	-1.71	0.38	-1.67	0.36	-1.67	0.36	-1.94	0.35	-1.88	0.25
Cement Base	24 hrs	+0.21	0.21	-1.20	0.39	-----	----	-0.92	0.17	-1.60	0.36	-1.67	0.46	-1.33	0.37
	48 hrs	+0.34	0.32	-1.02	0.48	-1.09	0.37	-0.92	0.17	-1.43	0.37	-1.20	0.38	-1.23	0.48
	72 hrs	+0.48	0.42	-1.29	0.38	-0.68	0.29	-0.68	0.39	-1.09	0.69	-0.95	0.38	-0.96	0.49
	0 hrs	-5.39	0.35	-2.63	0.74	-2.25	0.18	-2.80	0.43	-3.14	0.44	-4.56	0.44	-3.03	0.42
	6 hrs	-4.01	0.65	-2.07	0.78	-1.59	0.32	-2.21	0.43	+0.00	0.52	+0.17	0.63	+0.18	0.64
Resin Solution Pigmented	24 hrs	-3.52	0.75	-1.62	1.03	-0.93	0.49	-1.31	0.59	+0.17	0.63	+0.42	0.64	+0.52	0.53
	48 hrs	-2.59	1.15	-1.24	1.11	-0.69	0.71	-0.83	0.71	+0.45	0.54	+0.45	0.74	+0.66	0.54
	72 hrs	-2.11	0.94	-1.04	1.01	-0.55	0.72	-0.52	0.42	+0.21	0.62	+0.79	0.44	+0.66	0.54
	0 hrs	-5.58	0.35	-4.82	0.34	-3.90	0.46	-3.90	0.33	-3.80	0.34	-4.48	0.66	-3.22	0.43
	6 hrs	-4.65	0.52	-3.25	0.37	-2.70	0.08	-3.05	0.14	-1.09	1.83	-1.29	2.23	-0.75	1.94
Resin Solution Pigmented	24 hrs	-4.17	0.84	-2.05	0.33	-1.10	0.60	-1.78	0.78	-0.24	0.91	-0.30	1.43	-0.10	0.82
	48 hrs	-3.66	1.06	-1.33	1.12	-0.48	0.11	-0.89	1.02	+0.10	0.31	-0.03	0.62	+0.28	0.42
	72 hrs	-3.25	1.16	-0.93	1.33	-0.27	0.09	-0.55	0.82	-0.13	0.30	+0.45	0.41	+0.28	0.42
	0 hrs	-5.44	0.55	-5.28	0.44	-4.93	0.62	-4.41	0.12	-3.84	0.60	-5.03	0.84	-3.63	0.40
	6 hrs	-5.17	0.64	-4.66	0.32	-4.14	0.32	-4.21	0.23	-2.98	0.30	-1.26	0.79	-1.37	1.30
Resin Solution Pigmented	24 hrs	-5.10	0.64	-4.62	0.22	-3.66	0.02	-3.80	0.23	-2.22	1.18	-0.48	0.09	-0.38	0.40
	48 hrs	-4.79	0.54	-4.38	0.22	-3.63	0.11	-3.73	0.33	-1.71	1.60	-0.48	0.09	-0.07	0.21
	72 hrs	-4.58	0.52	-4.21	0.10	-3.46	0.23	-3.63	0.33	-1.67	1.29	-0.17	0.11	-0.07	0.21
	0 hrs	-3.73	0.16	-2.49	0.18	-2.04	0.09	-2.11	0.20	-2.79	0.02	-3.42	0.04	-3.13	0.10
	6 hrs	-3.07	0.08	-2.18	0.18	-1.55	0.01	-1.49	0.19	-2.04	0.09	-2.73	0.12	-2.66	0.09
Pigment in Oil	24 hrs	-2.46	0.09	-1.80	0.19	-----	----	-1.00	0.09	-1.93	0.08	-2.49	0.18	-2.24	0.40
	48 hrs	-2.11	0.30	-1.62	0.30	-1.24	0.19	-1.00	0.09	-1.79	0.19	-2.11	0.30	-2.07	0.39
	72 hrs	-1.76	0.71	-1.62	0.30	-1.07	0.09	-1.00	0.09	-1.62	0.09	-1.96	0.40	-1.97	0.40
	0 hrs	-2.94	0.24	-1.73	0.95	-1.21	1.36	-0.69	1.36	-0.90	0.11	-1.94	0.31	-1.66	0.31
	6 hrs	-2.73	0.24	-1.52	0.95	-1.11	1.36	-0.56	1.25	-0.52	0.20	-1.38	0.09	-1.35	0.32
Pigment in Oil	24 hrs	-2.61	0.55	-1.42	0.84	-----	----	-0.07	1.34	-0.52	0.20	-0.93	0.31	-0.97	0.22
	48 hrs	-2.46	0.55	-1.35	1.05	-0.83	1.36	-0.07	1.34	-0.47	0.10	-0.52	0.52	-0.80	0.32
	72 hrs	-2.42	0.44	-1.35	1.05	-0.66	1.45	+0.03	1.35	-0.28	0.42	-0.28	0.62	-0.66	0.53

* Each Value is an Average for three specimens

Table 3: (Cont'd) Original Data from 300 Cycles of Freezing and Thawing on Sixteen Coatings Used on 1x3x8-in. Specimens.

Category	Specimens Weighed After	Absorption Less Than Complete Saturation Expressed as a Percentage of Original Wet Weight of Specimen * Before Avg.	Before Range	50 Cycles Avg.	50 Cycles Range	100 Cycles Avg.	100 Cycles Range	150 Cycles Avg.	150 Cycles Range	200 Cycles Avg.	200 Cycles Range	250 Cycles Avg.	250 Cycles Range	300 Cycles Avg.	300 Cycles Range
Wax Solution	0 hrs	-5.64	0.41	-3.94	0.19	-2.91	0.20	-3.31	0.19	-3.45	0.28	-5.12	0.39	-3.66	0.18
	6 hrs	-4.65	0.95	-3.42	0.29	-2.56	0.32	-3.18	0.40	-2.94	0.30	-3.58	1.09	-1.87	1.37
	24 hrs	-4.00	1.29	-3.15	0.39	-1.91	0.75	-2.83	0.21	-2.04	1.56	-2.17	2.16	-0.95	1.08
	48 hrs	-3.52	1.39	-3.04	0.40	-1.53	0.87	-2.73	0.21	-1.32	1.89	-1.42	2.19	-0.68	0.69
	72 hrs	-3.17	1.41	-2.77	0.71	-1.40	0.96	-2.49	0.42	-1.46	1.68	-0.91	1.49	-0.68	0.69
Wax Solution	0 hrs	-5.81	0.08	-5.13	0.14	-3.67	0.98	-3.98	0.24	-3.73	0.13	-4.52	0.08	-3.60	0.16
	6 hrs	-4.66	0.85	-4.39	0.44	-3.57	0.36	-3.77	0.23	-3.12	0.16	-2.24	1.95	-1.02	1.02
	24 hrs	-3.94	0.74	-3.61	0.94	-2.72	0.48	-3.19	0.26	-2.35	0.65	-0.92	1.33	-0.37	0.31
	48 hrs	-3.30	0.94	-3.13	1.06	-2.38	0.43	-2.90	0.35	-1.64	0.93	-0.54	0.52	-0.21	0.31
	72 hrs	-2.45	1.03	-2.59	1.44	-1.84	0.74	-2.62	0.52	-1.40	1.04	-0.07	0.10	-0.21	0.31
Resin Emulsion	0 hrs	-5.39	0.44	-4.28	0.43	-3.84	0.43	-3.77	0.54	-3.73	0.22	-4.46	0.44	-3.18	0.32
	6 hrs	-1.11	0.10	-1.04	0.21	-1.14	0.22	-1.94	0.31	-0.97	0.11	-1.00	0.21	-1.45	00
	24 hrs	-0.73	0.21	-0.42	0.21	-0.17	0.31	-0.24	0.10	-0.07	0.31	00	0.20	-0.14	0.21
	48 hrs	-0.59	0.31	-0.46	0.31	-0.04	0.31	-0.07	0.31	+0.10	0.21	00	0.20	+0.21	0.21
	72 hrs	-0.45	0.41	-0.21	0.21	-0.14	0.41	-0.07	0.31	-0.11	0.31	+ .14	0.83	+0.21	0.21
Finely Ground Iron	0 hrs	-3.49	0.23	-2.70	0.45	-2.77	0.35	-2.80	0.35	-3.04	0.44	-3.08	0.54	-2.36	0.27
	6 hrs	-1.49	0.37	-1.76	0.57	-2.00	0.46	-2.15	0.41	-1.59	0.57	-1.21	0.78	-1.93	0.76
	24 hrs	-1.05	0.38	-1.25	0.78	----	----	-1.56	0.51	-0.87	0.99	-0.61	0.89	-1.31	0.98
	48 hrs	-0.98	0.38	-1.08	0.78	-1.76	0.67	-1.56	0.51	-0.57	0.79	-0.33	0.80	-1.08	1.08
	72 hrs	-0.88	0.49	-1.08	0.78	-1.52	0.78	-1.56	0.51	-0.57	0.79	-0.30	0.70	-0.98	0.98
Linseed Oil	0 hrs	-3.15	0.34	-2.04	0.41	-2.17	0.23	-2.24	0.21	-2.13	0.33	-2.54	0.33	-2.51	0.31
	6 hrs	-2.71	0.41	-1.87	0.31	-1.93	0.41	-1.97	0.23	-1.69	0.30	-2.24	0.33	-2.17	0.40
	24 hrs	-2.51	0.61	-1.80	0.20	----	----	-1.52	0.19	-1.69	0.30	-2.20	0.30	-2.14	0.40
	48 hrs	-2.28	0.39	-1.66	0.30	-1.73	0.20	-1.52	0.19	-1.79	0.30	-2.10	0.30	-2.00	0.51
	72 hrs	-2.07	0.50	-1.63	0.40	-1.56	0.30	-1.46	0.10	-1.79	0.30	-1.96	0.30	-1.97	0.51
Colorless Solution	0 hrs	-3.63	0.37	-2.00	0.49	-1.49	0.59	-1.66	0.21	-2.30	0.39	-2.72	0.38	2.24**	0.39
	6 hrs	-3.39	0.37	-1.83	0.59	-1.15	0.60	-1.22	0.50	-1.66	0.39	-2.00	0.38	2.03**	0.38
	24 hrs	-3.19	0.68	-1.66	0.69	----	----	-0.51	0.50	-1.23	0.39	-1.66	0.59	1.68**	0.49
	48 hrs	-2.99	0.58	-1.53	0.59	-0.81	0.50	-0.48	0.50	-1.32	0.50	-1.22	0.80	1.37**	0.50
	72 hrs	-2.82	0.79	-1.53	0.59	-0.51	0.60	-0.24	0.61	-1.12	0.49	-0.88	0.90	1.22**	0.60
Amber Solution	0 hrs	-3.81	0.19	-2.62	0.16	-2.02	0.22	-1.98	0.12	-2.59	0.14	-2.83	0.14	-2.32	0.17
	6 hrs	-3.47	0.15	-2.35	0.27	-1.77	0.13	-1.53	0.04	-1.84	0.15	-2.22	0.13	-2.11	0.13
	24 hrs	-3.30	0.25	-2.18	.27	----	----	-0.75	0.12	-1.46	0.19	-1.70	0.09	-1.60	0.12
	48 hrs	-3.00	0.35	-1.91	.28	-1.43	0.04	-0.75	0.12	-0.95	0.30	-1.12	0.04	-1.29	0.13
	72 hrs	-2.79	0.56	-1.91	.28	-1.12	0.22	-0.48	0.12	-0.75	0.30	-0.68	0.10	-1.15	0.14
Caulking Mastic	0 hrs	-5.43	0.23	-2.39	1.06	-1.64	0.57								
	6 hrs	-5.22	0.26	-1.91	1.26	-0.48	0.41								
	24 hrs	-5.12	0.26	-1.65	1.27	-0.10	0.51	Crumbled & broke at 131 cycles - Mortar Failure							
	48 hrs	-4.98	0.42	-1.61	1.58	-0.07	0.51								
	72 hrs	-4.71	0.76	-1.37	1.57	+0.17	0.61								

* Each value is an average for three specimens.
** Average Value of Two Specimens only.

Table 4: Data for Outdoor Change-in-Weight Test in Which Specimens were Placed in an Upright Position on a Platform and Weighed at Frequent Intervals

The Data Shown on Figure 4 are a Summary of the Data Shown in This Table.

Date of Weighing		Absorption Less Than Complete Saturation Expressed As A Percentage of Original Wet Weight of Specimen																	
		Cement Base		Cement Base		Cement Base		Iron Coating		Resin Solution		Wax Solution		Pigment-in-Oil		Pigment-in-Oil		Control Specimens	
Month	Day	Avg.	Range	Avg.	Range	Avg.	Range	Avg.	Range	Avg.	Range	Avg.	Range	Avg.	Range	Avg.	Range	Avg.	Range
Nov., '50	13	-5.85	0.33	-5.54	0.17	-5.99	0.21	-6.57	0.33	-5.80	0.46	-5.85	0.60	-5.78	0.33	-4.80	0.65	-5.63	0.10
	16	-5.15	0.66	-4.94	0.15	-5.29	0.11	-2.26	0.21	-5.76	0.50	-5.61	0.94	-5.74	0.43	-4.83	0.65	-3.30	0.13
	17	-5.23	0.66	-4.97	0.25	-5.39	0.29	-3.82	0.27	-5.69	0.40	-5.73	0.59	-5.71	0.43	-4.62	0.53	-3.85	0.29
	18	-5.19	0.59	-4.97	0.25	-5.39	0.29	-3.82	0.27	-5.73	0.50	-5.73	0.59	-5.71	0.43	-4.83	0.65	-3.96	0.24
	21	-3.38	1.10	-3.67	1.14	-4.37	0.58	-2.37	0.14	-5.62	0.39	-5.73	0.59	-5.81	0.53	-4.83	0.65	-2.17	0.26
	28	-3.31	0.68	-3.74	0.62	-4.37	0.25	-3.00	0.25	-5.37	0.34	-5.39	0.66	-5.67	0.32	-4.59	0.54	-3.09	0.49
Dec.	2	-3.06	0.58	-3.46	0.69	-4.05	0.04	-2.05	0.35	-5.33	0.45	-5.38	0.49	-5.49	0.43	-4.59	0.54	-2.40	0.37
	22	-2.61	0.49	-3.07	0.89	-3.56	0.86	-2.90	0.35	-5.33	0.45	-5.38	0.49	-5.81	0.43	-4.80	0.54	-3.29	1.11
	30	-2.68	0.38	-2.96	0.71	-3.74	0.44	-3.22	0.57	-5.12	0.46	-5.13	0.49	-5.46	0.44	-4.48	0.54	-3.12	0.18
Jan., '51	4	-0.80	0.12	-1.66	0.97	-2.28	1.08	-1.49	0.55	-4.66	0.41	-4.81	1.03	-5.35	0.54	-4.20	0.97	-0.69	0.42
	10	-2.79	0.28	-2.86	0.46	-3.39	0.74	-3.18	0.46	-4.87	0.57	-5.13	1.03	-5.85	0.54	-4.62	0.75	-1.56	0.31
	13	-2.26	0.17	-2.86	0.46	-3.46	0.64	-3.30	0.89	-4.62	0.73	-4.88	1.46	-5.63	0.22	-4.13	0.76	-1.00	0.30
	17	-1.01	0.22	-2.08	0.68	-2.72	0.64	-1.06	0.74	-4.73	0.84	-4.57	0.83	-5.49	0.22	-4.34	0.76	-2.32	0.30
	18	-1.77	0.30	-1.56	1.08	-2.08	0.75	-1.31	0.12	-4.66	0.78	-4.75	0.60	-5.64	0.54	-4.44	0.87	-1.72	0.24
Feb.	12	-5.19	0.57	-4.97	0.09	-5.32	0.22	-6.04	0.22	-5.84	0.39	-5.74	0.58	-5.67	0.53	-4.59	0.76	-5.07	0.19
	20	-1.33	1.07	-1.48	0.78	-2.08	0.80	-1.13	0.13	-5.09	0.62	-5.31	0.59	-5.74	0.55	-4.52	0.87	-1.21	0.12
	22	-1.01	0.12	-1.69	0.24	-2.19	0.10	-2.06	0.45	-4.91	0.53	-5.07	0.59	-5.53	0.43	-4.41	0.86	-2.09	0.22
	26	-2.37	0.35	-2.68	0.06	-3.20	0.20	-2.58	0.15	-4.80	0.51	-5.03	0.70	-5.39	0.34	-4.23	0.76	-2.30	0.20
Mar.	2	-2.61	0.35	-2.82	0.08	-3.27	0.11	-2.76	0.25	-5.02	0.62	-5.10	0.59	-5.60	0.53	-4.55	0.76	-2.59	0.10
	6	-3.20	0.27	-3.35	0.07	-3.80	0.23	-3.68	0.37	-5.26	0.72	-5.34	0.59	-5.78	0.52	-4.52	0.87	-3.20	0.09
	12	-3.87	0.68	-3.81	0.11	-4.19	0.22	-4.00	0.69	-5.84	0.62	-5.74	0.55	-6.23	0.34	-5.01	0.75	-3.58	0.33
	16	-2.09	0.56	-2.29	0.48	-2.78	0.74	-2.26	0.46	-4.91	0.73	-5.10	0.59	-5.67	0.53	-4.41	0.86	-2.22	0.05
	26	-3.20	0.48	-3.28	0.08	-3.63	0.22	-4.13	0.38	-5.13	0.52	-5.31	0.59	-5.67	0.53	-4.41	0.86	-3.33	0.18
	28	-2.04	0.81	-2.05	0.69	-2.33	0.94	-1.94	0.42	-4.87	0.61	-4.89	0.60	-5.56	0.52	-4.23	0.96	-1.78	0.20
April	3	-2.30	0.67	-2.57	0.38	-3.06	0.53	-2.86	0.57	-4.66	0.39	-4.89	0.60	-5.49	0.52	-4.09	1.08	-2.32	0.30
	6	-2.71	0.56	-2.51	0.38	-2.68	0.85	-1.49	1.72	-5.33	0.50	-5.52	0.60	-5.89	0.63	-4.84	0.85	-2.19	0.15
	10	-1.88	0.45	-1.73	0.26	-2.09	0.32	-2.16	0.46	-5.02	0.61	-5.17	0.60	-6.02	0.63	-4.65	0.65	-2.01	0.24
	12	-1.05	0.75	-1.55	0.55	-1.80	0.21	-1.84	0.45	-4.63	0.36	-4.99	0.59	-5.46	0.22	-4.38	0.75	-1.88	0.26
	14	-1.15	0.33	-1.20	0.54	-1.55	0.15	-1.91	0.45	-4.62	0.47	-4.85	0.60	-5.78	0.34	-4.45	0.96	-1.62	0.16
	16	-1.92	0.34	-2.78	0.15	-3.13	0.10	-3.07	0.36	-4.55	0.50	-4.85	0.60	-5.71	0.44	-4.48	0.96	-2.38	0.10
	23	-2.82	0.38	-2.82	0.08	-3.38	0.11	-3.88	0.37	-4.27	0.73	-4.43	0.60	-5.29	0.54	-3.85	1.10	-2.46	0.17
	25	-3.24	0.37	-3.28	0.37	-3.45	0.22	-3.14	0.15	-4.98	0.51	-5.17	0.39	-5.71	0.52	-4.41	0.97	-2.91	0.12
	27	-3.36	0.18	-3.28	0.37	-3.53	0.32	-3.18	0.25	-4.94	0.51	-5.31	0.59	-5.59	0.85	-4.37	1.07	-2.91	0.23
May	1	-3.48	0.59	-3.24	0.26	-3.49	0.11	-3.82	0.42	-4.94	0.51	-5.20	0.60	-5.67	0.52	-4.51	0.65	-3.25	0.40
	9	-3.73	0.58	-3.42	0.36	-3.63	0.22	-3.92	0.43	-5.06	0.51	-5.35	0.48	-5.71	0.62	-4.48	0.75	-3.25	0.19
	11	-1.32	1.38	-0.43	0.74	-0.71	0.11	-0.78	0.12	-4.52	0.50	-4.85	0.49	-5.49	0.56	-4.41	0.86	-0.56	0.21
	17	-3.34	0.48	-3.14	0.48	-3.21	0.21	-4.06	0.27	-4.84	0.51	-4.96	0.49	-5.22	0.65	-4.27	0.75	-3.46	0.05
	21	-3.94	0.45	-3.32	0.16	-3.73	0.22	-4.66	0.21	-5.37	0.40	-5.56	0.48	-5.81	0.63	-4.62	0.85	-3.84	0.08

Table 5: Loss in Dynamic E and Changes in Absorption Less Than Complete Saturation for 3x4x16-in. Coated Specimens when Subjected to Laboratory Freezing and Thawing Cycles.

The curves in Fig. 7A-7C summarize the data from this table

Category	Data Tabulated		Cycles of Freezing and Thawing 0	3	6	10	15	20	25	30	40	50	60	70	80	90	100
	Loss in Dynamic	Avg.	0.0	0.7	1.0	.80	1.6	1.1	3.4	8.5	23.3	39.4	59.1				
Cement	E, Per Cent	Range	——	1.1	0.2	0.0	0.6	0.8	6.0	9.6	15.6	21.5	19.5				
Base	Absorp. Less than	Avg.	-1.35	-1.34	-1.19	-1.07	-0.80	-0.75	-0.58	-0.42	-0.25	-0.05	-0.19				
	Complete Sat., Per Cent	Range	0.06	0.11	0.19	0.18	0.17	0.25	0.23	0.23	0.28	0.28	0.48				
	Loss in Dynamic	Avg.	0.0	-0.2	1.3	4.9	4.3	4.8	6.9	10.4	17.2	23.0	36.2	41.6	52.8		
Cement	E, Per Cent	Range	——	0.6	5.7	8.0	3.4	4.3	5.3	4.5	5.9	7.8	9.6	12.6	7.6		
Base	Absorp. Less than	Avg.	-0.44	-0.40	-0.27	-0.31	-0.36	-0.19	-0.23	-0.16	-0.06	-0.19	+0.07	+0.23	+0.28		
	Complete Sat., Per Cent	Range	0.66	0.06	0.09	0.09	0.27	0.12	0.09	0.12	0.01	0.34	0.12	0.11	0.12		
	Loss in Dynamic	Avg.	0.0	-0.6	-0.5	0.4	-0.6	-0.9	-0.7	1.0	6.1	13.4	38.9				
Cement	E, Per Cent	Range	——	1.1	0.9	1.1	1.2	1.7	2.2	4.4	6.7	10.6	33.6				
Base	Absorp. Less than	Avg.	-1.01	-0.67	-0.47	-0.45	-0.21	-0.13	-0.11	-0.08	+0.21	+0.29	+0.38				
	Complete Sat., Per Cent	Range	0.79	0.40	0.45	0.40	0.49	0.45	0.41	0.33	0.26	0.24	0.16				
	Loss in Dynamic	Avg.	0.0	0.9	0.9	1.0	0.8	1.0	1.1	1.7	4.8	13.1	35.3	40.0			
Resin	E, Per Cent	Range	——	0.5	1.8	1.8	1.9	1.5	0.5	2.5	10.3	26.4	54.7	58.0			
Solution	Absorp. Less than	Avg.	-1.60	-1.62	-1.49	-1.49	-1.22	-1.25	-1.09	-0.99	-0.69	-0.39	-0.15	+0.19			
Pigmented	Complete Sat., Per Cent	Range	0.68	0.66	0.69	0.71	0.88	0.78	0.89	0.88	1.04	1.10	1.21	1.06			
	Loss in Dynamic	Avg.	0.0	1.5	1.8	1.3	1.4	1.0	1.2	0.1	-2.2	-0.1	3.7	11.4	37.2	50.8	
Resin	E, Per Cent	Range	——	1.3	0.6	1.6	0.8	1.3	0.6	1.0	1.0	1.0	1.4	3.2	10.5	24.8	
Solution	Absorp. Less than	Avg.	-1.90	-1.78	-1.72	-1.55	-1.34	-1.13	-0.99	-0.90	-0.59	-0.40	-0.02	+0.15	+0.42	+0.44	
Pigmented	Complete Sat., Per Cent	Range	0.18	0.24	0.31	0.36	0.39	0.38	0.44	0.47	0.46	0.46	0.52	0.35	0.36	0.33	
	Loss in Dynamic	Avg.	0.0	0.9	1.2	1.2	1.2	0.7	0.5	-0.0	-0.8	0.4	16.6	20.2	13.3	14.4	31.0
Pigment	E, Per Cent	Range	——	1.4	1.8	0.7	0.5	1.6	1.1	1.4	2.7	1.4	52.9	66.9	45.1	54.7	68.3
in	Absorp. Less than	Avg.	-2.29	-2.11	-2.12	-2.11	-1.96	-1.86	-1.77	-1.72	-1.49	-1.37	-1.15	-0.69	-0.39	-0.38	-0.75
Oil	Complete Sat., Per Cent	Range	0.13	0.27	0.27	0.31	0.37	0.45	0.48	0.69	0.81	0.94	1.15	1.38	1.60	1.04	1.43
	Loss in Dynamic	Avg.	0.0	0.8	1.1	1.2	1.2	1.4	-0.1	0.8	0.4	0.6	-0.2	0.2	-0.7	0.7	0.3
Pigment	E, Per Cent	Range	——	0.0	0.4	1.3	0.4	0.5	1.3	2.0	1.7	0.8	1.8	1.3	2.2	0.5	0.8
in	Absorp. Less than	Avg.	-1.89	-1.88	-1.81	-1.91	-1.77	-1.78	-1.73	-1.66	-1.58	-1.44	-1.40	-1.22	-1.11	-0.88	-0.70
Oil	Complete Sat., Per Cent	Range	0.33	0.34	0.36	0.46	0.33	0.42	0.42	0.39	0.45	0.49	0.51	0.49	0.61	0.74	0.72
	Loss in Dynamic	Avg.	0.0	0.7	0.4	-0.1	-0.6	-0.4	0.7	2.5	6.1	12.2	21.6	32.1	46.4	51.4	
Wax	E, Per Cent	Range	——	1.0	0.5	0.8	1.0	1.3	3.5	6.1	10.2	19.3	24.6	34.0	3.2	4.1	
Solution	Absorp. Less than	Avg.	-1.19	-0.98	-0.99	-0.83	-0.66	-0.50	-0.46	-0.42	-0.17	-0.13	+0.09	+0.38	+0.68	+0.21	
	Complete Sat., Per Cent	Range	0.17	0.23	0.21	0.25	0.14	0.19	0.19	0.13	0.22	0.26	0.28	0.25	0.35	1.70	
	Loss in Dynamic	Avg.	0.0	0.3	0.3	1.5	3.4	4.3	5.8	8.2	14.7	18.9	26.7	33.1	49.3	59.2	
Finely	E, Per Cent	Range	——	1.4	0.8	2.7	1.6	2.7	4.0	5.3	6.4	10.8	13.0	15.2	18.5	24.7	
Ground	Absorp. Less than	Avg.	-0.41	-0.42	-0.29	-0.27	-0.21	-0.20	-0.20	-0.14	-0.05	-0.04	+0.02	+0.07	+0.15	-0.04	
Iron	Complete Sat., Per Cent	Range	0.63	0.40	0.36	0.40	0.40	0.34	0.37	0.36	0.34	0.34	0.26	0.35	0.08	0.46	
	Loss in Dynamic	Avg.	0.0	1.1	1.3	1.6	1.7	1.2	0.4	0.6	0.1	0.1	-1.1	0.3	1.6	3.1	5.9
Linseed	E, Per Cent	Range	——	2.5	2.2	2.3	2.0	1.5	1.1	1.2	2.5	2.5	1.7	1.7	1.9	5.4	13.7
Oil	Absorp. Less than	Avg.	-1.33	-1.36	-1.29	-1.33	-1.25	-1.30	-1.29	-1.24	-1.15	-1.11	-1.12	-1.08	-0.97	-0.75	-0.63
	Complete Sat., Per Cent	Range	0.15	0.09	0.06	0.12	0.07	0.13	0.16	0.14	0.11	0.17	0.24	0.33	0.34	0.28	0.33
	Loss in Dynamic	Avg.	0.0	0.1	1.0	-0.3	0.6	1.5	4.5	6.2	14.9	25.4	49.2	65.0			
Colorless	E, Per Cent	Range	——	1.4	1.4	1.2	1.1	1.8	4.2	3.0	2.3	7.8	8.9	9.4			
Solution	Absorp. Less than	Avg.	-0.93	-0.68	-0.52	-0.32	-0.07	+0.07	+0.13	+0.15	+0.35	+0.37	+0.48	+0.69			
	Complete Sat., Per Cent	Range	0.36	0.30	0.39	0.33	0.27	0.19	0.19	0.17	0.23	0.26	0.28	0.32			

Table 5: (Cont'd) Loss in Dynamic E and Changes in Absorption Less Than Complete Saturation for 3x4x16-in. Coated Specimens when Subjected to Laboratory Freezing and Thawing Cycles.

Category	Data Tabulated		Cycles of Freezing and Thawing														
			0	3	6	10	15	20	25	30	40	50	60	70	80	90	100
Caulking Mastic	Loss in Dynamic	Avg.	0.0	1.7	2.3	1.8	2.2	2.0	2.5	1.6	0.7	1.1	1.5	0.8	1.4	0.6	1.2
	E, Per Cent	Range	——	2.8	1.6	0.8	0.5	1.1	1.2	0.4	1.0	0.9	1.8	0.2	1.9	1.2	1.4
	Absorp. Less than	Avg.	-1.96	-1.93	-2.06	-1.98	-1.95	-1.89	-1.90	-1.90	-1.87	-1.88	-1.86	-1.77	-1.69	1.73	1.70
	Complete Sat., Per Cent	Range	0.18	0.12	0.20	0.13	0.12	0.10	0.11	0.07	0.08	0.12	0.08	0.05	0.08	0.09	0.14
Amber Solution	Loss in Dynamic	Avg.	0.0	-0.1	-0.4	-0.7	0.2	0.5	3.6	5.5	12.0	21.9	38.4	52.2			
	E, Per Cent	Range	——	0.2	0.7	0.8	0.9	2.0	1.9	3.8	7.8	11.1	16.3	15.3			
	Absorp. Less than	Avg.	-0.91	-0.68	-0.59	-0.39	-0.18	+0.05	+0.07	+0.11	+0.29	+0.33	+0.43	+0.64			
	Complete Sat., Per Cent	Range	0.28	0.30	0.26	0.29	0.30	0.31	0.32	0.26	0.28	0.24	0.20	0.30			
Control Specimens	Loss in Dynamic	Avg.[1]	0.0	0.5	0.5	0.5	2.0	2.6	4.0	5.0	8.0	12.0	16.0	20.0	32.0	41.0	52.0
	E, Per Cent	Range[2]	——	2.5	1.4	3.9	5.1	5.6	5.9	5.5	11.5	14.5	14.7	19.0	29.2	40.2	43.2
	Absorp. Less than	Avg.[1]	0.00	+0.15	+0.17	+0.20	+0.28	+0.32	+0.35	+0.33	+0.39	+0.43	+0.45	+0.52	+0.56	+0.39	+0.22
	Complete Sat., Per Cent	Range[2]	0.21	0.36	0.32	0.29	0.41	0.25	0.38	0.33	0.24	0.31	0.36	0.33	0.67	1.00	1.64

1. Average for nine specimens (three specimens from each of three mixes).

2. Range for nine specimens (three specimens from each of three mixes).

DISCUSSION OF RESULTS

First Series of Weathering Tests

As was noted in the previous section, two series of tests were conducted in this study. The first series consisted of two laboratory weathering tests, followed by outdoor exposure. These tests were performed consecutively on the same set of specimens, i.e., exposure to carbon-arc light, cycles of freezing and thawing, and 90 days of outdoor weathering. Each of the 103 coatings were subjected to these tests.

The results from the first series of tests are summarized in graphical form on Figs. 1–A through 1–D, and in tabular form in Table 1. These four figures illustrate the data that were obtained from the 72-hr immersion tests which were performed prior to, and immediately after, each of the laboratory weathering tests on 1-in by 3-in by 8-in coated specimens. On each figure, at the bottom of each of the three vertical columns, there is noted the weathering test which preceded the immersion test for which data are shown. To reduce the quantity of figures to a reasonable number it was necessary to group all the coatings according to the category into which they belonged. To reduce further the number of curves, only the upper and lower absorption curves are shown for each group of data so that essentially what is shown is a data envelope. Where an absorption curve was sufficiently different in slope from the group of curves it was drawn and identified by the code number of the coating.

The calculations for change-in-weights are based on the original weight of the specimen, which is expressed as zero percent change in weight from the original weight. The original weight was determined when the specimens were removed from molds 24 hr after mixing, at which time they still contained all the mix water that was added to the batch, so the specimens were saturated except for entrapped air which was negligible for the mixes used in this study.

The seven days of oven drying during the curing period caused the specimens to weigh less than the original weight, and this loss of weight was expressed as a negative percentage. Likewise, in the first weathering test the heat that was generated by the carbon-arc light dried the specimens to a lesser weight than the original weight, so again the loss in weight was expressed as a negative percentage change in weight from the original weight. At the completion of the cycles of freezing and thawing the specimens were nearly saturated because the thawing was done in water. In this instance the specimens were intentionally placed in the 90-deg F oven for 5 days to partially dry them so they would be capable of absorbing water during the subsequent 72-hr immersion test. Again the specimen weighed less than the original saturated weight, and thus the change in weight from the original weight is expressed as a negative percentage. As the specimens gain weight during the immersion tests they approach the original weight of the specimen, or in percentage terms the zero percent line, which represents a nearly saturated condition.

No attempt was made to dry the specimens to the exact same weight before each immersion test because of the different rates of drying of specimens that were coated with various coatings; thus the absorption curves do not have a common origin on the graphs. The weight of each coated specimen was corrected for the weight of the coating by subtracting the weight before painting from the weight after painting and deducting this difference from each weighing after the paint was applied.

The slopes of the data envelope curves pretty well illustrate the slopes of the individual curves which they represent. If the curves are flat-lying during the immersion tests, the specimens did not change weight, which in turn means that the coating was impermeable and thus an excellent waterproofing coating. The more steeply rising the curves, the less effective was the coating as a waterproofer. The uncoated control specimens were almost completely saturated after 1 hr of immersion and the absorption curve for them would rise almost vertically to the zero percent change in weight line and then proceed horizontally across the graph.

Cement-Base Coatings—Fifteen cement-base coatings were tested. These coatings were all applied with a stiff-bristled brush and kept moist for three days. As shown by the first row of curves in Fig. 1–A the permeability of this type of coating is fairly high particularly after exposure to the carbon-arc light of the weatherometer as indicated by the steeply-climbing curves of the middle graph. The curves in the graph to the right show that the coatings are less permeable as a result of the freezing and thawing tests. This is probably due to the additional hydration of the cement in the coating, and perhaps also to the clogging of capillaries and pores, during the time the specimens were in water in the thaw part of the freeze-thaw cycle. A visual inspection of the coatings during the weathering tests showed chalking and hair-line cracking as well as some peeling to be the prevalent indications of weathering.

Coating No. 86 was an experimental coating of Type I portland cement and water which was applied to the specimens with a stiff-bristled brush in two coats, one week apart. Each coat was kept damp for seven days. The curves from the last two immersion tests for the cement-water coating were of sufficiently different slope from the rest of the curves that they were excluded from the data envelopes and drawn individually. In addition, the cement-water coating was the least permeable of the cement-base coatings in the immersion test before weathering. This curve was not drawn in the graph to the left because it fell within the curves of the data envelope and was approximately parallel to the lower curve.

Resin Solutions—Pigmented. There were 14 pigmented resin solutions included in this study. Thirteen of these were applied with paint brushes, while the fourteenth was applied with a spray gun by the manufacturer's representative. None of the coatings was waterproof, as is shown by the fairly steeply rising curves in the second row of curves on Fig. 1–A. Frequent visual inspections showed blistering, cracking, and peeling to be the chief indications of weathering.

The curves for coating No. 71 are shown in the first two graphs because they had a flatter slope than the lower curves of the data envelopes. However, the deteriorating effects of the freezing and thawing cycles were sufficient to increase further the rate of permeability so that the coating was no longer any more waterproof than the other coatings of the group; thus the curve is not shown. Coating No. 71 was an aluminum powder pigment in a resin solution.

Resin Solutions. Seven of the coatings tested were non-pigmented resin solutions. These coatings were all applied with 2-in paint brushes. Typical indications of weathering were blistering and a general dulling of the coating. The results from the three immersion tests are shown in the third row of curves on Fig. 1–A. This group of coatings was one of the least waterproof of all the groups of coatings tested, as is indicated by the steeply rising curves in each of the three graphs.

Pigment-in-Oil. There were seven coatings which were classed as pigments-in-oils. Fish oil, soy bean oil, tung oil, and linseed oil were among the oils that were used by the manufacturers of the various coatings. These coatings were all applied with 2-in paint brushes. Slight chalking and some hairline cracking were the only evidences of weathering of these coatings. Three of these coatings were fairly waterproof and two were not. The results from the three 72-hr immersion tests are shown in the fourth row of curves on Fig. 1–A. Coating No. 67 was a white house paint that was used experimentally, and the individual curves in each of the three graphs show the high degree of impermeability of this type of paint.

Pigment-in-Oil House Paint. The results that were obtained with Coating No. 67, a white house paint, led to the testing of eight additional white house paints. The curves from the immersion tests for these coatings are shown in the bottom row of curves on Fig. 1–A. They show the generally high degree of impermeability of this type of coating. Frequent visual inspections during the weathering tests revealed that a few tiny blisters had formed on six of the eight coatings during the freezing and thawing cycles.

Remaining 15 Categories of Coatings. Of the remaining 15 categories of coatings, representing a total of 52 coatings, only linseed oil (Fig. 1–C) was sufficiently impermeable to warrant further discussion. Initially the linseed oil coating had a moderate rate of permeability, but became slightly less permeable after each of the weathering tests until it was practically impermeable during the last immersion test. The linseed oil was heated to 140–160 deg F before application to obtain better penetration into the surfaces of the specimens. The coating was then applied with a 2-in brush. After the weathering tests, when the coating was the most effective, the specimen surfaces no longer had the appearance of having been painted because the oil that had remained on the surfaces when the specimens were coated had weathered away.

In the silicate of soda category there was only a single sample. The specimens for this sample were prepared by etching in a dilute acid solution, as were the specimens for all other materials tested. The manufacturer of the sample contends the results that were obtained were adversely affected by the preparatory treatment. All tests were completed and laboratory work stopped before this comment was received so no confirming tests were made.

Neutralizing Concrete Surfaces to Prevent Saponification of Paint Oils on New Construction. Oil-base and resin-base paints and linseed oil should not be used on new construction because of the alkaline nature of the water that evaporates from the structural surfaces while the concrete is drying out. The alkalies that are brought to the surface may react with the paint oils to cause blistering and softening of the coating and loss of bond between the coating and the surface. This reaction between the alkalies in the concrete and the oils is a soap-forming reaction called saponification.

Investigators for the Bureau of Reclamation reported the results of a study in 1947 of the effects of pretreating concrete surfaces with various neutralizing solutions[1] which were intended to prevent saponification. They found that a solution of 2 percent ZnCl—3 percent H_3PO_4 in water was the most effective of the solutions tested for preventing blistering and cracking of resin-base paints when applied on one side of dry, porous mortar blocks ½ in thick, which were partially immersed in water with the painted surface up. After 10 days of this partial immersion no blisters had appeared in the coating on those specimens that had been pretreated with the solution of 2 percent ZnCl—3 percent H_3PO_4, while blistering occurred within the first 24 hr on those specimens that were pretreated with either hydrochloric acid or a zinc sulfate solution. Where no pretreatment was used the blistering occurred, although it was not as severe as when hydrochloric acid or the zinc sulfate solution pretreatment was used. The

[1] *Journal*, American Concrete Institute, June, 1947, page 1077.

authors explained that the excellent results that were obtained with the 2 percent ZnCl—3 percent H_3PO_4 pretreatment were due to the insoluble salts that were deposited on the concrete surfaces. The insoluble deposit created a barrier to osmotic forces which tended to draw moisture through the coating. On the other hand, the poor results with the hydrochloric acid or the zinc sulfate solution pretreatment were due to the readily soluble salts that were deposited on the concrete surfaces, which increased the potential osmotic forces, thus causing severe blistering within the first 24 hr of the immersion tests.

To determine what effects the 2 percent ZnCl—3 perecnt H_3PO_4 pretreatment might have on the waterproofing ability and durability of oil-base and resin-base coatings when subjected to the first series of tests in this study, three such coatings were chosen from those that had been tested and these were retested with and without the 2 percent ZnCl—3 percent H_3PO_4 pretreatment. Those specimens that were not treated with the 2 percent ZnCl—3 percent H_3PO_4 solution were etched with muriatic acid according to the established procedure. The etched specimens are classed as untreated because the specimens were rinsed thoroughly to neutralize all the effects of the etching solution.

The three sets of graphs in Fig. 2 show the results of the immersion tests on 1-in by 3-in by 8-in coated specimens. The dashed lines represent the absorption curves for the treated specimens, while solid lines represent the absorption curves for the untreated specimens. The absorption curves fail to indicate any beneficial effects that may have been obtained from the pretreatment. This is shown by the fact that the treated and untreated specimens had very nearly the same rates of absorption in each of the 72-hr immersion tests for each of the 3 coatings.

Visual inspection of the coatings during the weathering tests revealed that a few small blisters formed on the surfaces of both the treated and untreated specimens that were coated with the pigment-in-oil paint. Alligator cracking appeared on the surfaces of both the treated and untreated specimens that were coated with the synthetic resin solution. There was no visible damage to the rubber-base coating on either the treated or the untreated specimens. Under the conditions of test that were used in this study the zinc chloride-phosphoric acid pretreatment had no beneficial effects on the durability of the coatings.

Second Series of Weathering Tests

The second series of weathering tests were those that were performed to establish the severity of the first series of tests and to develop additional information about the durability of permeable and impermeable coatings. The data are presented graphically in Figs. 3 through 7, and again in tabular form in Tables 2 through 5.

1000 hr of Exposure to the Carbon-Arc Light of the Weatherometer and 300 Cycles of Freezing and Thawing. The first 2 tests that were performed were (1) exposure to carbon-arc light for 1000 hr of 1 face of 1-in by 3-in by 8-in coated specimens, and (2) exposure to 300 cycles of freezing and thawing of 1-in by 3-in by 8-in coated specimens. These two tests were run to establish the relative severity of the first series of weathering tests. The results are presented concurrently to facilitate discussion. In general, the results indicate that the 150 hr in the carbon-arc weatherometer and the 50 cycles of freezing and thawing were mild tests when viewed in the light of the amount of weathering necessary to produce failure of the coatings in either of these more extensive tests.

Figs. 3–A through 3–E show the data from immersion tests that were run during the tests. The left half of each graph shows the data from the specimens in the 1000-hr carbon-arc light exposure of the weatherometer, and the right half shows the data from the specimens in the 300 cycles of freezing and thawing. Dashed-line curves show the data from the immersion test before being exposed to weathering, and the solid-line curves show the data for immersion tests during and after the weathering tests.

Seventy-two hour immersion tests were performed after each 100 hr of exposure to the carbon-arc light of the weatherometer and after each 50 cycles of freezing and thawing. Only those curves are shown which convey information about changes in the permeability or durability of the coatings, except in each case the curves for the first and the last immersion tests are shown.

Fig. 3–A shows the results for the three cement-base coatings that were tested. A general observation would be that the coatings were damaged more by the carbon-arc light of the weatherometer than they were by the freezing and thawing cycles, which is what would be expected of a cementitious coating. Typical failures of the cement-base coatings in these weathering tests were chalking and random hair-line cracking in the weatherometer test, and loss of bond and flaking off the surface in the freezing and thawing test.

Fig. 3–B shows the results for the three pigmented resin solutions that were tested. For these coatings the freezing and thawing cycles was the more severe weathering test. There was no visible damage of the three coatings in the weatherometer test, whereas excessive chalking and cracking occurred in the freezing and thawing test.

Fig. 3–C shows the results for the two pigment-in-oil coatings and the two wax solutions. The action of the carbon-arc light of the weatherometer seemed to be beneficial to the pigment-in-oil coatings and even the freezing and thawing cycles did not produce any marked changes in the permeability of the coatings. One of the coatings was not visibly damaged in either of the weathering tests, while the other was completely destroyed in each. The destruction of the second coating was caused by an upset of the pigment-in-oil-drier ratio of the coating because of evaporation and frequent use. At the time the coating was used in these tests a fresh sample could not be obtained.

The two wax solutions behaved quite similarly in the weathering tests. Neither was damaged very much in the weatherometer test, but both were completely ineffective after 300 cycles of freezing and thawing. The wax content of the two coatings was approximated by evaporation tests, which showed that the first coating contained 39 percent solids and the second coating contained 4 percent solids.

Fig. 3–D shows the results for three different types of coatings. These are a styrene emulsion, a finely ground iron, and linseed oil.

The styrene emulsion is seen to be ineffective as a waterproofing coating both before and after each of the weathering tests.

The permeability of the finely ground iron coating was not appreciably affected by either of the weathering tests, as is shown by the similarity of position and slope of the curves from immersion tests before and after the weathering tests.

Referring to the lower graph, it is seen that the effects of the carbon-arc light of the weatherometer were actually beneficial to the linseed oil coating, and no significant change took place during the freezing and thawing test. A comparison of the curves on Fig. 3–A through Fig. 3–E shows that linseed oil was the most effective of those coatings subjected to these two tests. Two coats were used on the specimens for the weatherometer test, which accounts for the initial high permeability as shown by the dashed-line curve on the left. Three coats were used on the specimens for the freezing and thawing test, and a much more satisfactory rate of absorption was obtained as shown by the dashed-line curve on the right.

Fig. 3–E shows the results for a colorless solution, an amber solution, and a caulking mastic. Both the colorless solution and the amber solution had fairly good initial rates of permeability; however, both coatings failed rapidly in the two weathering tests. The caulking mastic performed well in the weatherometer test, as is shown by the curves on the left in the lower graph. The results in the freezing and thawing test, on the other hand, were disastrous. After 130 cycles the specimens beneath the tough coating crumbled apart because of expansive forces that were exerted during freezing. Apparently water was being absorbed by the specimens during the thawing part of the cycle faster than it could evaporate during the freezing part of the cycle. In a subsequent freezing and thawing test using larger specimens and a thawing temperature that was more severe, no such failure occurred and the specimens were still sound after 100 cycles.

Outdoor Absorption Test. The question was asked from time to time if coatings that were highly permeable in the laboratory immersion tests might not be just as effective as the more impermeable coatings when exposed only to rainfall and humidity changes, in other words, to outdoor weathering. To answer this question eight coatings were chosen for testing. The choice was made on the basis of the permeability of each coating in the laboratory immersion tests. Four were high-permeability coatings and four were low-permeability coatings. These were applied on 1-in by 3-in by 8-in specimens. After proper curing the coated specimens were placed on end in an outdoor exposure rack and weighed from time to time (see Illustration 6). An effort was made to weigh the specimens before and after each period of rainfall or snowfall and at frequent intervals during fair weather.

The coated specimens were left out for 66 days, from Nov. 13, 1950, to Jan. 18, 1951, and brought back to the laboratory for an immersion test to see if the permeability of the coatings had changed. After determining that there had been no appreciable change in the permeability of the coatings by comparing the curves from the immersion tests before and after the outdoor exposure, the specimens were again placed outdoors for 100 days, from Feb. 12, 1951, to May 21, 1951. During these two periods the amounts of rainfall and snowfall and the daily maximum and minimum temperature and humidity data were recorded.

Fig. 4 shows the changes in weight that occurred during the test. The dashed-line shows the average change in weight for four unpainted control specimens. The upper solid line shows the average change in weight data for the four high-permeability coatings, and the lower solid line shows the average change in weight data for the four low-permeability coatings. It is easily seen that the high-permeability coatings are more sensitive to changes in the weather than the low-permeability coatings. Also, it is evident that the high-permeability coatings are not effective as waterproofing coatings, since the specimens gain and lose weight in almost the same amounts as the unpainted control specimens.

Outdoor Weathering Test Using 1-In by 3-In by 8-In and 3-In by 4-In by 16-In Coated Specimens Half Buried in the Ground in an Upright Position. To determine what effects the contact with ground water might have on the durability of the coatings, 1-in by 3-in by 8-in specimens were coated with the 16 paints that were used in this series of tests and then half buried in the ground in a upright position (see Illustrations 5 and 6). After 14 months of weathering the specimens were removed and brought to the laboratory where they were placed in a 72-hr immersion test. The results of this test, along with those of an immersion test conducted before the weathering test, are shown on Fig. 5–A. On each graph are shown the curves from the

72-hr immersion tests for a single coating. The solid-line curves show the results from the immersion tests before, and the dashed-line curves show the results from the immersion test after, the 14 months of outdoor weathering.

The coatings which were least affected by the weathering, and at the same time were effective as waterproofing coatings, as indicated by the curves shown on Fig. 5–A, were the 3 pigmented resin solutions; 1 of the pigment-in-oil coatings; the wax solution containing 38 percent solids; and the caulking mastic.

The coatings which were significantly damaged by the 14 months of weathering were 1 of the cement-base-coatings; the wax solution containing only 4 percent solids; the unidentified colorless solution; and the unidentified amber solution.

The permeability of the remaining six coatings was sufficiently high that the waterproofing ability of the coatings was negligible.

To supplement the data from the tests just described 3-in by 4-in by 16-in specimens were coated with 13 of the 16 coatings previously used and half buried in the ground in an upright position just as the smaller specimens had been placed in the earlier tests. After a period of nine months, from June, 1950, to March, 1951, the specimens were pulled from the ground and brought to the laboratory for an immersion test.

On Fig. 5–B are shown the curves that were obtained from 72-hr immersion tests that were performed before (solid-line curves) and after (dashed-line curves) the 9 months of outdoor weathering. The parallelism of the two curves for each coating shows that, except for the colorless and amber solutions, the permeability rate for each coating was the same after the weathering as it had been before weathering. An inspection of the coatings showed that no visible damage had been done by the weathering.

Since the results of the tests using 3-in by 4-in by 16-in specimens were all fairly good it was concluded that:

1. The 3-in by 4-in by 16-in specimens were too insensitive to changes in weight to indicate significant differences in the permeability of various coatings. The 1-in by 3-in by 8-in specimens were much more sensitive and were considerably easier to handle.

2. The nine months of weathering was too short a period to produce any changes in the permeability of the coatings, and a much longer period would be necessary before any measurable deterioration would occur.

3. Such a test procedure would be useless as a short-term test to evaluate the durability and waterproofing ability of a coating.

The original intent was that these 3-in by 4-in by 16-in specimens would be returned to the outdoor weathering test, but when it was realized that no useful data would be obtained within a reasonable length of time they were kept in the laboratory and placed in a freezing and thawing test to supplement and substantiate the data from another group of specimens.

Laboratory Freezing and Thawing Test on 3-In by 4-In by 16-In Coated Specimens. One further question remained to be answered in the investigation of impermeable versus permeable waterproofing. How would each type of waterproofing affect the durability of concrete when exposed to weathering conditions that would normally cause rapid deterioration of unprotected concrete? In all the previous tests the highly impermeable coatings, more specifically the pigment-in-oil coatings in which the vehicle was principally linseed oil, and the linseed oil coatings, had shown good durability and had retained a high degree of impermeability through all the weathering tests more consistently than any of the other types of coatings. It remained to be seen whether or not these coatings would protect from deterioration the concrete specimens on which they were used when the specimens were subjected to cycles of freezing and thawing. It was reasoned that the impermeability of the pigment-in-linseed oil coatings and of the linseed oil coatings would prevent the absorption of water in sufficient amounts to be harmful during freezing and thawing cycles. It was expected, therefore, that the coatings would cause the specimens to be more durable than the unpainted control specimens. The unknown factor in the investigation was what effect the permeable coatings would have on the durability of the concrete specimens on which the coatings were used.

For this investigation a series of 3-in by 4-in by 16-in specimens was fabricated and coated with 7 of the 16 paints which had been chosen for the additional series of tests of which this test was a part. A coarse aggregate of very poor quality was used in the concrete mix to make certain that the unpainted control specimens would fail within 40 to 60 cycles of freezing and thawing. The concrete specimens were 28 days old when they were coated, and the coatings were dried 5 days at 90 deg F before the specimens were placed in the freezing and thawing test.

Specimens from three concrete mixes were used for this test and it soon became apparent that no comparison of the durability of the specimens from another mix could be made because the losses in strength of the control specimens for the mixes were not comparable. The discrepancy in the durability of specimens from duplicate concrete mixes had not been anticipated; however, it was believed that the quality of the coarse aggregate was sufficiently variable to cause most of the discrepancy, so it was decided to repeat the test using concrete containing a coarse aggregate of exceptionally good quality. It was expected that less variability in the durability of concrete mixes would result from the use of the better quality aggregate.

For the second freezing and thawing test the specimens were used which had previously been subjected to nine months of outdoor exposure half buried in the ground in an upright position. The results of immersion tests before and after the outdoor weathering had shown that the permeability of all but two of the coatings did not change or had changed for the better. The use of these specimens saved approximately two months of time which would have been necessary to fabricate and cure the necessary specimens and to apply the coatings and allow them to cure before the freezing and thawing cycles could be initiated.

Thirteen coatings were tested involving concrete specimens from four mixes. Extremely uniform rates of deterioration and of absorption were obtained on the control specimens from three of the four mixes. No control specimens were provided for the fourth mix; however, it duplicated in every way the other three mixes and it was assumed that control specimens for that mix would have shown similar results to those for the other three mixes. Fig. 6 shows the average results from the freezing and thawing test on the control specimens from the three mixes. The upper half of the figure shows the loss in dynamic modulus of elasticity, and the lower half shows the changes in weight for the control specimens during the cycles of freezing and thawing. The uniformity of the results is readily apparent.

The specimens were placed in the freezing and thawing test immediately after the 72-hr immersion test that was performed in connection with the previous outdoor weathering; consequently the control specimens began the freezing and thawing test in a near-saturated condition. The degree of saturation for the coated specimens at the beginning of the freezing and thawing test varied, depending on the permeability of the coatings during the immersion test.

The dynamic modulus of elasticity and the weight of each specimen were determined at frequent intervals of freezing and thawing cycles using equipment similar to that to be found in any fairly large testing laboratory. Tests in our own laboratory have shown that a loss of 30 percent of the dynamic modulus of elasticity is roughly equivalent to a fifty percent loss in flexural strength, which is well beyond the condition for sound concrete. The 30 percent loss in dynamic modulus of elasticity is used in this discussion as a basis of comparison of the relative durability of the specimens on which the different coatings were used.

The upper half of Fig. 7–A shows the results that were obtained with three cement-base coatings, and the lower half shows the results that were obtained with two pigmented-resin solutions. The data are shown in the same manner as the data for the control specimens in Fig. 6, i.e., the loss in dynamic modulus of elasticity data are shown in the upper portion of each graph, and the change in weight data are shown in the lower portion. The dashed-line curves which show the results for control specimens are identical for each of the graphs for Figs. 7–A through 7–C, and are the average of the curves for the control specimens as shown on Fig. 6.

A study of the upper graph, which shows the results for the cement-base coatings, reveals a characteristic which was common to all of the highly permeable coatings; i.e., the coatings actually caused a more rapid rate of deterioration than if the coatings had not been used. This fact is clearly shown by the more rapid loss in "E" for the coated specimens than for the unpainted control specimens. It took 80 cycles of freezing and thawing to reduce the dynamic modulus of elasticity of the control specimens by 30 percent, while it took only 44, 55 and 57 cycles of freezing and thawing to produce the same loss for the 3 cement-base coatings.

The curves for the change-in-weight data are of significance in that they show at what rate the specimens approached complete saturation, as approximated by the zero percent change-in-weight line.

The curves for the loss in "E" data for the pigmented-resin solutions in the upper portion of the lower graph show the coated specimens to be more durable than the control specimens until the coated specimens had reached a highly saturated condition, as is shown by the change-in-weight curves in the lower graph, whereupon the coated specimens failed rapidly. The specimens that were coated with the two pigmented-resin solutions lost 30 percent of "E" in 59 and 77 cycles of freezing and thawing compared to 80 cycles for a comparable loss for the control specimens, as previously stated.

The upper half of Fig. 7–B shows the very good durability of the two pigment-in-oil coatings. The flat slope of the change-in-weight curves for the coated specimens reflects the low rate of permeability of each of the coatings. The low rate of permeability of the coatings prevented the saturation of the specimens and was directly responsible for the good durability that was obtained.

The lower half of Fig. 7–B shows the results that were obtained when a wax solution and a finely ground iron coating were used. Only 69 cycles of freezing and thawing were required to reduce by 30 percent the dynamic modulus of elasticity of the coated specimens.

In the upper half of Fig. 7–C are shown the results of tests when linseed oil, or the unidentified colorless solution, were used as waterproofing coatings. The loss in "E" curves shows the linseed oil coating to contribute considerably to the durability of the specimens on which it was used when compared to the durability of the unpainted control specimens. On the other hand, the colorless solution caused earlier deterioration than if no coating at all had been used. The reason, as before, was the permeability of the two coatings, as shown by the change-in-weight curves. Only 53 cycles of freezing and thawing were required to cause a 30 percent loss in "E" for the specimens that were coated with the colorless solution.

In the lower half of Fig. 7–C are shown the results of tests when the caulking mastic and the unidentified amber solution were used as coatings. Here again the use of a highly impermeable coating—the caulking mastic—resulted in excellent durability, while the use of a highly permeable coating—the amber solution—resulted in more rapid loss in "E" than if no coating had been used. Only 56 cycles of freezing and thawing were required to cause a loss in "E" of 30 percent when the amber solution was used as a waterproofing coating (see Illustration 7 for visible damage that occurred during freezing and thawing test).

From the results of the freezing and thawing test it is evident that the impermeable, or nearly impermeable, type of coating is the only type of coating which can be used successfully as a waterproofing coating wherever freezing and thawing is a common cause of concrete deterioration. This statement must be qualified of course, as it was in the introduction, by saying that the concrete must have no other source of moisture than those surfaces that are to be waterproofed.

1–1/2 Years of Outdoor Exposure of 9-Sq Ft Test Panels. To determine the relative durability of permeable and impermeable coatings 14 of the 16 coatings that were chosen for the additional series of tests were applied on the surfaces of the south-facing wing walls of an overpass structure in July 1950 (see Illustrations 8, 9 and 10). The two coatings which were not used were the styrene emulsion and the caulking mastic.

The concrete surfaces were prepared by etching with a 15 percent muriatic acid solution and rinsing with water 2 days before the coatings were applied. The coatings were then applied on an area measuring 9 sq ft, in the number of applications that were recommended by each manufacturer.

After a year and a half the two pigment-in-oil coatings appear to be intact. The linseed oil coating had hardened and chalked off the surface by the end of the first year, leaving no signs of the surface having been coated. Similar results were obtained in all the laboratory tests in which linseed oil was used, and the fact that the coating is gone from the surface does not mean that it is no longer effective as a waterproofer. On the other hand the colorless solution and the amber solution had also chalked until the surface no longer appeared to have been coated, and with these two coatings the laboratory tests clearly indicated that the effectiveness as waterproofing coatings was lost when the coating was no longer visible on the surface.

The most extensive damage has occurred on one of the cement-base coatings, where between 5 and 7 percent of the surface area has developed isolated, long hair-line cracks, or the bond between the surface and the coating has been lost. The other two cement-base coatings were beginning to show the same sort of deterioration, but not as extensively as the first.

One of the pigmented-resin solutions has cracked and loosened from the surface in isolated areas. The other two pigmented-resin solutions are weathering in the same manner but to a lesser extent.

The two wax solutions have chalked until the surface has returned to its original appearance, and presumably some of the effectiveness as a waterproofing coating has been lost, although it is intended that the coatings should penetrate into the surface and seal off pores and capillaries rather than to form a protective surface coating.

The iron coating appears to be intact after a year and a half, but laboratory tests have shown that the coating is highly permeable, and it is extremely doubtful if it is acting as a waterproofer.

The results after a year and a half of weathering indicate that the impermeable pigment-in-linseed-oil coatings are more durable than the more permeable types of surface coatings that form protective films on the concrete surface.

The writer would recommend to those who are planning to waterproof a structure that slab-like concrete specimens measuring 6 in by 6 in by 2 in or 8 in by 8 in by 2 in be fabricated and allowed to cure for 28 days in water and dried for at least a month, and then be coated with the coating to be used on the structure, and preferably at the same time. The coated specimens should then be placed in a container surrounded by insulation so that only one 6-in by 6-in or 8-in by 8-in face is exposed. At least three such specimens should be used.

When the structure is waterproofed, the coated specimens imbedded in the protective frame should be placed at the site and left to weather right along with the coating on the structure. When the question arises as to whether or not the structure should be repainted, the specimens can be taken into a laboratory and placed in an immersion test of perhaps 96-hr duration to determine whether or not the coating is still effective as a waterproofer. If the coating is still waterproof, as indicated by the specimens, then perhaps only minor repairs would be necessary on isolated spots of deterioration. If the coating is no longer waterproof, then it is time to repaint the structure, and the results of such a test should make this fact known.

CONCLUSIONS

When the results of all the tests are reviewed together, the following conclusions appear to be valid.

1. The impermeable type of coating can be applied satisfactorily to concrete surfaces that are exposed to severe outdoor weathering so long as all the surfaces that are subject to moisture absorption can be coated.

2. The impermeable type of coating is superior to the permeable type of coating in preventing the passage of moisture, in either the vapor or the liquid form, in total immersion tests, or in outdoor absorption tests.

3. The impermeable type of coating is superior to the permeable type of coating from the standpoint of the durability of the coating, as well as the durability of the concrete when the coated concrete is subjected to freezing and thawing.

4. The impermeable type of coating is more durable than the permeable type of coating when applied to structures, as is evidenced by the results of tests in which coatings were applied to the south-facing wing walls of an overpass structure.

5. Only 2 of the 85-commercial waterproofing coatings that were tested were sufficiently waterproof to be classed as impermeable. These were both pigmented linseed oil coatings.

6. Nine pigmented-oil house paints used experimentally showed good durability and waterproofing ability when subjected to the first series of weathering tests. These results were substantiated by data on one of these from the second series of weathering tests. Two undercoats and one finish coat were used.

7. Linseed oil used experimentally showed good results in both the first and second series of weathering tests when 3 coats were applied at 140–160 deg F.

8. A specification for waterproofing coatings can be written on the basis of the results of this investigation, which would involve some sort of weathering procedure, coupled with before-weathering and after-weathering immersion tests that would insure the use of a coating which was initially effective, which would be durable during the weathering test, and which would retain its effectiveness as a waterproofing coating.

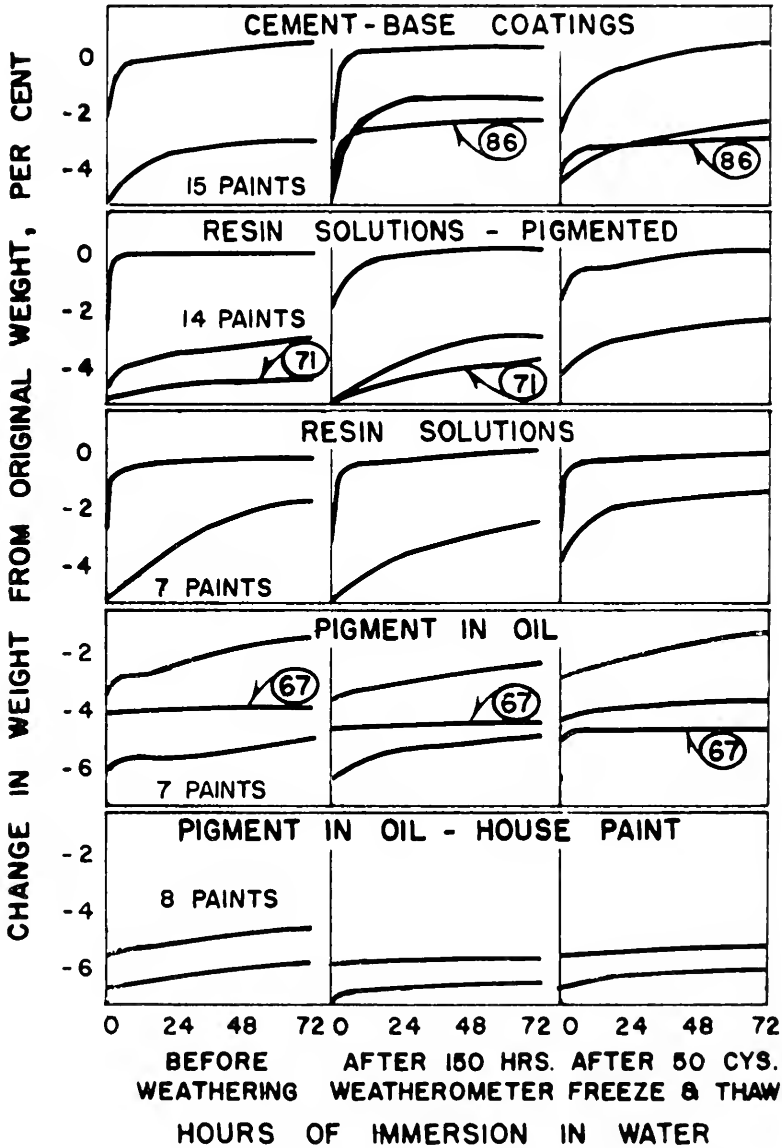


FIG. 1-A—RESULTS OF 72-HR. IMMERSION TESTS ON 1×3×8-IN. COATED SPECIMENS BEFORE AND AFTER EACH SUCCESSIVE WEATHERING TEST.

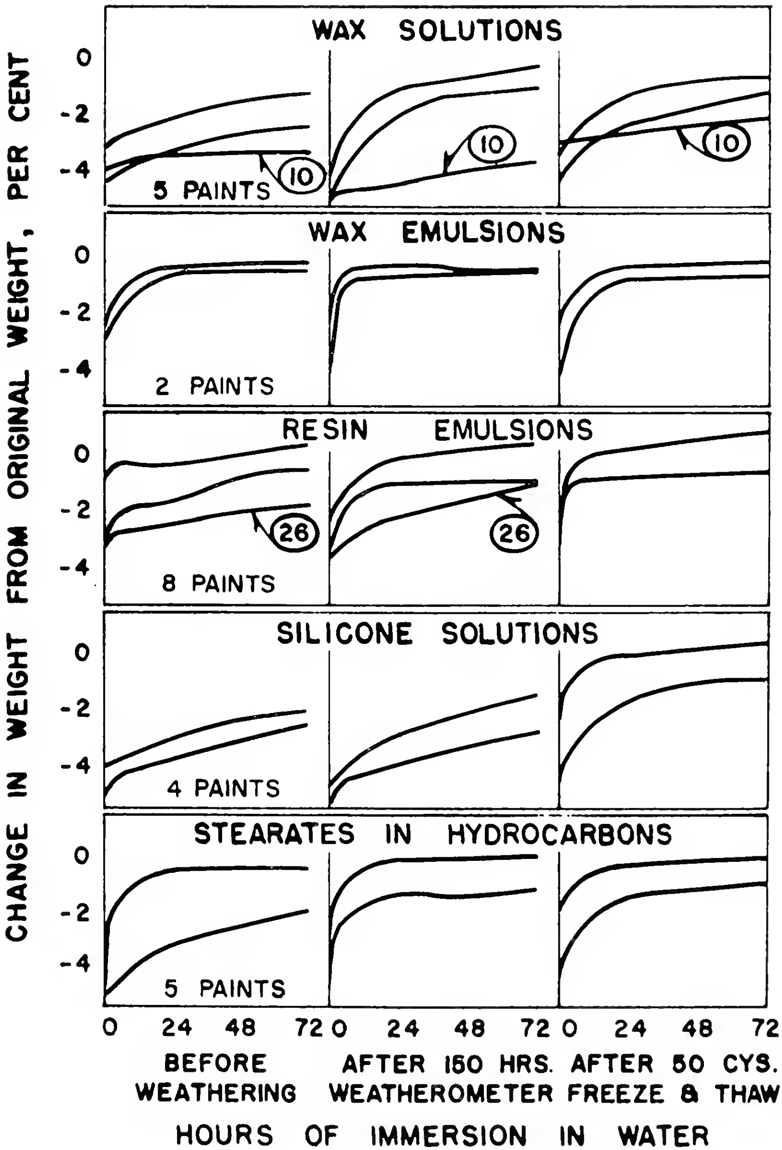


FIG. 1-B—RESULTS OF 72-HR. IMMERSION TESTS ON 1 x 3 x 8-IN. COATED SPECIMENS BEFORE AND AFTER EACH SUCCESSIVE WEATHERING TEST.

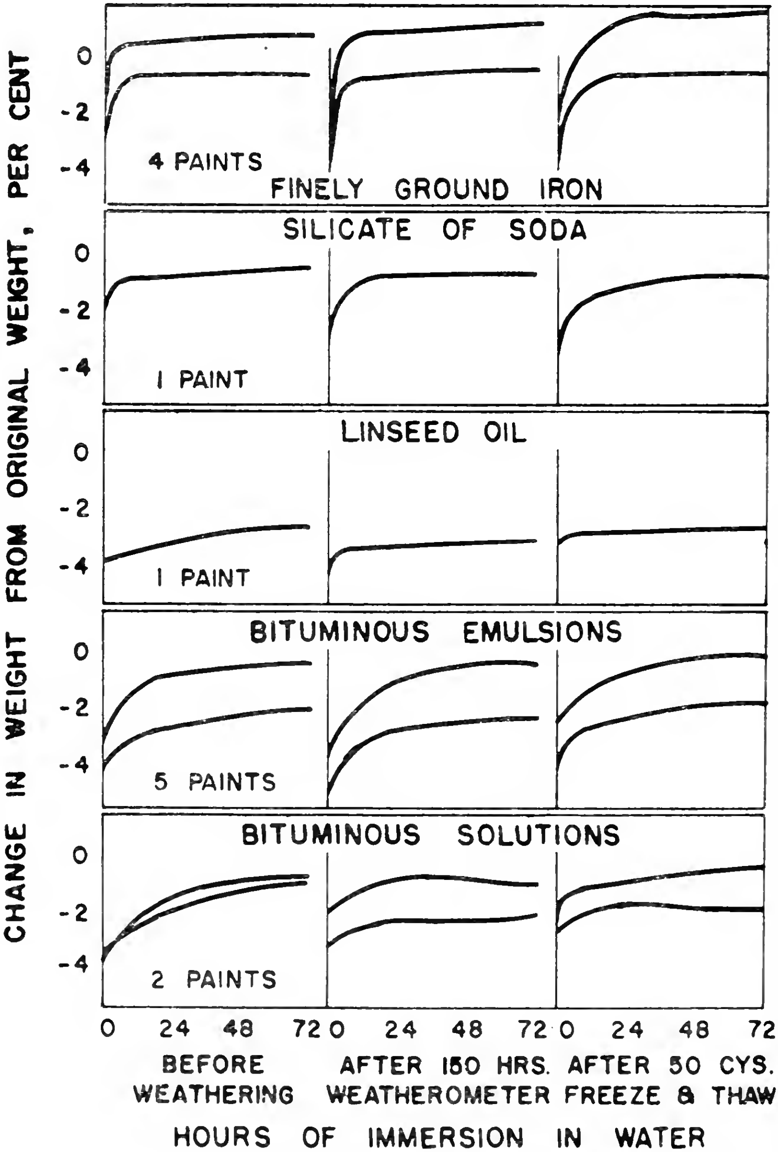


FIG. 1-C—RESULTS OF 72-HR. IMMERSION TESTS ON 1 x 3 x 8-IN. COATED SPECIMENS BEFORE AND AFTER EACH SUCCESSIVE WEATHERING TEST.

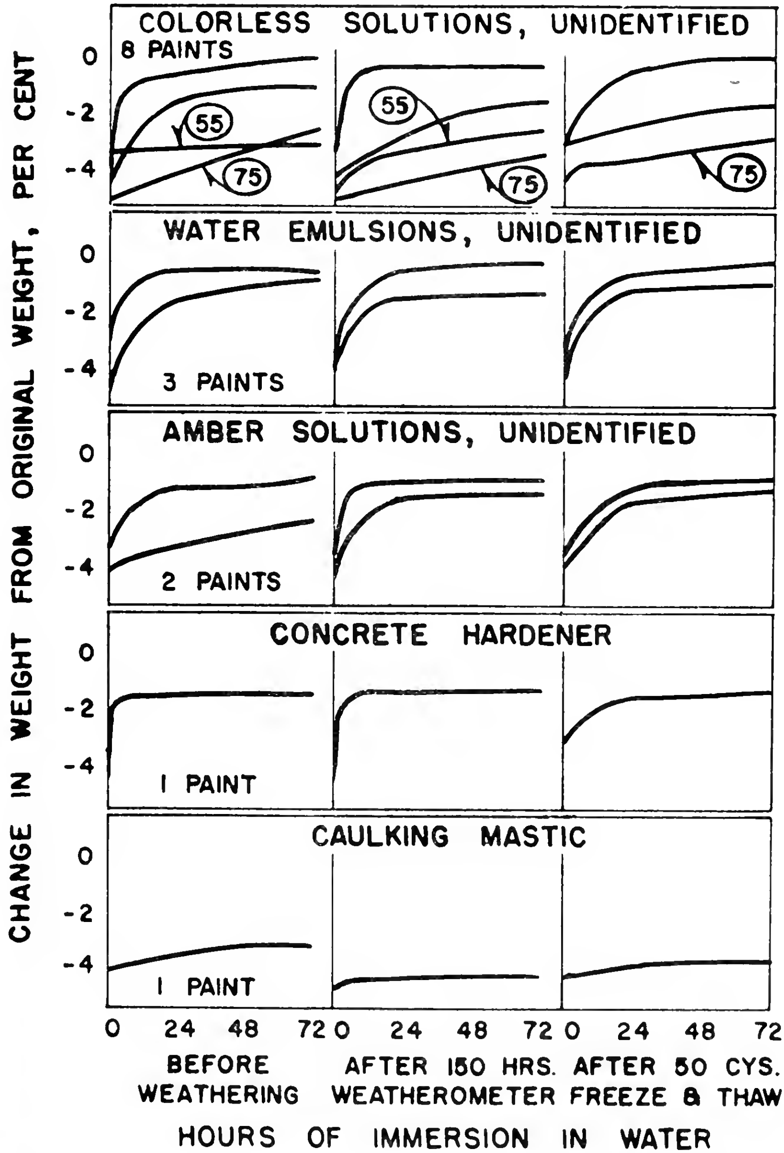


FIG. 1-D—RESULTS OF 72-HR. IMMERSION TESTS ON 1×3×8-IN. COATED SPECIMENS BEFORE AND AFTER EACH SUCCESSIVE WEATHERING TEST.

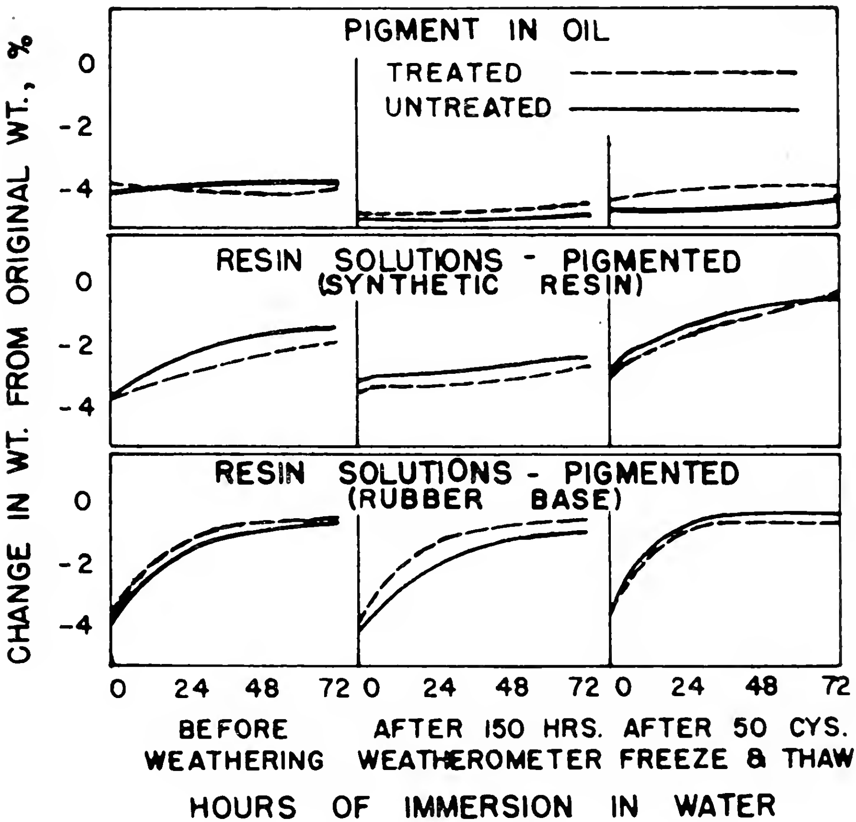


FIG. 2 — EFFECT OF 2% ZnCl - 3% H_3PO_4 PRETREATMENT ON THE WATERPROOFING ABILITY OF THREE DIFFERENT TYPES OF COATINGS AS SHOWN BY 72-HR. IMMERSION TESTS ON 1×3×8-IN. COATED SPECIMENS.

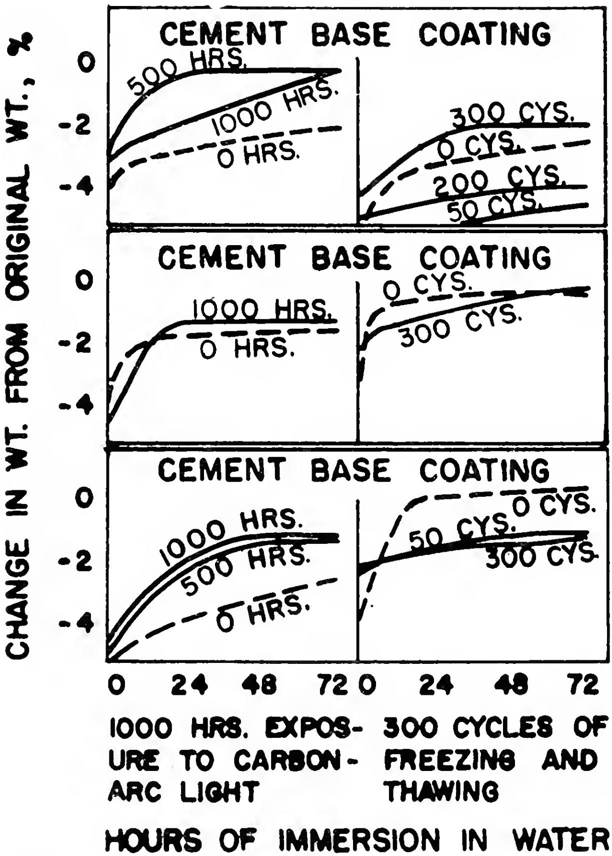


FIG. 3-A—EFFECT OF EXTENSIVE EXPOSURE TO CARBON-ARC LIGHT AND TO CYCLES OF FREEZING AND THAWING ON THE WATER-PROOFING ABILITY OF COATINGS.

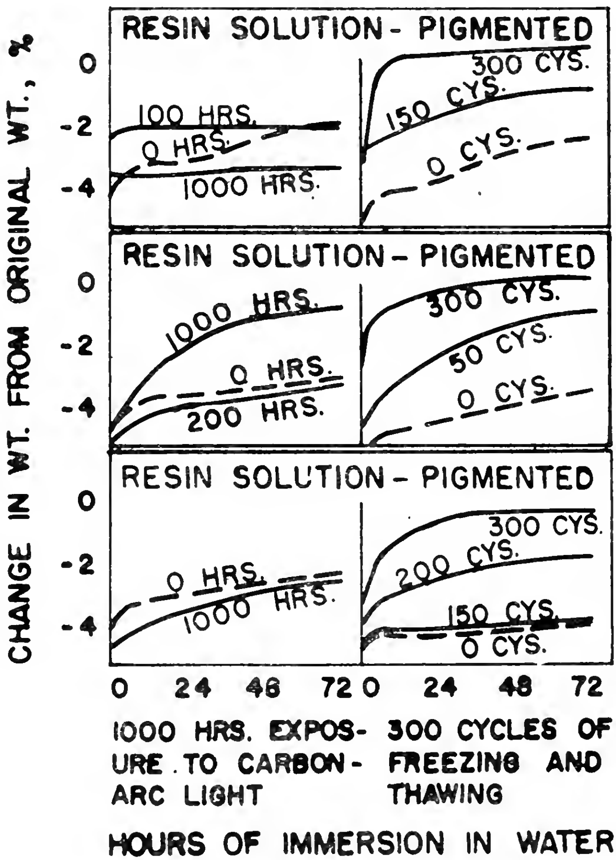


FIG. 3-B—EFFECT OF EXTENSIVE EXPOSURE TO CARBON-ARC LIGHT AND TO CYCLES OF FREEZING AND THAWING ON THE WATERPROOFING ABILITY OF COATINGS.

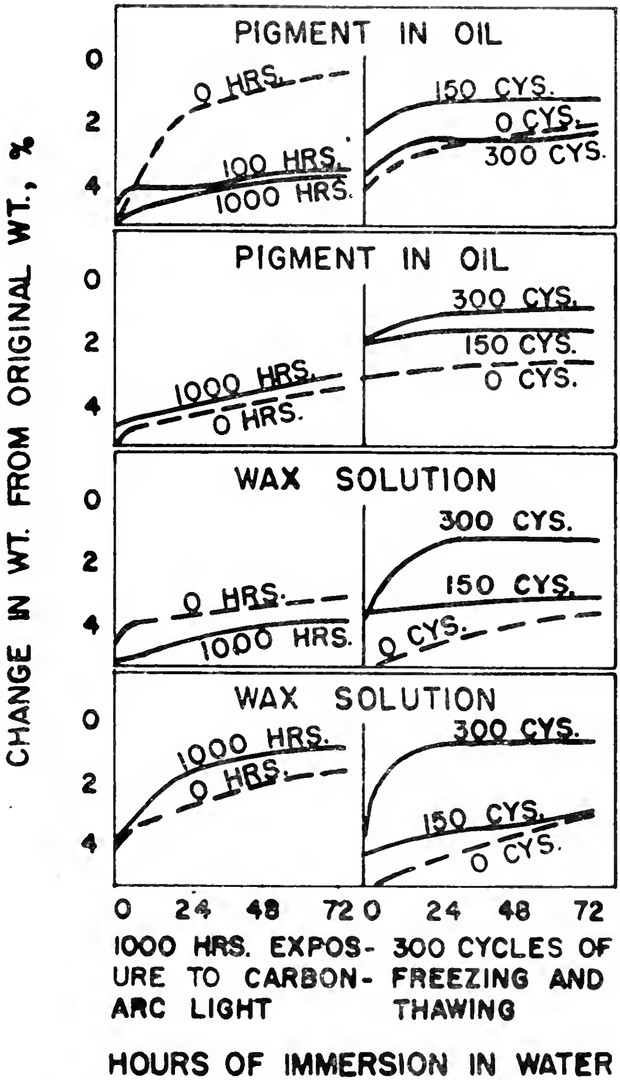


FIG. 3-C—EFFECT OF EXTENSIVE EXPOSURE TO CARBON-ARC LIGHT AND TO CYCLES OF FREEZING AND THAWING ON THE WATERPROOFING ABILITY OF COATINGS.

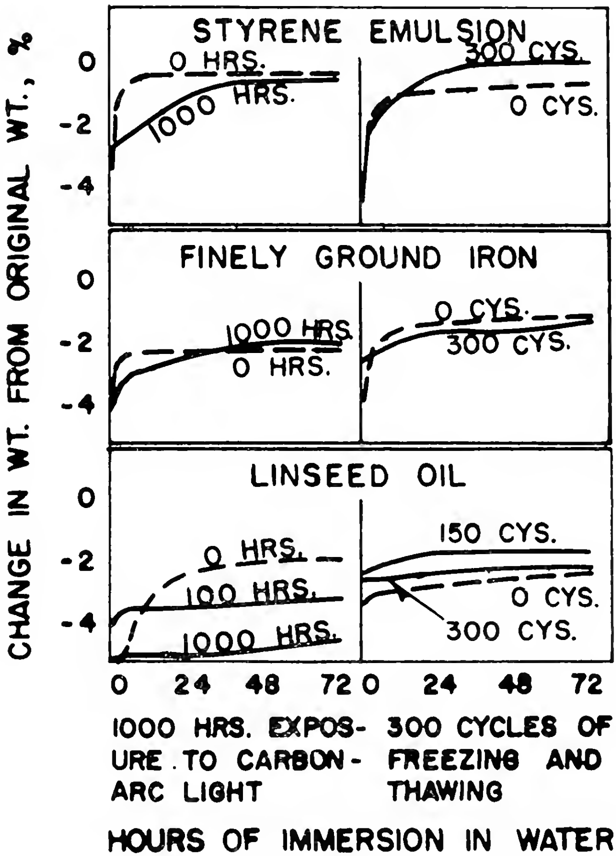


FIG. 3-D—EFFECT OF EXTENSIVE EXPOSURE TO CARBON-ARC LIGHT AND TO CYCLES OF FREEZING AND THAWING ON THE WATER-PROOFING ABILITY OF COATINGS.

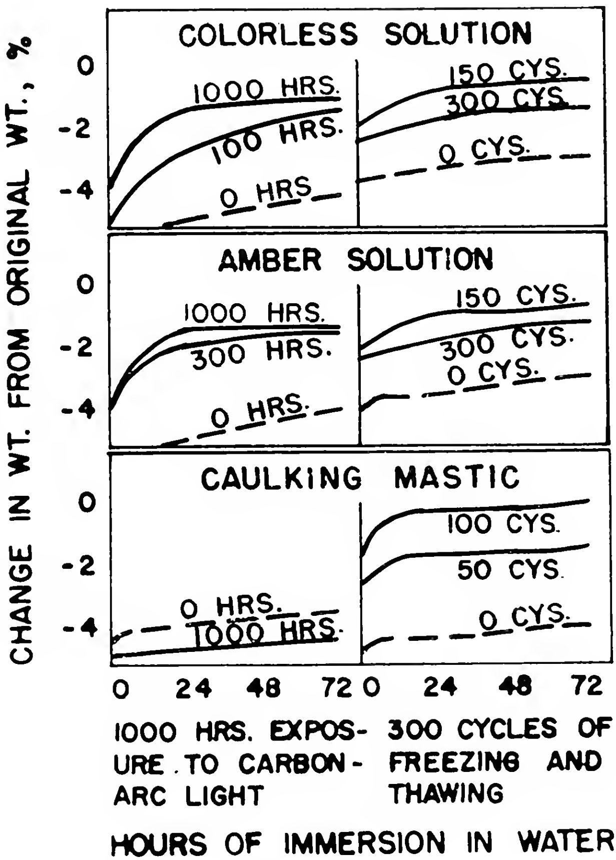


FIG. 3-E—EFFECT OF EXTENSIVE EXPOSURE TO CARBON-ARC LIGHT AND TO CYCLES OF FREEZING AND THAWING ON THE WATER-PROOFING ABILITY OF COATINGS.

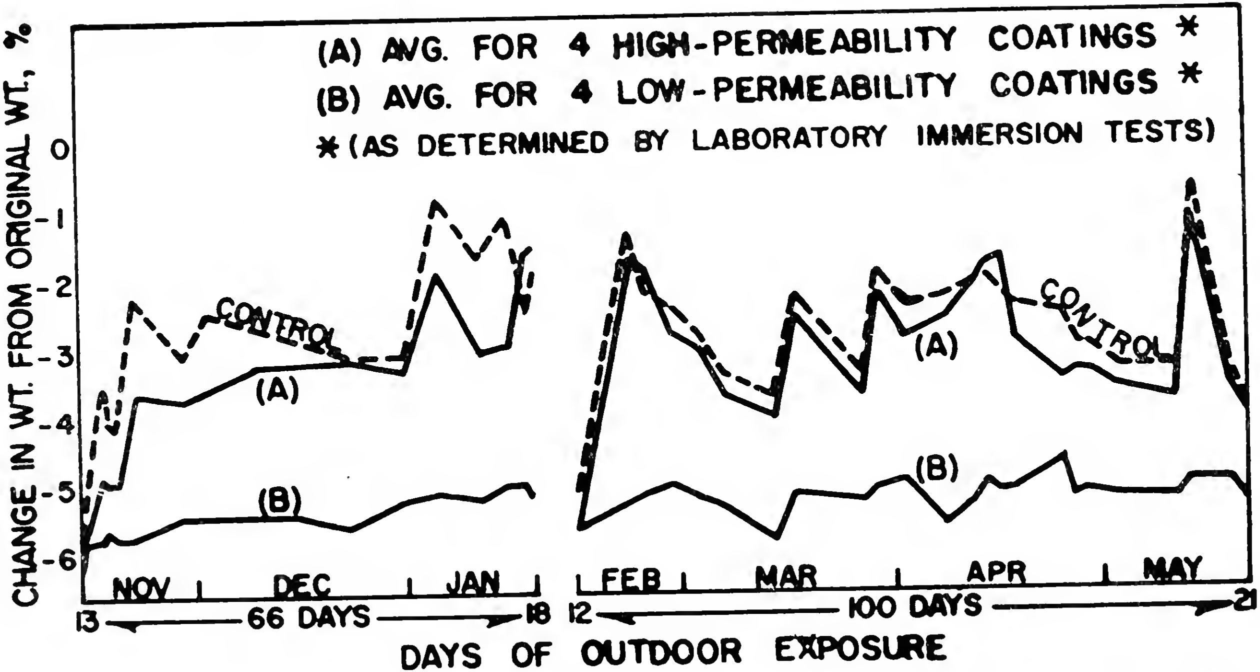


FIG. 4 — COMPARISON OF THE WATERPROOFING ABILITY OF COATINGS WHEN EXPOSED TO THE WEATHER USING 1 x 3 x 8-IN. COATED SPECIMENS SET ON END ON AN OUTDOOR TEST RACK.

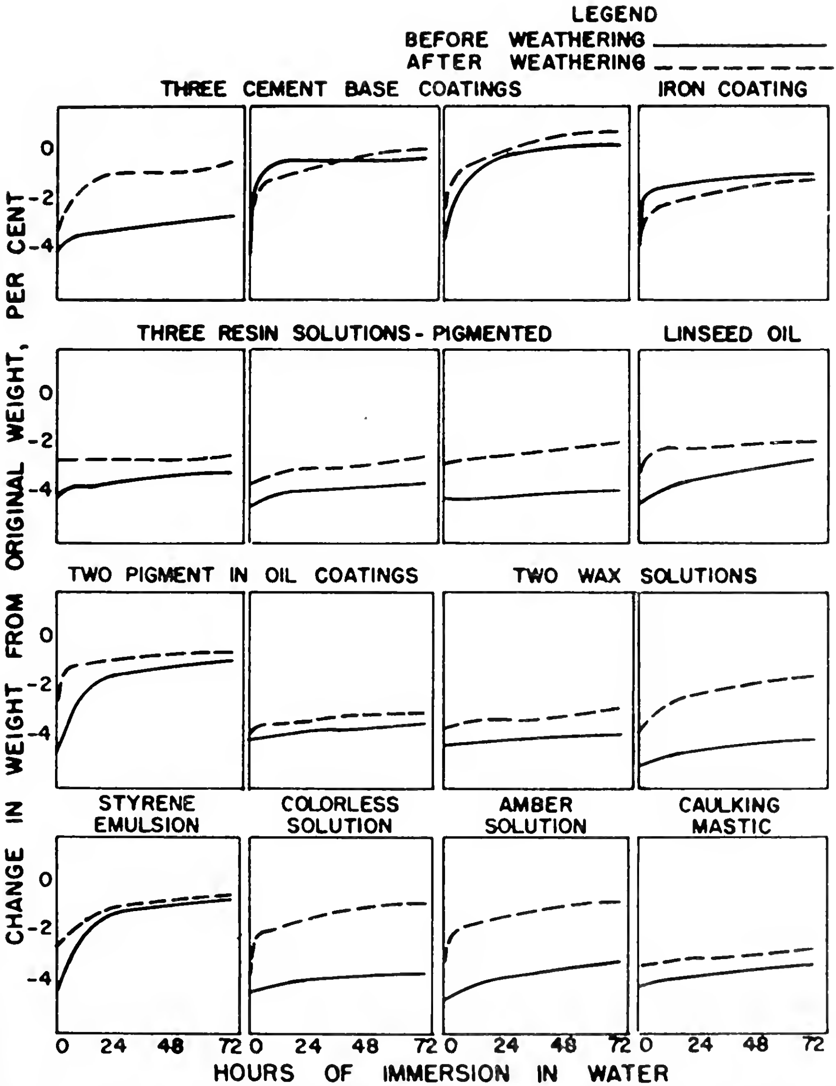


FIG. 5-A—EFFECT OF 14 MONTHS OF OUTDOOR WEATHERING ON THE PERMEABILITY OF TEN TYPES OF COATINGS USING 1 x 3 x 8-IN. COATED SPECIMENS HALF-BURIED IN THE GROUND IN AN UPRIGHT POSITION.

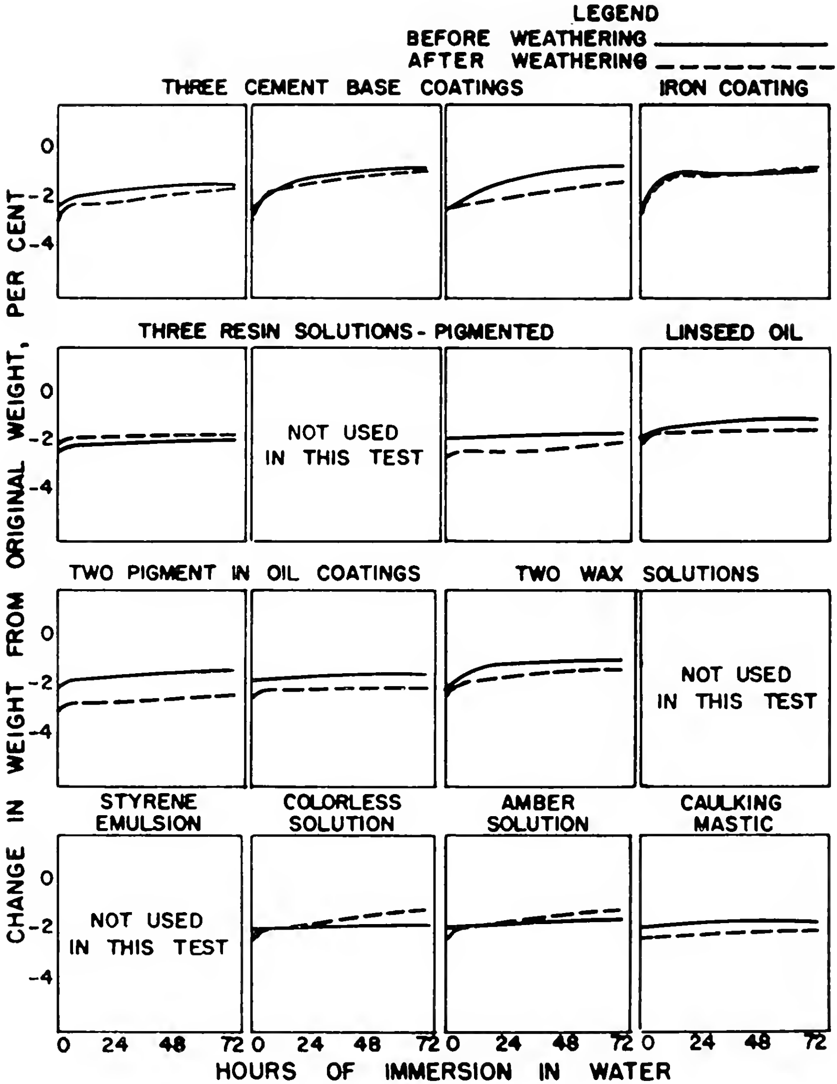


FIG. 5-B—EFFECT OF 9 MONTHS OF OUTDOOR WEATHERING ON THE PERMEABILITY OF NINE TYPES OF COATINGS USING 3 x 4 x 16-IN. COATED SPECIMENS HALF-BURIED IN THE GROUND IN AN UPRIGHT POSITION.

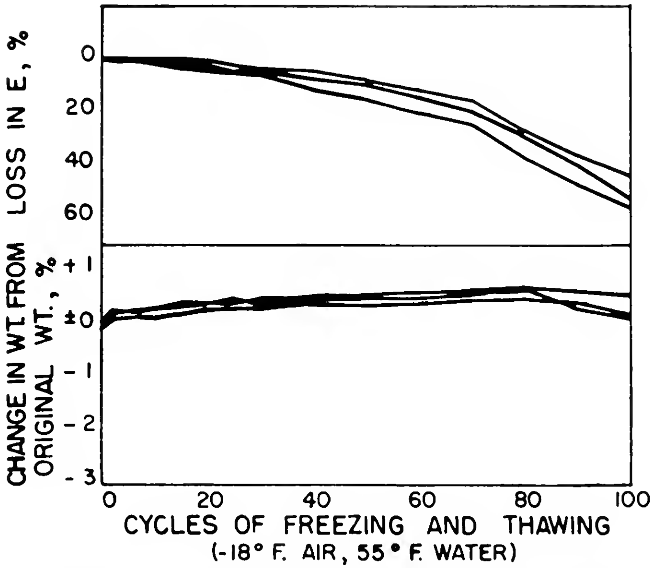


FIG. 6— RESULTS OF FREEZING AND THAWING CYCLES ON UNPAINTED 3 x 4 x 16-IN. CONTROL SPECIMENS FROM THREE MIXES SHOWING THE UNIFORMITY OF RESULTS THAT WERE OBTAINED.

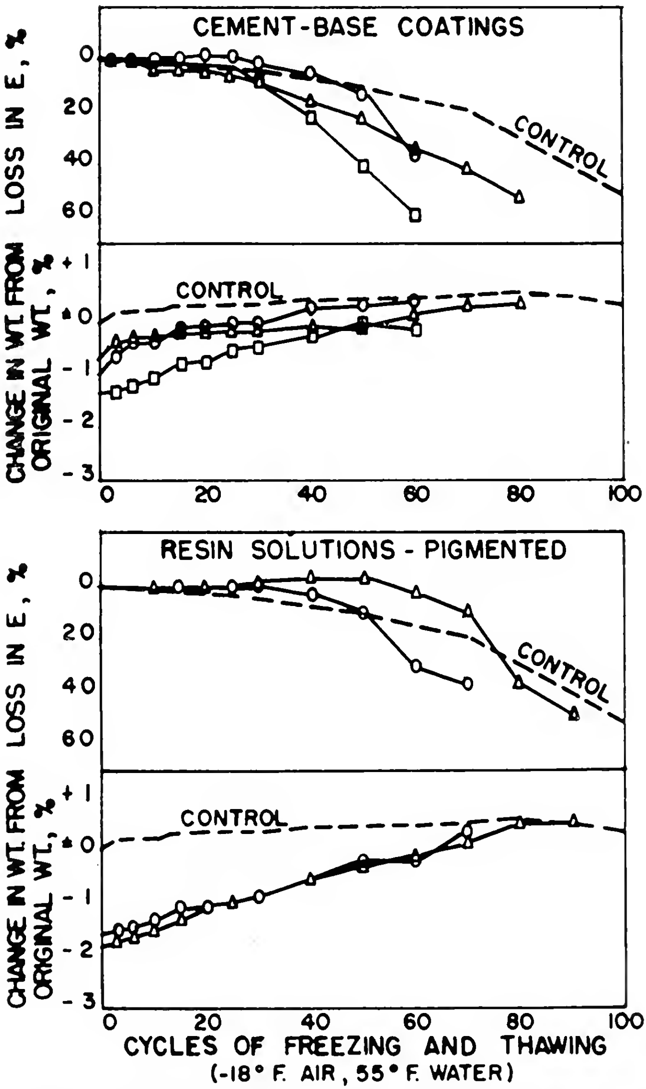


FIG. 7-A—RESULTS OF FREEZING AND THAWING CYCLES ON 3 x 4 x 16-IN COATED SPECIMENS COMPARED WITH THE RESULTS ON UNCOATED CONTROL SPECIMENS.

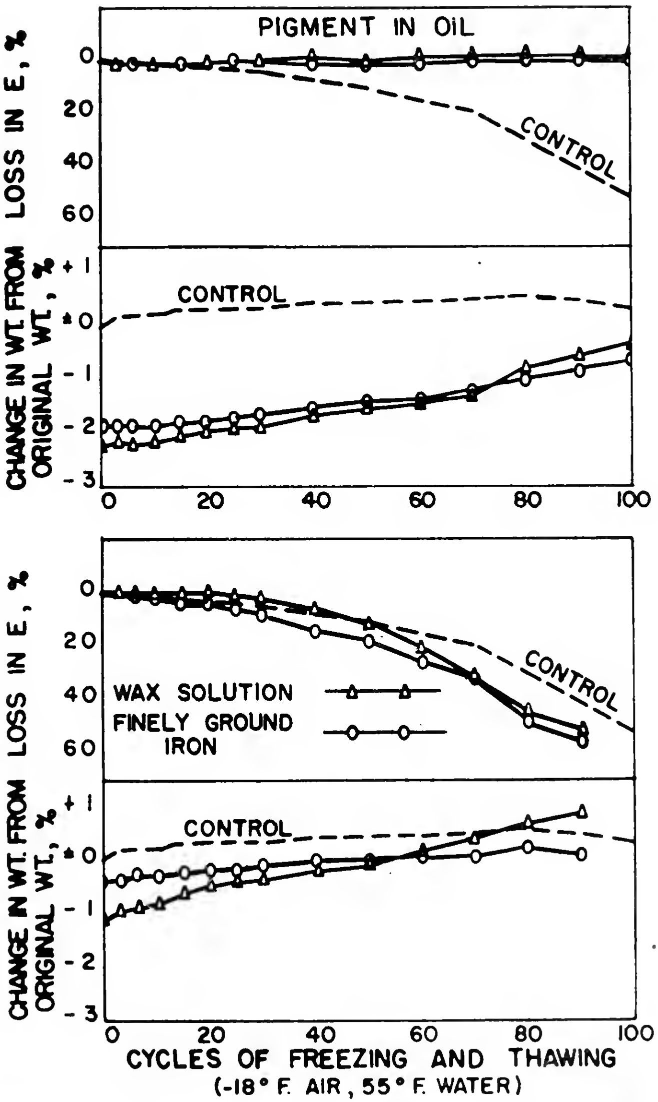


FIG. 7-B—RESULTS OF FREEZING AND THAWING CYCLES ON 3 x 4 x 16-IN COATED SPECIMENS COMPARED WITH THE RESULTS ON UNCOATED CONTROL SPECIMENS.

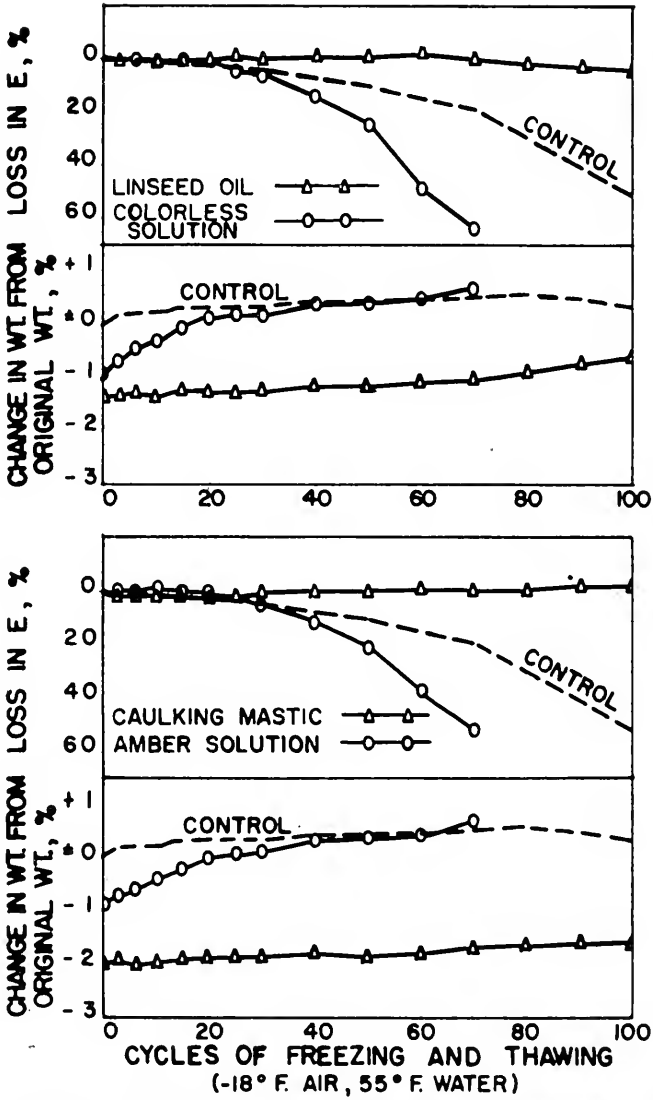


FIG. 7-C—RESULTS OF FREEZING AND THAWING CYCLES ON 3 x 4 x 16-IN COATED SPECIMENS COMPARED WITH THE RESULTS ON UNCOATED CONTROL SPECIMENS.

Advance Report of Committee 30—Impact and Bridge Stresses

Description and Analysis of Impact Tests Made on Reinforced Concrete Bridges Under Diesel and Steam Locomotives

DIGEST

This report embraces a description and analysis of tests made on 3 reinforced concrete pile trestles with test spans varying in length from 19 ft to 19 ft 3½ in and on a reinforced concrete 4-span continuous structure, the end spans having a length of 33 ft and the 2 center spans a length of 38 ft 3 in. The tests were made under both diesel and steam locomotives operating over a complete range of speeds from 5 mph up to a maximum of 80 mph. The purpose of the tests was to determine the static and dynamic effects of diesel and steam locomotives operating over concrete bridges at a complete range of speeds. Stresses were measured under 194 diesel locomotives and 492 steam locomotives, or a total of 686 locomotive test runs on the 4 bridges.

The stresses were measured by means of electro-magnetic and wire resistance strain gages, with oscillograph recordings, in various parts of the bridges, and data on the following were obtained:

Top of the curbs at the center of the simple spans.

Slabs at the center of the simple and continuous spans and slabs near the supports of the continuous spans.

Compressive reinforcing bars at the center of the simple spans.

Tensile reinforcing bars at the center of the simple and continuous spans and over the supports of the continuous spans.

Tensile concrete at the center of the simple spans.

Concrete piles near the ground line of the simple spans.

Concrete columns of the continuous spans.

Running rails.

The data secured during these tests were analyzed for the purpose of determining the static stresses, maximum stresses, total impacts effects, lateral forces and longitudinal forces. A brief summary of the data follows:

1. The recorded simultaneous strains in the concrete and reinforcing bars on the tension side of the slab under the diesel and steam locomotives showed that the concrete was carrying part of the tensile stresses. A comparison of the simultaneous tensile strains recorded in the concrete and reinforcing bars are shown by the diagrams of Fig. 134.
2. The recorded static stresses in the concrete and reinforcing bars of the slabs were appreciably lower than the calculated stresses, based on the usual assumption that the concrete is not taking any tension, and were generally lower than those calculated on the basis that the concrete is taking tension. A comparison of the recorded and calculated static stresses in the slabs is shown in Tables 2, 4, 6 and 8.
3. The low recorded static stresses in the reinforcing bars of these bridges were in agreement with those recorded in laboratory specimens under comparable loads, as is shown by the diagram of Fig. 27.

4. A comparison of the recorded and calculated static stresses in the piles of the trestles and columns of the continuous structures is shown in Tables 3, 5, 7 and 9, where it can be seen that, in general the recorded stresses were lower than those calculated, except for the trestle on the Chicago & North Western Railway bridge where the south pile of the three pile bent was carrying over half of the total vertical load.
5. The impacts and stresses in the slab are increased considerably by the locomotive wheels passing over a poorly supported rail joint near the center of the span, as shown by the typical oscillogram on Fig. 25 and the diagrams of maximum recorded stresses and impacts on Figs. 57 to 82, incl.
6. The summary in Table A of the maximum impacts and concrete stresses recorded in the tops of the curbs of the three trestles indicates that while many impact values exceed the AREA values, the recorded maximum stresses were, on the average, only 28 percent of the calculated maximum stresses.
7. The summary in Table B of the maximum impacts and concrete stresses recorded in the tops of the slabs of the three trestles indicates that while most of the recorded impacts exceeded the AREA impact values, the recorded maximum stresses were, on the average, only 82 percent of the calculated maximum stresses.
8. The summary in Table C of the maximum impacts and stresses recorded in the compressive reinforcing bars of the two trestles on the Missouri Pacific Railroad indicates that both the impacts and stresses in these bars exceed the AREA design values. However, these reinforcing bars are close to the calculated neutral axis of the section when the concrete is assumed not capable of taking any tension and any change in the location of the neutral axis would result in an appreciable change in the calculated stresses in these bars.
9. The summary in Table D of the maximum impacts and stresses recorded in the tensile reinforcing bars of the three trestles indicates that while the recorded impacts were generally greater than the AREA design impact allowances, the recorded maximum stresses were only about 20 percent of those calculated. The effect of the poorly supported rail joint on the impacts and stresses in the west slab of the Missouri Pacific bridge 637 is clearly shown in this table.
10. The summary in Table E of the maximum impacts and stresses recorded in the top of the concrete slab near the center of the spans of the Grand Trunk Western Railroad bridge indicates that while some of the recorded impacts exceeded the AREA design impact allowances, the recorded maximum stresses were only about 50 percent of the calculated stresses.
11. The summary in Table F of the maximum impacts and stresses recorded in the bottom reinforcing bars near the center of the spans of the Grand Trunk Western bridge indicates that while some of the recorded impacts exceeded the AREA design impact allowances, the recorded maximum stresses were less than 20 percent of the calculated stresses.
12. The summary in Table G of the maximum impacts and stresses recorded in the bottom of the concrete continuous slab near the supports of the Grand Trunk Western bridge indicates that while some of the recorded impacts exceeded the AREA design impact allowances, the recorded maximum stresses were less than 50 percent of the calculated stresses.

13. The summary in Table H of the maximum impacts and stresses recorded in the top reinforcing bars of the continuous slab over the supports of the Grand Trunk Western bridge indicates that while the recorded impacts were in close agreement with the AREA impact allowances, the recorded maximum stresses were less than 14 percent of the calculated stresses.

14. The summary in Table J of the maximum impacts and stresses recorded in the concrete piles and columns of the four bridges indicates that while most of the impacts exceeded the AREA design values, the recorded maximum stresses were considerably smaller than the calculated stresses, except in the south pile of the Chicago & North Western bridge where the recorded stresses were about twice the calculated stresses.

15. The tests on the Grand Trunk Western bridge were made with and without ½-in rubber pads under the steel tie plates, and the data shown on Figs. 95 to 109, incl., indicate that the use of the rubber pads did not reduce the impacts and stresses in this structure.

16. The tests conducted with the gages located on the piles indicated that the locomotive was producing a sinusodial lateral force on the bents, as shown by the typical oscillogram, Fig. 26. The lateral forces required to produce these lateral stresses in the piles are shown by the left diagrams of Figs. 132 and 133. The maximum lateral force was 6 kips as compared with the AREA design force of 20 kips.

17. The tests conducted with the gages located on the piles afforded an opportunity to determine the forces produced by the locomotive braking, and it can be seen by the center and right diagrams of Figs. 132 and 133 that the locomotive braking at the higher speeds did not increase materially the bending stresses in the piles over those produced by the normal train operation without braking. The maximum longitudinal forces were produced when the locomotive braked to a stop on the structure, and the maximum force on one bent, as determined from the recorded stresses in the piles, was about 6 kips as compared with an AREA design force of 35 kips.

18. The stresses recorded by the longitudinal gages on the webs of the rails indicated that the rails were carrying the greater part of the total longitudinal force produced by the locomotive braking to a stop on the structure.

(Text continued on page 250)

TABLE A
Top of Curb

Railroad Bridge No. Span	Slab	Locomotive Type	Fig. No.	Total Impacts - Percent: AREA Design	Total Impacts - Percent: Maximum Recorded	Total Impacts - Percent: Average Recorded (6 Highest)	Maximum Stresses - KSI: AREA Design	Maximum Stresses - KSI: Maximum Recorded	Maximum Stresses - KSI: Average Recorded (6 Highest)
C.& N.W. Ry. 19'-0	North	2-Axle Diesels	32	53	41	27	-0.64	-0.23	-0.21
		3-Axle Diesels	33	55	42	28	-0.70	-0.21	-0.19
		Mikado "J"	34	62	57	48	-1.01	-0.34	-0.32
	South	2-Axle Diesels	32	53	62	37	-0.64	-0.18	-0.16
		3-Axle Diesels	33	55	59	46	-0.70	-0.12	-0.11
		Mikado "J"	34	62	91	66	-1.01	-0.27	-0.24
M.P.R.R. #131 19'-0	East	Mountain	44	59	46	31	-0.73	-0.19	-0.17
	West	Mountain		59	56	43	-0.73	-0.20	-0.18
M.P.R.R. #637 19'-0	East	2-Axle Diesels	57	50	88	55	-0.48	-0.12	-0.12
		3-Axle Diesels	58	52	71	46	-0.52	-0.15	-0.14
		Mikado	59	62	71	52	-0.84	-0.20	-0.18
		Mountain	63	58	46	33	-0.69	-0.17	-0.15
		Pacific	64	63	86	42	-0.78	-0.21	-0.16
	West	2-Axle Diesels	57	50	101	86	-0.48	-0.15	-0.14
		3-Axle Diesels	58	52	114	90	-0.52	-0.18	-0.17
		Mikado	61	61	130	85	-0.78	-0.23	-0.19
		Mountain	63	58	114	60	-0.69	-0.21	-0.16
		Pacific	64	63	86	62	-0.78	-0.20	-0.17

TABLE B
Top of Slab

Railroad Bridge No. Span	Slab	Locomotive Type	Fig. No.	Total Impacts - Percent: AREA Design	Total Impacts - Percent: Maximum Recorded	Total Impacts - Percent: Average Recorded (6 Highest)	Maximum Stresses - KSI: AREA Design	Maximum Stresses - KSI: Maximum Recorded	Maximum Stresses - KSI: Average Recorded (6 Highest)
C.& N.W. Ry. 19'-3½	North	2-Axle Diesels	35	53	56	46	-0.25	-0.19	-0.18
		3-Axle Diesels	36	55	86	45	-0.27	-0.23	-0.18
		Mikado "J"	37	62	99	84	-0.40	-0.31	-0.28
	South	2-Axle Diesels	35	53	70	43	-0.25	-0.20	-0.17
		3-Axle Diesels	36	55	95	63	-0.27	-0.20	-0.16
		Mikado "J"	37	62	81	59	-0.40	-0.28	-0.25
M.P.R.R. #131 19'-0	East	2-Axle Diesels	45	50	42	19	-0.16	-0.09	-0.09
		Mikado	47	59	70	40	-0.24	-0.23	-0.19
		Mountain	48	59	54	46	-0.24	-0.20	-0.19
	West	2-Axle Diesels	45	50	21	8	-0.16	-0.12	-0.10
		Mikado	47	59	59	50	-0.24	-0.20	-0.19
		Mountain	48	59	63	45	-0.24	-0.23	-0.20
M.P.R.R. #637 19'-0	East	2-Axle Diesels	65	50	75	58	-0.16	-0.14	-0.13
		3-Axle Diesels	66	52	88	49	-0.17	-0.17	-0.14
		Mikado	69	61	89	75	-0.26	-0.16	-0.15
		Mountain	71	58	114	81	-0.23	-0.19	-0.16
		Pacific	72	62	93	55	-0.26	-0.21	-0.17
	West	2-Axle Diesels	65	50	103	94	-0.16	-0.16	-0.15
		3-Axle Diesels	66	52	137	122	-0.17	-0.20	-0.19
		Mikado	69	61	94	67	-0.26	-0.19	-0.17
		Mountain	70	57	83	78	-0.21	-0.18	-0.17
		Pacific	72	62	134	104	-0.26	-0.23	-0.19

TABLE C
Top Reinforcing Bars

Railroad Bridge No. Span	Slab	Locomotive Type	Fig. No.	Total Impacts - Percent: AREA Design	Total Impacts - Percent: Maximum Recorded	Total Impacts - Percent: Average Recorded (6 Highest)	Maximum Stresses - KSI: AREA Design	Maximum Stresses - KSI: Maximum Recorded	Maximum Stresses - KSI: Average Recorded (6 Highest)
M.P.R.R. #131 19'-0	East	Mountain	49	59	62	38	-0.69	-1.14	-0.97
	West	Mountain		59	66	54	-0.69	-1.34	-1.32
M.P.R.R. #637 19'-0	East	2-Axle Diesels	73	50	50	40	-0.44	-0.75	-0.70
		3-Axle Diesels	74	52	74	49	-0.48	-0.91	-0.86
		Mikado	76	61	80	59	-0.73	-1.33	-1.19
		Mountain	78	57	105	57	-0.60	-1.37	-1.06
		Pacific	80	63	98	46	-0.71	-1.61	-1.19
	West	2-Axle Diesels	73	50	138	116	-0.46	-1.05	-0.96
		3-Axle Diesels	74	52	132	98	-0.50	-1.29	-1.16
		Mikado	76	61	155	122	-0.76	-1.68	-1.46
		Mountain	78	57	103	91	-0.62	-1.26	-1.21
		Pacific	80	63	140	102	-0.74	-1.66	-1.40

TABLE D
Bottom Reinforcing Bars

Railroad Bridge No. Span	Slab	Locomotive Type	Fig. No.	Total Impacts - Percent: AREA Design	Total Impacts - Percent: Maximum Recorded	Total Impacts - Percent: Average Recorded (6 Highest)	Maximum Stresses - KSI: AREA Design	Maximum Stresses - KSI: Maximum Recorded	Maximum Stresses - KSI: Average Recorded (6 Highest)
C.& N.W. Ry. 19'- 3½	North	2-Axle Diesels	38	53	26	23	+5.11	+0.83	+0.80
		3-Axle Diesels	39	55	91	63	+5.60	+1.55	+1.32
		Mikado	40	62	49	46	+8.07	+1.51	+1.48
	South	2-Axle Diesels	38	53	31	22	+5.11	+0.74	+0.69
		3-Axle Diesels	39	55	94	47	+5.60	+1.21	+0.92
		Mikado	40	62	54	34	+8.07	+1.33	+1.15
M.P.R.R. #131 19'- 0	East	2-Axle Diesels	50	50	37	18	+4.24	+0.84	+0.73
		Mikado	52	59	67	43	+6.49	+2.00	+1.67
		Mountain	53	59	61	53	+6.49	+1.58	+1.50
	West	2-Axle Diesels	50	50	52	35	+4.24	+0.92	+0.83
		Mikado	52	59	65	43	+6.49	+2.11	+1.83
		Mountain	53	59	89	80	+6.49	+1.84	+1.76
M.P.R.R. #637 19'- 0	East	2-Axle Diesels	81	50	67	52	+4.17	+1.09	+0.92
		3-Axle Diesels	82	52	66	56	+4.54	+1.15	+1.12
		Mikado	84	61	79	62	+6.95	+1.81	+1.65
		Mountain	86	57	91	69	+5.66	+1.53	+1.33
		Pacific	88	63	87	63	+6.74	+1.58	+1.39
	West	2-Axle Diesels	81	50	112	109	+4.31	+1.21	+1.14
		3-Axle Diesels	82	52	118	108	+4.69	+1.41	+1.32
		Mikado	84	61	141	105	+7.17	+2.04	+1.73
		Mountain	86	57	135	126	+5.84	+1.49	+1.44
		Pacific	88	63	126	88	+6.96	+1.86	+1.54

G.T.W.R.R. BRIDGE TESTS
(Continuous Spans)

TABLE E
Top of Slab (Near ℄ Span)

Span No. Length	Locomotive Type	Fig. No.	Total Impacts - Percent			Maximum Stresses - KSI		
			AREA Design	Maximum Recorded	Average Recorded (6 Highest)	AREA Design	Maximum Recorded	Average Recorded (6 Highest)
3 38'-11 3/4	2-Axle Diesels Northern	94 95	50 66	48 54	36 49	-0.18 -0.39	-0.10 -0.20	-0.09 -0.19
4 33'-7 1/2	2-Axle Diesels Northern	96 97	47 57	78 85	64 55	-0.21 -0.34	-0.10 -0.20	-0.09 -0.18

TABLE F
Bottom Reinforcing Bars (Near ℄ Span)

Span No. Length	Locomotive Type	Fig. No.	Total Impacts - Percent			Maximum Stresses - KSI		
			AREA Design	Maximum Recorded	Average Recorded (6 Highest)	AREA Design	Maximum Recorded	Average Recorded (6 Highest)
3 38'-11 3/4	2-Axle Diesels Northern	98 99	50 66	57 48	45 43	+3.84 +8.33	+0.65 +1.53	+0.63 +1.46
4 33'- 7 1/2	2-Axle Diesels Northern	100 101	47 57	60 52	54 47	+4.54 +7.24	+0.77 +1.27	+0.72 +1.19

TABLE G
Bottom of Slab (At Piers)

Span No. Length	Locomotive Type	Fig. No.	Total Impacts - Percent			Maximum Stresses - KSI		
			AREA Design	Maximum Recorded	Average Recorded (6 Highest)	AREA Design	Maximum Recorded	Average Recorded (6 Highest)
3 38'-11 3/4	2-Axle Diesels Northern	102 103	46 55	54 39	45 35	-0.29 -0.45	-0.14 -0.20	-0.13 -0.19
4 33'- 7 1/2	2-Axle Diesels Northern	104 105	44 53	56 33	49 26	-0.29 -0.44	-0.12 -0.18	-0.12 -0.17

Table H
Top Reinforcing Bars (At ℄ Pier)

Pier No.	Locomotive Type	Fig. No.	Total Impacts - Percent			Maximum Stresses - KSI		
			AREA Design	Maximum Recorded	Average Recorded (6 Highest)	AREA Design	Maximum Recorded	Average Recorded (6 Highest)
2	2-Axle Diesels Northern	106 107	44 55	26 52	18 43	+6.33 +10.18	+0.73 +1.38	+0.68 +1.29
3	2-Axle Diesels Northern	108 109	42 52	44 39	30 36	+6.24 +10.00	+0.78 +1.15	+0.70 +1.12

TABLE J

CONCRETE PILES & COLUMNS

Railroad Bridge No.	Bent No. Pier No.	Locomotive Type	Fig. No.	Pile	Total Impacts - Percent: AREA Design	Total Impacts - Percent: Maximum Recorded	Total Impacts - Percent: Average Recorded (6 Highest)	Maximum Stresses - KSI: AREA Design	Maximum Stresses - KSI: Maximum Recorded	Maximum Stresses - KSI: Average Recorded (6 Highest)
C.& N.W. Ry	4	2-Axle Diesels	41	North Center South	46	48 39 36	38 33 19	-0.10 -0.12 -0.11	-0.10 -0.10 -0.12	-0.09 -0.09 -0.18
C.& N.W. Ry	4	3-Axle Diesels	42	North Center South	46	106 100 64	76 74 41	-0.10 -0.12 -0.11	-0.11 -0.11 -0.25	-0.10 -0.10 -0.22
C.& N.W. Ry	4	Mikado 2-8-2	43	North Center South	55	85 59 45	58 40 34	-0.16 -0.19 -0.18	-0.13 -0.13 -0.31	-0.11 -0.12 -0.28
M.P.R.R. BR. NO. 131	5A	Mountain 4-8-2	54	East Center West	56	40 25 41	28 17 21	-0.13 -0.25 -0.13	-0.09 -0.12 -0.10	-0.08 -0.11 -0.09
M.P.R.R. BR. NO. 131	39	Mountain 4-8-2	55	East Center West	70	30 24 19	23 17 16	-0.18 -0.31 -0.18	-0.11 -0.14 -0.14	-0.10 -0.13 -0.13
M.P.R.R. BR. NO. 131	40	Mountain 4-8-2	56	East Center West	69	30 27 26	24 18 22	-0.20 -0.32 -0.20	-0.15 -0.13 -0.10	-0.14 -0.12 -0.10
M. P. R. R. BR. NO. 637	25	2-Axle Diesels	89	East Center West	50	70 68	48 32	-0.09 -0.17 -0.09	-0.08 -0.11	-0.07 -0.08
M. P. R. R. BR. NO. 637	25	3-Axle Diesels	90	East Center West	50	73 67	64 44	-0.09 -0.18 -0.09	-0.08 -0.11	-0.07 -0.09
M. P. R. R. BR. NO. 637	25	Mikado 2-8-2	91	East Center West	61	94 62	71 45	-0.15 -0.30	-0.13 -0.16	-0.12 -0.14
M. P. R. R. BR. NO. 637	25	Mikado 2-8-2	92	East Center West	56	88 71	83 60	-0.14 -0.27 -0.14	-0.12 -0.16	-0.12 -0.15
M. P. R. R. BR. NO. 637	29	Mikado 2-8-2	93	East Center West	56	62 53 23	31 33 21	-0.13 -0.26 -0.13	-0.11 -0.12 -0.07	-0.09 -0.11 -0.06
G.T.W.R.R.	Pier 3	Northern 4-8-4	110	Col. 2 Col. 3 Col. 4	39.6	55 26 33	55 24 27	-0.02 -0.14 -0.11	-0.02 -0.08 -0.06	-0.02 -0.08 -0.06

FOREWORD

The concrete bridge impact tests analyzed in this report were conducted for AREA Committee 30—Impact and Bridge Stresses, and were carried out under the direction of G. M. Magee, director engineering research, Association of American Railroads. The fund necessary for the tests were provided by the AAR.

The conduct of the tests, analysis of data, and preparation of the report were in charge of E. J. Ruble, structural engineer, research staff, AAR, assisted with the analysis of the data by A. A. Sirel, assistant structural engineer, and with the tests on the bridges in the field by L. E. Monson, assistant structural engineer.

Assignment 5 of Committee 30 is: Concrete structures, collaborating with Committee 8. To secure data for this assignment the research staff arranged to test three reinforced concrete trestles with ballasted decks which were considered typical of present-day construction, and one continuous reinforced concrete viaduct having the rails supported directly on the concrete slab. These particular bridges were selected as they afforded an opportunity to secure tests under both diesel and steam locomotives at a full range of speed.

Assignment 6 of Committee 30 is: Determination of braking and traction forces in bridge structures, collaborating with Committees 7, 8 and 15. Two of the reinforced concrete trestles selected for testing were long structures which made it possible to secure data on the bending stresses in the concrete piles resulting from braking or traction.

One of the reinforced concrete trestles selected and tested is on the single-track line of the Chicago & North Western Railway, between Milwaukee, Wis., and St. Paul, Minn., where several diesel locomotives as well as steam locomotives are operating each day. The bridge tested and analyzed in this report consists of 5 precast reinforced concrete ballasted slab spans supported by reinforced concrete 3-pile bents, located near Adams, Wis.

The two reinforced concrete trestles selected and tested on the Missouri Pacific Railroad are in single-track territories where several high-speed diesel and steam locomotives are operating each day. The first bridge tested and analyzed in this report consists of 2 approach structures separated by 107 ft of embankment, a 125 ft deck truss span and two 85-ft deck plate girder spans over the Little river and is near Rochelle, La. The south approach structure consists essentially of precast reinforced concrete ballasted slab spans supported by reinforced concrete 3-pile bents, while the north approach structure consists essentially of steel beam spans with a ballasted timber floor supported by reinforced concrete 3-pile bents. Strain gage readings were taken on concrete slabs and piles of the south approach and on the concrete piles of the north approach. The tests on the second bridge, located near Arkadelphia, Ark., were all conducted on the north approach structure to the through truss spans over the Ouachita river. The approach structure consists essentially of precast reinforced concrete ballasted slab spans supported by reinforced concrete 3-pile bents, and strain gage readings were taken on both the slabs and piles.

The continuous reinforced concrete structure tested and analyzed in this report is located on the Grand Trunk Western Railway in Flint, Mich. The bridge is in double-track territory and consists of four continuous spans supported by reinforced concrete piers and abutments. Strain gage readings were taken on the slab at the center of the span and over the supports, as well as on the concrete columns of the piers.

The majority of the test runs were secured under regular scheduled trains as the maximum stresses in these short spans occurred under the locomotive only. Arrangements were made with the operating department of the railroad to have the trains cross the bridge at various speeds ranging from 5 mph, which is considered the same as static loading, to the maximum operating speeds of the locomotive. Further tests were made on the continuous bridge of the Grand Trunk Western and the two bridges of the Missouri Pacific under a special test steam locomotive and cars operating at various speeds over the bridge. The principal use of the test train on the Missouri Pacific bridges was to secure data on the braking and traction effects, while higher speeds under a heavy steam locomotive were desired on the Grand Trunk Western tests.

TEST SPANS AND LOCATION OF GAGES

Chicago & North Western Bridge

This structure, built in 1938 and located near Adams, Wis., consists of five single-track precast reinforced concrete slab spans as shown in Figs. 1 and 2. The slabs vary in length from 17 ft 10¾ in to 19 ft 3½ in, with a thickness of 2 ft 4½ in. The variable span length resulted from driving the piles through the former timber pile trestle under traffic and the spacing of the former timber piles prevented a uniform spacing of the concrete piles. The slabs are heavily reinforced with ¾-in round bars in the top and 1¼-in square bars in the bottom, and were cast in 6-ft widths for ease of handling so that it requires 2 slabs per span, as shown. The capacity of the 19 ft 3½-in test span, using the present AREA design stresses and impact for steam locomotives, with strength of concrete as determined from test cylinders and assuming the concrete not capable of taking any tension, would be Cooper E 75.7. The floor is of the ballasted type, that is, the track ties supporting the 112-lb rails rest on about 6 in of crushed rock ballast. The ballast is supported directly by the precast slabs.

The bents supporting the slabs consist of three 24-in octagonal precast reinforced concrete piles per bent, capped with a poured-in-place reinforced concrete cap 38 in wide, 51½ in deep, and 15 ft 6 in long. All 3 piles were driven vertically and were spaced at about 5-ft 6-in centers.

The strain gages were erected on various parts of the structure, as shown in Fig. 2, to determine the compressive stresses in the top of the concrete slab and curb, the tensile stresses in the reinforcing bars on the underside of the slab, the tensile stresses in the concrete on the bottom of the slab, and the compressive axial and bending stresses in the concrete piles just above the water line.

In order to mount the electro-magnetic gages on the top of the concrete slabs it was necessary to remove the ballast between the ties and then place heavy timbers against the ties to prevent any disturbance of the ballast under the ties, as shown in Fig. 3. It is realized that there was some change in the normal track condition, but it is felt that the axle loads carried by the two ties would be about the same as carried originally. As mentioned previously, strain gages were placed on the underside of the slab to determine the tensile stresses in the reinforcing bars and concrete. Fig. 4 shows these gages in place.

A small hole was cut in the concrete protective covering over the tensile reinforcement by an electric air hammer, as shown in Figs. 5 and 6, so that the ¼-in SR4 wire gages could be placed on the bars. The hole in the concrete was only large enough to permit the mounting of the gages and it is doubtful if the strains in the bars were changed very much by this removal of the concrete.

The 28-day strength of the concrete cylinders taken at the time the slabs were poured varied from 4200 psi to 6800 psi, with an average of 5000 psi. Accordingly, a value of 5,000,000 psi was assumed for the modulus of elasticity in determining the concrete stresses from the measured strains.

Missouri Pacific Bridges

Bridge 131

This structure, located near Rochelle, La., and built in 1942, consists of 2 approach structures separated by 107 ft of embankment, a 125-ft deck truss span and two 85-ft deck plate girder spans over the Little river.

The south approach structure, built in 1942, consists of 12 single-track precast reinforced concrete slab spans, one 24-ft 6 in beam span, and one 50-ft deck plate girder span, as shown in Figs. 7 and 8. The reinforced concrete slabs varied in length from 11 ft to 19 ft, with a thickness of 2 ft 5 in. This structure replaced a timber pile trestle and the spacing of the former timber piles prevented a uniform spacing of the concrete pile bents. The slabs are heavily reinforced with 1¼-in square bars in both the top and bottom and were cast in 6-ft 9-in widths for ease of handling so that 2 slabs are required for each span, as shown. The capacity of the 19-ft test span, using the present AREA design stresses and impact for steam locomotives with strength of concrete as determined from test cylinders and assuming the concrete not capable of taking any tension, would be Cooper E 94.4. The floor is of the ballasted type, that is, the track ties supporting the 112-lb rails rest on about 6 in of crushed rock ballast.

The bents supporting the concrete slabs of the south approach structure consist of three 24-in octagonal precast reinforced concrete piles per bent with a poured-in-place reinforced concrete cap at the top of the piles and a collar at the ground line. All 3 piles in each bent were driven vertically and were spaced at about 5-ft centers.

The strain gages were erected on the various parts of the south approach structure, as shown in Fig. 8, to determine the compressive stresses in both the concrete and reinforcement in the top of the slab, the tensile stresses in both the reinforcing bars and concrete in the bottom of the slab, and compressive axial and bending stresses in the concrete piles just above the ground line. The strains in the concrete were measured with 6-in SR4 wire gages, as shown in Fig. 9, for the underside of the slab, and in Fig. 10 for the piles.

The north approach structure, built in 1935, consists of 47 single-track wide-flange beam spans, supported by reinforced concrete pile bents, as shown in Figs. 11 and 12. The beam spans varied in length from 24 ft to 27 ft with a ballasted track carried by a solid timber floor.

The bents supporting the beam spans of the north approach structure consist of three 24-in octagonal precast reinforced concrete piles per bent with a poured-in-place reinforced concrete cap at the top of the pile and a collar at the ground line. All 3 piles in each bent were driven vertically and were spaced at about 5-ft centers.

The only stresses determined in the north approach structure were those in the piles of bents 39 and 40, and in the rails over bents 37 and 42, as shown in Fig. 12. The 6-in SR4 wire gages on the piles near the ground line can be seen in the pictures of Fig. 11. The principal purpose of measuring the strains in the piles and rails of this structure was to determine the magnitude of the longitudinal forces produced by the braking and traction efforts of the locomotives.

The general plans covering this structure specified that the concrete should develop a minimum strength of 3000 psi in 28 days, but tests of the concrete cylinders indicated an average strength of 4500 psi in 28 days. Accordingly, a value of 4,500,000 psi was assumed for the modulus of elasticity in determining the concrete stresses from the measured strains.

Bridge 637

This structure, located near Arkadelphia, Ark., consists of two approach structures to through truss spans over the Ouachita river. All tests were conducted on the north approach structure, built in 1948, consisting of 35 single-track precast reinforced concrete slab spans and one 27-ft wide-flange beam span, as shown in Figs. 13 and 14. The reinforced concrete slabs varied in length from 16 ft to 19 ft with a thickness of 2 ft 5 in. This structure replaced a timber pile trestle and the spacing of the former timber piles prevented a uniform spacing of the concrete pile bents. The slabs are heavily reinforced with 1¼-in square bars in both the top and bottom, and were cast in 6-ft 9-in widths for ease of handling so that two slabs are required for each span, as shown. The capacity of the 19-ft test span, using the present AREA design stresses and impact for steam locomotives with strength of concrete as determined from test cylinders, and assuming the concrete not capable of taking any tension, would be Cooper E 94.4

The track is the ballasted type, that is, the track ties supporting the 112-lb rails rest on about 6 in of crushed rock ballast. The center line of the track was off center ½ in to the west at the center of span 24 so that the west part of the span was carrying slightly more of the load than the east part of the span. It can be seen from a study of the detail plan of span 24, shown on Fig. 14, that the ties over bents 24 and 25 were tight, but that considerable play existed between the rail and ballast on the remaining ties on the span. In addition, a rail joint was located in the west rail near the center of the span, and, while the ends of the rails were not battered, a considerable amount of tie pumping was taking place under the joint.

The bents supporting the concrete slabs consist of three 24-in octagonal precast reinforced concrete piles per bent with a poured-in-place reinforced concrete cap at the top of the piles and a collar at the ground line. All 3 piles in each bent were driven vertically and were spaced at about 5-ft centers.

The strain gages were erected on the various parts of the structure, as shown in Fig. 14, to determine the compressive stresses in both the concrete and reinforcement in the top of the slab, the tensile stresses in both the reinforcing bars and concrete in the bottom of the slab, and the compressive axial and bending stresses in the concrete piles just above the ground line. In addition, ¼-in SR4 wire gages were placed longitudinally on the webs of the rails near bents 23 and 31 to determine what part of the longitudinal force, produced by the braking and traction efforts of the locomotives, was being carried by the rails.

The general plans covering this structure specified that the concrete should develop a minimum strength of 3000 psi in 28 days, but tests of the concrete cylinders indicated an average strength of 4500 psi in 28 days. Accordingly, a value of 4,500,000 psi was assumed for the modulus of elasticity in determining the concrete stresses from the measured strains.

Grand Trunk Western Bridge

This structure, built in 1941 and located in Flint, Mich., consists of four double-track poured-in-place reinforced concrete continuous slab spans, as shown in Figs. 15

and 16. The slabs are skewed with the supporting piers at an angle of 78 deg 53 min and vary in length from 33 ft to 38 ft 3 in center to center of piers, with a total width of 30 ft 9 in and a thickness of 3 ft 8 in. A construction joint was placed between tracks, making one slab 14 ft wide and the other 16 ft 9 in. The slabs are heavily reinforced with 1⅛-in square bars in the top as well as the bottom to take care of the negative moment over the supports. The capacity of the slab over the supports using the present AREA design stresses and impact for steam locomotives, and assuming the concrete not capable of taking any tension, would be Cooper E 85.3. The track structure consists of the rails, heavy steel tie plates, and ½-in rubber-fabric tie pads fastened directly to the concrete slab, as shown in Fig. 17. Additional tests were made with timber shims driven under the rail, as shown in the lower picture of Fig. 17, to eliminate any damping effects of the rubber-fabric pads.

The slabs are supported on end abutments and three center piers (see Fig. 15). The intermediate piers each consist of a 4-span reinforced concrete rigid frame with the columns at 9-ft 8½-in centers, as shown in Fig. 18. The slabs are separated from the piers or abutments by a ⅛ in thick lead sheet so that the piers or abutments do not have any induced moments from the slabs, except that resulting from eccentricity of the applied load.

The strain gages were erected on the various parts of the structure carrying the westbound track, as shown in Figs. 16 and 18, to determine the top compressive stresses in the concrete at the center of spans 3 and 4, the bottom compressive stresses in the concrete near the supports at piers 2 and 3, the top tensile stresses in the reinforcement over piers 2 and 3, the bottom tensile stresses in the reinforcement at the center of spans 3 and 4, the compressive axial and bending stresses in the concrete and reinforcement of the three center columns of pier 3, and the tensile stresses in the reinforcement of the bridge seat beam and footing of pier 3. The strains in the concrete were measured with the 4-in electro-magnetic gages, while those in the reinforcing bars were measured with the ¼-in SR4 wire gages.

The 28-day strength of the concrete cylinders taken at the time the slabs were poured varied from 3680 psi to 5112 psi, with an average of 4275 psi. Accordingly, a value of 4,275,000 psi was assumed for the modulus of elasticity in determining the concrete stresses from the measured strains. Tests conducted on small beams in flexure to determine the modulus of rupture indicated that the concrete had a tensile strength of about 800 psi in 28 days.

TEST TRAINS

The tests were conducted in most cases, as explained previously, under regularly scheduled trains. The locomotive numbers were recorded as the trains passed over the bridge, and the locomotives were than grouped for analysis of data according to their particular type, and then further grouped according to their weight. Since the wheel-base of the steam locomotives was greater than the length of the test spans, it was not necessary to make corrections for the amount of coal and water in the tenders of the steam locomotives. Some tests were made with a special work train and are described under the particular locomotive type.

The necessary information regarding all the locomotives used in these tests, such as axle weights, axle spacings and nominal wheel diameters, was furnished by the mechanical department of the railroad. No effort was made to calculate the components and resultant unbalanced weights on the driving wheels of the steam locomotives as previous tests on short-span bridges, such as those reported in AREA Proceedings, Vol. 46, 1945, page 189, had indicated that the dynamic effects produced by the unbalanced weights on the drivers cannot be separated from those produced by the track conditions on short spans.

A general description of all the locomotives under which test records were obtained on the four bridges of the three railroads is as follows:

TEST LOCOMOTIVES

Chicago & North Western Bridge Test

Mikado Type, 2–8–2 (Class J)

The locomotives of this class are used in freight service and all the necessary information required in the analysis of the test data is shown in Fig. 19. The rating of the locomotives of this class in terms of Cooper loading for moment at the center of the 19-ft 3½-in test span is E 49.6, as shown in Table 1.

Locomotives of this class have been used in previous tests conducted on steel girder spans of the Chicago & North Western, where it was necessary to consider the component and resultant unbalanced weights in the driving wheels. These data can be found in AREA Proceedings, Vol. 52, 1951, page 14. These locomotives have average reciprocating unbalance per side per 1000 lb of locomotive weight in working order of 6.28 lb, and an average reciprocating compensation of 24 percent. The main drivers are cross-balanced, while the front, intermediate and rear drivers are straight balanced.

Diesel Locomotives—3-Axle Trucks

The 2-unit diesel locomotives of this group, consisting of 3-axle trucks with 36-in nominal wheel diameter, are used in passenger service, and all necessary information required in the analysis of the data is shown in Fig. 19. The rating of the locomotives of this class in terms of Cooper loading for moment at the center of the 19-ft 3½-in test span is E 36.1, as shown in Table 1.

Diesel Locomotives—2-Axle Trucks

The 2-unit diesel locomotives of this group, consisting of 2-axle trucks with 40-in nominal wheel diameter, are used in freight service, and all necessary information required in the analysis of the data is shown in Fig. 19. The rating of the locomotives of this class in terms of Cooper loading for moment at the center of the 19-ft 3½-in test span is E 33.3, as shown in Table 1.

Missouri Pacific Bridge Tests

Mikado Type, 2–8–2

The locomotives of this type, consisting of a 2–8–2 type locomotive and a 4-axle tender, are used in freight service, and all necessary information required in the analysis of the data, such as axle weights, axle spacing, and wheel diameters, are shown in Fig. 20 for the four different locomotive groupings of this type. The ratings of the locomotives of this type, in terms of Cooper loading for moment at the center of the 19-ft test spans, varied from E 48.4 to E 56.1, as shown in Table 1.

In addition to the readings secured under the regular trains with this type of locomotive, a special work-train consisting of locomotive No. 1547, a tender, six loaded hopper cars, and caboose, was used during the tests on bridge 637 to secure data on the longitudinal forces produced by the braking effort of the train and the traction produced by the drivers of the locomotive.

Mountain Type, 4–8–2

The locomotives of this type, consisting of a 4–8–2 type locomotive and a 6-axle tender, are used in freight service, and all necessary information required in the analysis of the data are shown in Fig. 21 for the three different locomotive groupings of this type. The ratings of the locomotives of this type, in terms of Cooper loading for moment at the center of the 19-ft test span, varied from E 45.6 to E 50.6, as shown in Table 1.

In addition to the readings secured under the regular trains with this type locomotive, a special work-train consisting of locomotive No. 5337, a tender, six loaded hopper cars, and caboose, was used during the tests on bridge 131 to secure data on the longitudinal forces produced by the braking effort of the train and the traction produced by the drivers of the locomotive. The car weights and axle spacings of this work train are shown in Fig. 131.

Pacific Type, 4–6–2

The locomotives of this type, consisting of a 4–6–2 type locomotive and a 6-axle tender, are used in passenger service, and all necessary information required in the analysis of the data are shown in Fig. 21 for the two different locomotives of this type. The ratings of these two locomotives, in terms of Cooper loading for moment at the center of the 19-ft test span is E 47.8 and E 53.0, as shown in Table 1.

Diesel Locomotives—2-Axle Trucks

The diesel locomotives of these groups, consisting of 2-axle trucks with 40-in nominal wheel diameters. are used in freight service, and all necessary information required in the analysis of the data are shown in Fig. 22. Locomotives 1513 to 1557 belonged to the Texas & Pacific Railway and were operating over bridge 637, near Arkadelphia, Ark., at the time of the tests. The ratings of the locomotives of this type, in terms of Cooper loading for moment at the center of the 19-ft test spans. varied from E 31.8 to E 35.0. as shown in Table 1.

Diesel Locomotives—3-Axle Trucks

The diesel locomotives with 3-axle trucks of this grouping consist of one group of 2-unit locomotives having 36-in nominal wheel diameters and another group of 1-unit locomotives having 40-in nominal wheel diameters. These locomotives are used in passenger service, and all necessary information required in the analysis of the data is shown in Fig. 22. The ratings of the 1-unit locomotives, in terms of Cooper loading for moment at the center of the 19-ft test spans, is E 34.6, while that for the 2-unit locomotive is E 37.6. as shown in Table 1.

Grand Trunk Western Bridge Tests

Northern Type, 4–8–4

The locomotives of this type, consisting of a 4–8–4 type locomotive and a 6-axle tender, are used in both passenger and freight service, and all the necessary information required in the analysis of the test data, such as axle loads. axle spacing and wheel diameters, are shown in Fig. 23. It was necessary to use a special test train for the completion of the tests on this bridge as an insufficient number of runs were secured under this type of locomotive from the regular trains. The test train consisted of the locomotive, tender, two gondola cars, two box cars, and a caboose. The gondola cars were loaded as shown on Fig. 23. The rating of the locomotives of this type, in terms of Cooper loading for simple span moment at the center of the 38-ft 11¾-in span, is E 57.1, as shown in Table 1.

Diesel Locomotives—2-Axle Trucks

The diesel locomotives of this type, consisting of 2-axle trucks with 40-in nominal wheel diameters, are used in freight service, and all necessary information required in the analysis of the data are shown in Fig. 23. The rating of the locomotives of this group, in terms of Cooper loading for simple span moment at the center of the 38-ft 11¾-in span, is E 36.6, as shown in Table 1.

INSTRUMENTS

The electrical-type instruments used in these tests consisted principally of two 12-element oscillographs with the magnetic-type galvanometers, using either the electro-magnetic gages or SR4 wire resistance gages. A detail description of the electro-magnetic gages, control units, power unit and oscillographs appears in the AREA Proceedings, Vol. 46, 1945, page 201, while a description of the SR4 wire resistance gages, power unit and amplifier appears in the AREA Proceedings, Vol. 52, 1951, page 152.

The SR4 wire resistance gages were used in all cases to measure the strains in the reinforcing bars, and had a gage length of ¼ in. The strains in the concrete were measured in some cases with the electro-magnetic gages over a 4-in gage length, while in other cases 6-in SR4 wire resistance gages were used.

A close check was maintained on the sensitivity of each gage so that the relation between the strain in the concrete or steel, produced by the locomotives passing over the bridge, and the amount of deflection of the trace on the oscillogram can be considered accurate to within a small percentage. In general for these tests, a 1-in deflection of the light trace on the film indicated a strain in the steel of 0.0000833 in per in for the ¼-in gages on the reinforcing bars, which is equivalent to a unit stress of 2500 psi, assuming a modulus of elasticity of 30,000,000 psi. A 1-in deflection of the light trace on the film for the gages on the compression concrete indicated a strain of 0.0000833 in per in for the 4-in electro-magnetic gages, or 6-in SR4 wire resistance gages, which is equivalent to a unit stress of 375 psi, assuming a modulus of elasticity of 4,500,000 psi as determined from the ultimate strength tests of cylinders on the Missouri Pacific bridges.

ANALYSIS OF FIELD RECORDS

Test Records

The test records, or oscillograms, were photographed on sensitized paper, 10 in wide and 200 ft long. Each oscillogram was marked with the name of the railroad bridge number, and date. The oscillograph and run number, which is photographed on the record after each run, refers to the log of test runs which shows the engine number, direction, approximate speed, type of train, and all other necessary information regarding the test runs. The inclusion of all the test records, consisting of 1246 oscillograms for the 429 tests under the steam locomotives and 194 tests under the diesel locomotives, would make this report too voluminous. Thus, only typical oscillograms are reproduced, as shown in Figs. 24, 25 and 26. The remaining oscillograms are now on file in the Engineering Division offices, AAR, Chicago.

Reading of Oscillograms

For an analysis of the oscillograms it was first necessary to find the base line representing zero stress. The first 2 or 3 in of the record was taken before the locomotive reached the bridge; the oscillographs were then started when the locomotive was about two spans away from the test span and continued until the locomotive and tender were off the span. The final 2 or 3 in of oscillogram were then taken after the entire train had passed over the bridge. Base lines representing zero stress were then drawn from one side of the light trace for all gages connecting the two "no-load" parts of the record. The maximum deviation of the light trace from the base line was then read for each gage position. For example, in Fig. 24 the trace of gage B7, located on the top of the curb, deflected upward a maximum distance of 0.59 in when the drivers were located as shown in the "Part Elevation" on the figure. A deflection of 0.59 in of the light trace indicates that the concrete at this location was strained 0.000049 in per in, which is equivalent to a stress of 221 psi, assuming a modulus of elasticity of 4,500,000 psi.

The irregularities in the traces or the amplitudes of stress are produced by vibrations in the span induced by uneven track, out-of-round wheels, and the effect of the locomotive hammer blow. At slow speeds, such as 5 to 10 mph, the traces are usually very regular, indicating very little track or hammer-blow effects, so that the oscillograms secured at these speeds can be used for the static stresses.

The typical oscillogram shown on Fig. 25 indicates the type and duration of stress induced in the reinforcement by the locomotive wheels passing over the poor joint near the center of the span in the west rail. The maximum deflection of the light trace from the base line to the tip was read for each trace, as shown.

The typical oscillogram shown on Fig. 26 indicates the type and duration of stress induced in the concrete piles by the lateral forces of the locomotive. In this figure, gages B1 to B12 were located on the piles of Bent 5A, as shown by the "Part Elevation" and "Section B-B"; the even numbered gages were located to determine any longitudinal forces and the odd numbered gages were located to determine any lateral forces.

It can be seen from this oscillogram that the piles were bending laterally as the two odd numbered gages on the same pile were going in opposite directions. This opposite action of the gages means that one side of the piles, say gage positions B3, B7 and B11, were in compression, while the opposite side, gage positions B1, B5 and B9, were in tension due to the lateral force. To determine the magnitude of the lateral stresses in the piles and to separate these stresses from the axial stresses produced by the wheel loads on the span, light lines were drawn on the records indicating the upper and lower envelope curves through the peaks of the oscillations on the traces, as is shown on the typical oscillogram. One-half of this oscillation, or the semi-amplitude of vibration, is then the bending stress on that particular side of the pile resulting from the lateral force, while the distance from the base line to the mean stress curve is the axial load. The average semi-amplitude recorded on the two sides of each pile was taken as the stress in the pile resulting from the lateral force.

Stress Corrections

The center of gravity of the "air gap" on the magnetic strain gages being 0.69 in from the concrete surface, when the gages were fastened to the triangular fastening plates shown in Fig. 3, the strains were correspondingly recorded on a plane 0.69 in from the concrete surface. The stresses recorded in the concrete when in flexure were accordingly corrected by assuming that the stress is proportional to the distance from the neutral axis.

It was not necessary to make any correction to the strains recorded in the concrete and reinforcement by the SR4 wire resistance gages as these gages are cemented directly to the surface of the concrete or steel and the wires of the gages are strained the same as that in the concrete or steel.

STATIC, DYNAMIC AND OTHER EFFECTS

The data as taken from the oscillograms were tabulated and analyzed for the particular purpose of segregating and determining the magnitude of the various static, dynamic, lateral, longitudinal and other effects of the live load. The results of this study are as follows:

STATIC STRESSES

The recorded static stresses in the concrete and reinforcement at the various locations were determined from the oscillograms under slow-speed runs of approximately 5 mph for each locomotive class and are shown in Table 2 to 9, incl. The static stress in the concrete curb was the greatest stress recorded by the one gage on the curb of each split slab, but the static stresses in the other parts of the structure, such as the top of the concrete slab or the reinforcing bars, were the average of the greatest simultaneous stresses recorded by the three or four gages on the concrete or steel. In like manner the recorded static stresses in the piles or columns were the average of the greatest simultaneous stresses recorded by either the two or four gages on the member.

In calculating the static stresses in the pile trestles slabs for the various locomotives used in the tests the axle loads were assumed as uniformly distributed longitudinally over a length of 3 ft plus the depth of the ballast under the tie, plus twice the effective depth of the slab; however, in most cases the distribution was limited by the axle spacing. This longitudinal distribution of the axle loads is in agreement with the AREA specification for design of plain and reinforced concrete members. The locomotive was placed on the span in a position which produced the maximum bending moment according to the criteria.

In computing the static stresses in the continuous slabs of the Grand Trunk Western subway for the various locomotives used in the tests the axle loads were assumed concentrated without any longitudinal distribution. The exact position of the locomotive wheels which produced the maximum recorded stress was secured from the oscillograms and the same locomotive position was used for the calculated stress. The moment-distribution method of analysis with constant moment of inertia was used to determine the negative and positive moments in the slabs.

In computing the vertical static loads and the resulting stresses in the piles of the trestles and the columns of the continuous-span subway, the piles and cap were assumed to form a rigid frame. The live load was assumed to be distributed uniformly on the top of the cap under the slabs.

The static stresses in the concrete and reinforcement of the slabs produced by the bending moments under the various locomotives were calculated first on the usual assumption that the concrete is not taking any tension. However, it soon became evident from the strain gage readings on the concrete encasing the tensile reinforcement that the concrete and steel were working together in resisting the tensile forces.

Therefore, the static stresses in the concrete and steel were then calculated on the basis of a monolithic section.

In determining the resisting properties of the concrete and reinforcement for both assumptions, the moment of inertia of the section was calculated after locating the neutral axis by the method of transformed sections, taking into consideration the concrete curb and assuming the appropriate value of "n" for the particular bridge under consideration. The neutral axis was assumed to remain in a horizontal position. It is interesting to note that the calculated stresses in the top of the concrete slabs are not changed very much by either assumption regarding the concrete below the neutral axis. The reason for this small change is that when the concrete is assumed not to take any tension, the neutral axis is fairly close to the top of the slab and the moment of inertia is small. When the concrete is assumed to carry tension, the neutral axis is lowered, with an increase in the moment of inertia. The result is that the $\frac{I}{C}$ of the section remains about the same for the top of the slab.

Considerable data has been collected in various laboratories in the past on the action of a reinforced concrete beam in resisting imposed bending moments, and it is generally recognized that the concrete on the tension side of the neutral axis is helping the reinforcing bars resist the tensile stresses. Consequently, the stresses in the bars are considerably smaller than those calculated on the assumption that the concrete is not taking any tension. It has also been shown that the concrete continues to help the reinforcing bars resist the tensile stresses by a decreasing amount until the yield point of the reinforcing bars is reached. Some of the more recent data on this composite action appeared in the Journal of the American Concrete Institute, October and November, 1948. These data were secured by Professor Richart during the testing of reinforced concrete wall and column footings at the University of Illinois. To compare the data secured during the testing of the four bridges in this study with the data developed by Professor Richart, the diagram on Fig. 27 was prepared from data appearing in the ACI Journal.

The abscissa of the diagram on Fig. 27 shows the recorded stresses in the tensile reinforcement of reinforced concrete laboratory specimens, while the ordinate represents the calculated stresses in these specimens, based on the assumption that the concrete is not taking any tension. It can be seen that if the concrete was not taking any tension, the action of the specimens could be represented by the 45-deg dash line. However, the results of the laboratory tests indicate that the specimens were acting according to that shown by the heavy solid line. For example, when the calculated stress in the laboratory specimens was 10.0 ksi, the recorded stress was only 1.2 ksi, and when the calculated stress was 25.0 ksi the recorded stress was 10.8 ksi, but when the recorded stress in the reinforcing bars reached the yield point, the calculated and recorded stresses were in close agreement.

A comparison of the recorded static stresses with the calculated static stresses in the four test bridges under the various types of locomotives is shown on the enlarged diagram "A" of Fig. 27. It is interesting to note that there is excellent agreement with the field test values and the solid curve representing laboratory results.

The comparison of the recorded and calculated live load static stresses in the concrete and reinforcement of the four bridges tested under the various locomotives operating over the bridges is shown in Tables 2 to 9, incl. The calculated static stresses shown were first determined on the assumption that the concrete is not taking any tension, and then shown on the assumption that the concrete is acting in helping the reinforcing steel resist the tensile forces. The stress factors shown in these tables are the ratios of the recorded static stresses to the calculated static stresses, with the concrete assumed to be carrying tension for the calculated stresses.

Chicago & North Western Bridge

The recorded and calculated live load static stresses in the top of the concrete curb, top of concrete slab, and in the bottom reinforcing bars of the 19-ft 3½-in concrete slabs are shown in Table 2. The maximum recorded stress in the concrete curb was 220 psi compression under the Class "J" locomotive, while the calculated stress was 387 psi for a stress factor of 0.57. In general, the recorded static stresses in the curb varied from 34 percent to 80 percent of the calculated stresses, as shown in Col. 8. The maximum recorded static stress in the top of the concrete slab was 163 psi compression under the Class "J" locomotive as compared with a calculated stress of 230 psi. The recorded static stresses in the top of the slab varied, on the average, from 67 percent to 99 percent of the calculated stresses, as shown in Col. 13. The maximum recorded static stress in the bottom reinforcing bars was 1125 psi tension under the Class "J" locomotive, while the calculated stress was 1375 psi. In general, the recorded static stresses in the reinforcement varied from 63 percent to 102 percent of the calculated stresses, as shown in Col. 18. It can be seen from this table that the lowest stress factors were determined for the steam locomotives, and that they are appreciably lower than expected, especially since the concrete is assumed to be carrying tension in determining the calculated stresses. These low stress factors for the steam locomotives indicate that there has been some redistribution of the locomotive axle loads.

The recorded and calculated static live load stresses in the concrete of the reinforced concrete piles of bent 4 supporting one end of the 19-ft 3½-in slabs and 18-ft 2-in slabs are shown in Table 3. The recorded stresses are the average of four gages on each of the three piles and represent the direct or axial stress in each pile. A maximum static stress of 222 psi compression was recorded in the south pile under a Class "J" locomotive, compared with a calculated stress of 114 psi, which indicates that this pile was carrying 195 percent of the calculated stress, as shown in Col. 5. The average stress factor for the Class "J" locomotives was 1.75 in the south pile, 0.67 in the center pile, and 0.62 in the north pile, for an average of 1.01 for the 3 piles. It is apparent that the total vertical load carried by the three piles is in agreement with the calculated load, but for some unknown reason the south pile is carrying considerably more than its proportion.

As mentioned previously, the recorded static stresses shown in Tables 2 to 9, incl., are the average of several gages on the particular part of the structure. A considerable variation in the recorded stresses was found between the individual gages, which is shown in Fig. 28 for the slabs and piles under a Class "J" locomotive crossing the bridge at about 5 mph. It can be seen that the stresses in the top of the south slab varied from —111 psi to —259 psi compression, for an average of —164 psi, a maximum variation of 58 percent from the average. The stresses in the reinforcing bars of the south slab varied from +750 psi to +1100 psi tension, for an average of +910 psi, a maximum variation of 21 percent from the average.

A similar variation of the recorded static stresses was found in the piles, as shown in Fig. 28, but this variation can be partially explained by the possibility of eccentric loads on the caps produced by unequal reactions from the slabs.

Missouri Pacific Bridges

Bridge 131

A comparison of the recorded and calculated static live load stresses in the top of the concrete curb, top of concrete slab, top reinforcing bars and bottom reinforcing bars at the center of the 19-ft split slabs is shown in Table 4. The maximum concrete stress occurred in the top of the west concrete slab where a stress of —165 psi compression was recorded (see Col. 9), under the Mountain-type locomotive, compared with the calculated stress of —142 psi, with a resulting stress factor of 1.16. It can be seen from Col. 13 that the average recorded stresses in the top of the concrete slab varied from 80 percent to 98 percent of the calculated stresses, while the recorded stresses in the curbs were less than half of the calculated stresses. The maximum recorded static stress in the bottom reinforcing bars was +1230 psi tension in the west slab under the Mountain-type locomotive, while the calculated stress was +970 psi, resulting in a stress factor of 1.27. It can be seen from Col. 23 that the average recorded stresses in the bottom reinforcing bars varied from 92 percent to 105 percent of the calculated stresses. The comparison between the recorded and calculated static stresses in the top of the concrete slab and in the bottom reinforcing bars is remarkably good for this span, but it should be kept in mind that the calculated stresses are based on the concrete taking tension.

A comparison of the recorded and calculated static stresses in the concrete piles of the three bents tested in this bridge under the Mountain-type test locomotive is shown in Table 5. The recorded stresses shown are the average of four gages on each pile of bent 5A, and the average of two gages on each pile of bents 39 and 40. It can be seen that the recorded stresses in the piles of these three bents were appreciably lower than the calculated stresses. The average stress factors in the three piles of bent 5A varied from 0.57 to 0.84, with an average value of 0.72. The average stress factor in the three piles of bent 39 was 0.82, and averaged 0.72 in the three piles of bent 40. From these average stress factors it appears that these particular pile bents were only carrying about 72 to 82 percent of the calculated pile loads. It is interesting to note that while the calculated load on the center pile is from 44 to 50 percent of the total load on the bent, the actual load carried by the center pile of the bents was only from 35 to 41 percent of the total load.

The variation in the recorded static stresses in the slabs and piles of the three bents tested is shown in Fig. 29 for a Mountain-type locomotive crossing the bridge at about 5 mph. It can be seen that the stresses in the top of the east slab varied from —109 psi to —184 psi compression, for an average —146 psi, a maximum variation of 26 percent from the average. The stresses in the bottom reinforcing bars of the east slab varied from +825 psi to +1350 psi tension, for an average of +1080 psi, a variation of 25 percent from the average.

Bridge 637

A comparison of the recorded and calculated static live load stresses in the top of the concrete curb, top of concrete slab, top reinforcing bars, and bottom reinforcing bars at the center of the 19-ft split slab is shown in Table 6. The maximum concrete stress occurred in the curb of the west slab where a stress of —143 psi, compression was recorded (see Col. 4), under the Mikado-type locomotive, compared with the calculated stress of —298 psi, with a resulting stress factor of 0.48. It can be seen from Col. 8 that the average recorded stresses in the curb carried from 36 to 50 percent of the calculated stresses. The maximum stress of —139 psi compression in the top of the west concrete slab, which occurred simultaneously with the maximum stress in the curb, is 86 percent of the calculated stress. The average recorded stresses in the top of the slabs varied from 68 to 94 percent of the calculated stresses, as shown in Col. 13. The maximum recorded static stress in the bottom reinforcing bars was +1140 psi tension in the east slab under the Mikado-type locomotive, while the calculated stress was +1091 psi, with the concrete taking tension, resulting in a stress factor of 1.04. It can be seen from Col. 23 that the average recorded stresses in the bottom reinforcing bars varied from 70 to 98 percent of the calculated stresses.

A comparison of the recorded and calculated static stresses in the concrete piles of the two bents tested in this bridge under the Mikado-type locomotive is shown in Table 7. The recorded stresses shown are the average of either the two or four gages on the piles, as shown on Fig. 14. It can be seen that the recorded stresses in the piles of these two bents were appreciably smaller than the calculated stresses. The average stress factors in the three piles of bent 29 varied from 0.48 to 0.78, with an average value of 0.63. No readings were secured on the west pile of bent 25, but the stress factors on the east and center piles are about the same as those found on bent 29. The calculated load on the center pile of bent 29 is shown to be 49 percent of the total load carried by all three piles, but actually the center pile was only carrying about 40 percent of the total load.

The variation in the recorded stresses in the slabs and piles of the two bents tested is shown in Fig. 30 for a Mikado-type locomotive crossing the bridge at about 5 mph. It can be seen that the stresses in the top of the east slab varied from —60 psi to —150 psi compression, for an average of —114 psi, a maximum variation of 47 percent from the average. The stresses in the bottom reinforcing bars of the east slab varied from +800 psi to +1375 psi tension, for an average of +1080 psi, a maximum variation of 27 percent from the average.

Grand Trunk Western Bridge

A comparison of the recorded and calculated static live load stresses in the top of the concrete slab and in the bottom reinforcing bars at the center of the span, and in the bottom of the slab and in the top reinforcing bars at the pier, are shown in Table 8. The maximum concrete stress occurred in the bottom of the slab of span 3 under the westbound track where a stress of —154 psi compression was recorded under a Northern-type locomotive. This recorded stress was only 89 percent of the calculated stress of —173 psi. The maximum recorded static steel stress was +1075 psi tension in the top reinforcing bars at the pier where the calculated stress was +1240 psi, with the concrete taking tension, resulting in a stress factor of 0.87.

As mentioned previously, the bending moments in the continuous slabs of this bridge were calculated by the method of moment distribution, and, as shown in Table 8. the moments and resulting stresses at the pier are greater than those at the center of the span. It can be seen that the averaged recorded concrete stress at the center of span 4 under the westbound track produced by a Northern-type locomotive was —105 psi compression, or 66 percent of the calculated stress, while the recorded concrete stress at the pier was —127 psi compression, or 73 percent of the calculated stress, indicating that the slab at the pier was carrying slightly more of the total moment than that predicted by theory. The average recorded steel stress at the center of span 3 under the westbound track produced by a Northern-type locomotive was +960 psi tension, or 85 percent of the calculated stress, while the recorded steel stress at the pier was only +939 psi tension, or 76 percent of the calculated stress, indicating in this case that the slab at the pier was carrying slightly less of the total moment than that predicted by theory. However, a study of the concrete stresses in the slab under the westbound track indicates that the slab at the pier is carrying more of the total moment.

A comparison of the recorded and calculated static stresses in the concrete and reinforcing bars of the columns of pier 3 under the Northern-type locomotive No. 6332 is shown in Table 9. The direct column loads and resulting stresses were calculated on the basis of rigid-frame action, with a uniform load on the bridge seat under the slabs. It can be seen that the recorded stresses were appreciably smaller than those calculated, except in column 2, where both calculated and recorded stresses were quite small.

The variation in the recorded stresses in the slabs and columns of this bridge is shown in Fig. 31 for the Northern-type locomotive crossing the bridge at about 5 mph. It can be seen that there was considerable variation in the concrete stresses on the irregular top of the slab at the center of both spans 3 and 4, but the concrete stresses on the flat surfaces of both spans near the piers were quite consistent. The irregular concrete surface did not appear to have any effect on the stresses in the reinforcing bars as they are fairly uniform.

MAXIMUM STRESSES

The maximum live load plus impact stresses recorded in the concrete and reinforcing bars at various locations on the test bridges under the various locomotive classes at a full range of speeds are shown in Figs. 32 to 111, incl. The maximum stresses in the concrete curbs were the greatest stress recorded by the one gage on the curb of each split slab, but the maximum stresses in the other parts of the structure, such as the top of the concrete slab or the reinforcing bars, are the average of the greatest simultaneous stresses recorded by the several gages on the concrete or steel of each split slab. In like manner, the recorded maximum stresses in the piles or columns are the average of the greatest simultaneous stresses recorded by either the two or four gages on the member.

The calculated maximum stresses shown on the diagrams were determined by computing the live load static stress produced by the particular locomotive on the assumption that the concrete is not taking any tension, and then adding a percentage of the stress for impact as specified by the current AREA specification for design of plain and reinforced concrete members.

Chicago & North Western Bridge

The maximum stresses recorded in the top of the concrete curbs, top of the concrete slab, and in the bottom reinforcing bars at the center of the span, under the passage of the diesel and steam locomotives over the bridge at various speeds are shown in the left diagrams of Figs. 32 to 40, incl. These diagrams also show the recorded and calculated static stresses and the calculated maximum stresses.

It can be seen from these diagrams that there is a general increase in the recorded stresses with an increase in locomotive speed, but even at the highest speeds the stresses are appreciably lower than those calculated. The maximum stress recorded in the concrete was 0.34 ksi, and occurred in the curb of the north slab under the passage of a Mikado-type locomotive at a speed of 2.6 rps (see Fig. 34). This recorded stress is only 34 percent of the calculated maximum stress of 1.0 ksi. The maximum stress recorded in the reinforcing bars was 1.60 ksi and occurred in the north slab under the passage of the 3-axle diesel at a speed of 97 mph (see Fig. 39), which is only about 29 percent of the calculated maximum stress of 5.60 ksi.

It is interesting to note from these diagrams that it is not unusual to record stresses at the higher speeds which are as low as or lower than those recorded at very low speeds. This phenomenon is undoubtedly the result of either a heavy rolling of the locomotive about a longitudinal axis, which would increase the load on one slab with a corresponding decrease in the load on the other slab, or a vertical acceleration of the sprung weight of the locomotive, which would decrease the load on both slabs.

The maximum axial stresses recorded in the three piles of bent 4 under the passage of the diesel and steam locomotives over the bridge at various speeds are shown in the left diagrams of Figs. 41, 42 and 43. It can be seen from these diagrams that there was a gradual increase in the stresses in the piles with an increase in speed, and, in addition, that the south pile was carrying more of the load than the other two piles. The analysis of the static stresses indicated that the south pile was carrying over half of the total load, and this same relation appears to apply to the maximum stresses. As a result of this unequal distribution of the load carried by the piles, a maximum stress of 0.31 ksi was recorded in the south pile under a Mikado-type locomotive at about 2.76 rps, which exceeded the calculated maximum stress in this pile by about 73 percent. An average unit stress of 0.31 ksi in this pile, when multiplied by the equivalent transformed area of 496 sq in, indicates that the pile is carrying about 154,000 lb. An explanation of why the south pile should carry such a large proportion of the load is not available. A study of the pile-driving records of the three piles in this bent shows that the south pile required 7 blows per final inch of penetration, while the other 2 piles required 8 blows, with a single-acting O. R. Vulcan hammer with a 9300-lb ram and a stroke of 39 in.

Missouri Pacific Bridges

Bridge 131

The maximum stresses recorded in the top of the concrete curb, top of concrete slab, top reinforcing bars, and in the bottom reinforcing bars, at the center of the span under the passage of the diesel and steam locomotives over the bridge at various speeds are shown in the left diagrams of Figs. 44 to 53, incl. These diagrams also show the recorded and calculated static stresses and the calculated maximum stresses.

The recorded maximum stresses in the top of the concrete slab under the steam locomotives at the higher speeds (Figs. 46, 47 and 48) are only slightly below the calculated maximum stresses, on the assumption that the concrete is not taking any tension. However, the calculated stresses in the top of the concrete slab are not changed much by either assumption, as mentioned under the discussion of the stat'c stresses and as shown by the calculated static stresses. The maximum stress recorded in the concrete was 0.23 ksi, and occurred in the top of the east slab under a Mikado-type locomotive at a speed of 3.53 rps (see Fig. 47). This recorded stress is about 96 percent of the calculated maximum stress, but is only about 13 percent of the permissible design stress for the concrete used in this bridge.

The recorded maximum stresses in the top reinforcing bars exceed the calculated maximum stresses by a considerable amount, as shown on Fig. 49. The principal reason is that the concrete is taking tension, which makes an appreciable difference in the calculated static stress in the top bars. Only a few recorded stresses would exceed the calculated maximum stress of 1.15 ksi in the top reinforcing bars on the basis that the concrete is taking tension.

The maximum stresses recorded in the bottom reinforcing bars are appreciably lower than the calculated maximum stresses, as shown on Figs. 50 to 53, incl. The maximum recorded stress was 2.1 ksi, and occurred in the west slab under a Mikado-type locomotive at about 4.7 rps (see Fig. 52). This recorded stress is only about 32 percent of the calculated maximum stress and only about 10 percent of the permissible design stress in the reinforcing bars.

The maximum axial stresses recorded in the three piles of bents 5A, 39 and 40 under the passage of the Mountain-type locomotive used in the test train over the bridge at various speeds are shown in the left diagrams of Figs. 54, 55 and 56. It can be seen from the calculated static stresses shown on these diagrams that the center pile should carry about 94 percent more of the load than an outside pile on account of the continuity of the cap. However, in bents 39 and 40, one of the outside piles is carrying more of the vertical load than the inside pile. In all three bents the maximum stresses are well below the calculated maximum stress, using the AREA design impact. A maximum stress of 0.143 ksi was recorded in the east pile of bent 40, Fig. 56, under the locomotive at a speed of 3.45 rps. An average stress of 0.143 ksi in this pile, when multiplied by the equivalent transformed area of 549 sq in, indicates that the maximum vertical load on the pile is about 78,000 lb.

Bridge 637

The maximum stresses recorded in the top of the concrete curb, top of concrete slab, top reinforcing bars, and in the bottom reinforcement at the center of the span under the passage of the diesel and steam locomotives over the bridge at various speeds are shown in the left diagrams of Figs. 57 to 88, incl. These diagrams also show the recorded and calculated static stresses and the calculated maximum stresses.

The recorded maximum stresses in the top of the concrete curb are appreciably smaller at all speeds than those calculated. It can be seen from Figs. 57 to 64, incl., that there was an increase in the recorded stresses in the curbs with an increase in locomotive speed, but the low recorded static stresses account for the maximum stresses at the higher speeds being so much below those calculated. The maximum stress recorded in the concrete curb was 0.24 ksi and occurred under a Mikado-type locomotive at a speed of 3.03 rps (see Fig. 61). This recorded stress is only about 30 percent of the calculated maximum stress.

The recorded stresses in the top of the concrete slab are shown on Figs. 65 to 72, incl., and it can be seen that some values under the 3-axle diesels exceed the calculated stresses by a small amount. The calculated maximum stress shown is based on the concrete not taking any tension, but it would be about the same if the concrete were assumed to take tension, as shown by a comparison of the calculated static stresses on these diagrams. The maximum stress recorded in the slab was 0.23 ksi and occurred under the passage of a Pacific-type locomotive at 2.72 rps (see Fig. 72). While this recorded stress is about 89 percent of the calculated maximum stress it is only about 13 percent of the permissible stress for the concrete used in this bridge.

The recorded maximum stresses in the top reinforcing bars exceed the calculated maximum stresses by a considerable amount, as shown in Figs. 73 to 80, incl., and would exceed the calculated stresses even if they had been based on the assumption that the concrete was taking tension. The maximum stress recorded in the top reinforcing bars was 1.68 ksi and occurred in the west slab under the Mikado-type locomotive at

4.6 rps (see Fig. 76). This recorded stress exceeds the calculated stress by about 127 percent, but only exceeds the calculated stress by about 32 percent when assuming the concrete is taking tension.

The maximum stresses recorded in the bottom reinforcing bars are appreciably smaller than the calculated maximum stresses, as shown on Figs. 81 to 88, incl., but they would exceed in some cases the calculated maximum stresses if they were based on the concrete taking tension. The maximum recorded stress was 2.06 ksi and occurred in the west slab under a Mikado-type locomotive at 4.6 rps (see Fig. 84). This recorded stress is only about 29 percent of the calculated maximum stress and only about 10 percent of the permissible stress in the reinforcing bars.

The maximum axial stresses recorded in the 3 piles of bent 25 under the passage of the 2-axle diesels, 3-axle diesel, and the Midako-type locomotives are shown in the left diagrams of Figs. 89 to 92, incl., while those in bent 29 under only the Mikado-type locomotive used in the test train are shown in Fig. 93. It can be seen in most cases that the east pile is carrying about as much of the axial load as the center pile, even though the calculated static stress values shown on these diagrams indicate that each outside pile should only carry about 52 percent of that carried by the center pile. A maximum stress of 0.16 ksi was recorded in the center pile of bent 25, Fig. 91, under a Mikado-type locomotive at a speed of 2.64 rps, which is only about 54 percent of the calculated stress in this pile, using AREA design impact. An average stress of 0.16 ksi in this pile, when multipled by the equivalent transformed area of 505 sq in, indicates that the maximum vertical load on the pile is about 81,000 lb.

Grand Trunk Western Bridge

The maximum stresses recorded in the top of the concrete slab and in the bottom reinforcing bars at the center of spans 3 and 4, in the bottom of the slab and in the top reinforcing bars of span 3 at pier 2, and in the bottom of the slab and in the top reinforcing bars of span 4 at pier 3, under the passage of diesel and steam locomotives over the bridge at various speeds are shown in the left diagrams of Figs. 94 to 109, incl. These diagrams also show the recorded and calculated static stresses and the calculated maximum stresses.

As explained previously, the normal rail support consisted of heavy steel tie plates resting on ½-in rubber-fabric tie pads, and all recorded test values on these diagrams are shown by the open or closed circles for this type of rail support. The recorded test values shown on the diagrams by the open or closed squares were secured with the rail supported on timber shims.

The recorded maximum stresses in the top of the concrete slab near the center of spans 3 and 4 under the diesel and steam locomotives are shown on Figs. 94 to 97, incl., and it can be seen that the recorded stresses are appreciably smaller than the calculated stresses. The maximum stress recorded in the concrete was 0.20 ksi, and occurred in span 4 under the passage of the Northern-type locomotive at a speed of 4.26 rps (see Fig. 97). This recorded stress is only about 59 percent of the usual calculated maximum stress and is only about 12 percent of the permissible design stress for the concrete used in this bridge.

A study of the maximum stresses recorded in the top of the slab at the center of span 3 under the Northern-type locomotive, Fig. 95, would indicate that the stresses were slightly lower when the rail was supported by the rubber pads. However, by referring to the values recorded in span 4, Fig. 97, it can be seen that the stresses recorded with the rubber pads under the rails were larger than those recorded with the wood shims.

The recorded maximum stresses in the bottom reinforcing bars near the center of spans 3 and 4 are shown on Figs. 98 to 101, incl., and it can be seen that the recorded stresses were well below the calculated values, considering the concrete as not taking any tension, and are also below the calculated values when the concrete is assumed to carry tension. The maximum stress recorded in the reinforcing bars was 1.60 ksi, and occurred in span 3 under the Northern-type locomotive at 4.62 rps (see Fig. 99). This recorded stress is about 19 percent of the usual calculated stress and only about 8 percent of the permissible design stress in reinforcing bars.

The recorded maximum stresses in the bottom of the concrete slab of span 3 at pier 2, and in span 4 at pier 3 under the diesel and steam locomotives are shown on Figs. 102 to 105, incl., and it can be seen that the recorded stresses are well below the calculated maximum stresses, and that in most cases the maximum stresses at the high speeds are even below those calculated for static loading, on the assumption that the concrete is taking tension. It appears that the stresses recorded with the rubber pads are slightly greater than those recorded with the wood shims. The maximum stress recorded in the concrete was 0.198 ksi and occurred in span 3 with the rubber pads (see Fig. 103), while the maximum stress recorded with the wood shims was 0.181 ksi in the same span. The recorded stress of 0.198 ksi is about 44 percent of the usual calculated maximum stress and only about 10 percent of the permissible design stress for the concrete used in this bridge.

The recorded maximum stresses in the top reinforcing bars at the center line of piers 2 and 3 under the diesel and steam locomotives are shown on Figs. 106 to 109, incl. The maximum stress recorded in the reinforcing bars was 1.4 ksi, and occurred at the center of pier 2 under the Northern-type locomotive at a speed of about 4.5 rps, with the rubber pads (see Fig. 107). This recorded stress is only about 14 percent of the usual calculated stress. It should be pointed out that slightly higher stresses might have been recorded at the edge of the pier than at the actual gage location on the center line of the pier. It is also obvious that the gages should have been placed on the reinforcing bars outside of the rails to record maximum stresses produced by the rolling of the locomotive about a longitudinal axis.

The maximum axial stresses recorded in the concrete and reinforcing bars of the columns of pier 3 under the Northern-type test locomotive operating eastbound over the westbound track are shown on Figs. 110 and 111. It can be seen that the recorded maximum concrete stresses in columns 3 and 4 are considerably below those calculated, while those in column 2 are slightly above the calculated values. The maximum average concrete stresses occurred in column 3, the maximum being 0.078 ksi, which, when multiplied by the equivalent transformed area of 1879 sq in, indicates that the maximum axial load on the column was about 146,000 lb. It should be pointed out that the maximum stresses in these columns will occur with both tracks loaded.

TOTAL IMPACTS

The total impacts recorded in the concrete and reinforcement at various locations on the test bridges under the diesel and steam locomotives operating at a full range of speeds are shown in the right diagrams of Figs. 32 to 111, incl. The total impact percentage in each test run for a particular speed is the increase in the stress in the member over that occurring at a slow-speed run for the same locomotive class. The total impacts are the combinations of (1) speed effect, (2) roll effect, and (3) track and hammer-blow effects, although it would be only by chance that the maximum for all effects would occur simultaneously.

The maximum impacts in the concrete curbs were the percentages recorded by the one gage on the curb of each split slab, but the impacts in the other parts of the structure, such as the top of the concrete slab or the reinforcing bars, are the average of the greatest simultaneous impacts recorded by the three or four gages on the concrete or steel of each split slab. In like manner, the total impacts in the piles or columns are the average of the greatest simultaneous impacts recorded by the several gages on the member.

The AREA design impact values shown on the diagrams were determined from the current AREA specifications for design of plain and reinforced concrete members.

The diagrams of recorded total impacts show that there is considerable scatter of the impact values, even at the same speeds, indicating that not all of the impact effects are a maximum at the same time.

A study of the total impact values shown on Figs. 32 to 111, incl., indicates that many values exceeded the AREA design impacts, but it should be kept in mind that the concrete in these slabs is taking tension, which results in low stresses and a very stiff structure. It has been found during tests on steel structures (see 1945 Proceedings, Vol. 46, 1945, page 190) that impacts resulting from track irregularities increase with an increase in span stiffness, and this apparently holds true for the concrete spans.

Chicago & North Western Bridge

The total impacts recorded in the top of the concrete curbs, top of the concrete slab, and in the bottom reinforcing bars at the center of the span under the passage of the diesel and steam locomotives over the bridge at various speeds are shown in the right diagrams of Figs. 32 to 40, incl.

It can be seen from these diagrams that there was a gradual increase in the total impacts with an increase in locomotive speed. The impacts in the concrete curbs under the diesel locomotives are somewhat smaller than those under the steam locomotives, but the impacts in the top of the concrete slabs under the diesels are about the same as those under the steam locomotives. The maximum impact of 95 percent in the top of the concrete slab under the 3-axle diesel at about 73 mph was the same as that recorded under the Mikado-type steam locomotive at about 30 mph (see Figs. 36 and 37). A considerable number of the recorded impact values in the concrete under both the diesel and steam locomotives exceeded the AREA design impacts by a large amount.

The total impacts in the bottom reinforcing bars are shown on Figs. 38, 39 and 40, and it can be seen that they were below the design values for the 2-axle diesels and Mikado-type steam locomotives, but exceeded the design value for the 3-axle diesels by a large amount. However, the maximum speed of the 3-axle passenger diesels was about 100 mph, while that of the 2-axle freight diesel and steam locomotives was below 60 mph.

The total impacts recorded in three concrete piles of bent 4 are shown on Figs. 41, 42 and 43. It can be seen from these diagrams that the maximum impacts were recorded under the 3-axle passenger diesel, which is in line with that found for the bottom reinforcing bars. In general, the impacts recorded in the north and center piles appear to be larger than those in the south piles. However, the impact stress in the south pile was greater than that recorded in the other piles.

Missouri Pacific Bridges

Bridge 131

The total impacts recorded in the top of the concrete curbs, top of the concrete slabs, top reinforcing bars, and bottom reinforcing bars at the center of the span under the passage of the diesel and steam locomotives over the bridge at various speeds are shown in the right diagrams of Figs. 44 to 53, incl.

There was fair agreement between the recorded impacts in the top of the concrete curb and top of concrete slab with the AREA design values, with only two recorded values exceeding the design value. The maximum recorded impact was 70 percent in the top of the concrete slab under a Mikado-type locomotive, compared with a design value of 58 percent (see Fig. 47). It is interesting to note that where a large number of runs were secured under one locomotive class there appears to be a critical speed at about 10 to 15 mph where the impacts were high in the west slab, and another critical speed at about 50 mph (see Figs. 44 and 48). The lower critical speed is undoubtedly the result of some track condition, such as a soft spot under the ties of the west rail.

The recorded total impacts in the top reinforcing bars slightly exceeded the AREA design values for only three runs under the Mountain-type locomotive (Fig. 49). The recorded total impacts in the bottom reinforcing bars were considerably larger than those recorded in the top of the concrete slab or top reinforcing bars, under the same locomotive with a maximum recorded value of 89 percent, compared with a design value of 59 percent (see Fig. 53).

The total impacts recorded in the three concrete piles of bents 5A, 39, and 40, under the Mountain-type steam locomotive are shown on Figs. 54, 55 and 56. It can be seen that the impacts in the three piles of the same bent were about the same, and that the maximum values were appreciably lower than the design values.

Bridge 637

The total impacts recorded in the top of the concrete curbs, top of the concrete slab, top reinforcing bars, and bottom reinforcing bars at the center of the span under the passage of the diesel and steam locomotives over the bridge at various speeds are shown in the right diagrams of Figs. 57 to 88, incl.

It can be seen from these diagrams that exceedingly high impact values were recorded in various locations of this bridge, and that practically all of them occurred in the slab under the west rail. As explained previously, the west rail contained a joint near the center of the span, and the effect on the stresses in the top of the concrete slab and bottom reinforcing bars of the wheels of the 3-axle diesel passing over this joint is shown on the typical oscillogram, Fig. 25. It should be kept in mind that while high impact percentages were recorded in this span, the impact stresses are not exceedingly large.

Total impact values as large as 114 percent in the top of the concrete curb and 137 percent in the top of the concrete slab were recorded under the diesel locomotives as compared with a design impact value of 52 percent (see Figs. 58 and 66). In general, the impacts in the curb and top of slab were greater under the diesels than those under the steam locomotives, with the exception of one high value under a Mikado-type locomotive (see Fig. 61). However, the speeds of the diesels were considerably greater than those of the steam locomotives.

Exceedingly high impact values were recorded in the top and bottom reinforcing bars under both the diesel and steam locomotives, with values as high as 155 percent in the top reinforcing bars and 141 percent in the bottom reinforcing bars under the

Mikado-type steam locomotive, compared with the design value of 61 percent (see Figs. 76 and 84). It should be pointed out that while the impact percentages are quite high, the recorded impact stress was only 1.02 ksi in the top reinforcing bars and 1.19 ksi in the bottom reinforcing bars.

The total impacts recorded in the east and center piles of bent 25, and in all three piles of bent 29, are shown in Figs. 89 to 93, incl. It can be seen that the impacts recorded in the two piles of bent 25 exceed the design values by a large amount, and these impact values are undoubtedly a direct result of the high impact values in the test slab which bent 25 supports. The impact values in bent 29 are considerably smaller than those recorded in bent 25 under the same test locomotive, with only one value exceeding the design value (see Figs. 92 and 93).

Grand Trunk Western Bridge

The total impacts recorded in the top of the concrete slab and in the bottom reinforcing bars near the center of spans 3 and 4, in the bottom of the slab and in the top reinforcing bars of span 3 and pier 2, and in the bottom of the slab and in the top reinforcing bars of span 4 at pier 3, under the passage of diesel and steam locomotives over the bridge at various speeds are shown in the right diagrams of Figs. 94 to 109, incl.

A study of these diagrams indicates that in some locations the total impacts recorded under the diesel locomotives were greater than those recorded under the steam locomotives, but that in other locations the impacts under the steam locomotives were larger. For example, the impacts in the bottom reinforcing bars at the center of span 3 were somewhat larger under the diesel locomotives than under the steam locomotives (see Figs. 98 and 99), while the impacts in the top reinforcing bars of span 4, near pier 3, were somewhat larger under the steam locomotives (see Figs. 108 and 109). The maximum impact under the diesel locomotives occurred in the top of the concrete slab near the center of span 4, where a value of 78 percent was recorded with the rubber pads, compared with the design value of 47 percent (see Fig. 96). The maximum impact under the steam locomotives occurred at the same location and amounted to 85 percent, compared with the design value of 57 percent (see Fig. 97). While the impact percentages exceed the design values by a considerable amount, the recorded impact stress under the diesel locomotive was only 45 psi compared with the calculated impact stress of 48 psi, based on the concrete taking tension. The recorded impact stress under the steam locomotive was 98 psi, while the calculated impact stress was 91 psi.

It can be seen from these diagrams that there is no definite indication that the recorded impacts in this bridge are either larger or smaller with the rubber-fabric pads. In some locations, such as the top of the slab at the center of span 3, the impacts recorded with the hardwood shims are slightly larger than those with the rubber pads (see Fig. 95), while the impacts recorded in the bottom reinforcing bars at the center of span 3 were considerably smaller with the hardwood shims (see Fig. 99). The average of all the recorded impacts in the concrete and reinforcing bars under the steam test locomotive is 24.5 percent with the rubber pads, compared with an average of 24 percent with the hardwood shims.

The maximum recorded impacts in the columns of pier 3, as determined from the axial stresses in the concrete and reinforcing bars under the Northern-type test locomotive operating eastbound over the westbound track, are shown on the right diagrams of Figs. 110 and 111. It can be seen that the impacts in column 2, as determined from the concrete stresses, are larger than those recorded in the other two columns; however, the recorded static stresses were quite small in this column, so that any impact stress would have a large percentage value.

The maximum recorded impact values in columns 3 and 4, as determined from the axial stresses in the reinforcing bars, exceed the design values at the higher speeds, and are about the same in the two columns.

LATERAL AND LONGITUDINAL BENDING IN PILES

A considerable variation in the recorded stresses at all speeds was found between the individual gages located on the piles of the three concrete trestles and on the columns of the continuous-span subway. This variation is shown for several typical slow-speed runs in Figs. 28 to 31, incl. It can be seen from Fig. 28 that the compressive stresses in the center pile under the Mikado-type locomotive for this particular slow-speed run varied from —77 psi to —120 psi, with an average of —102 psi. A study of the four recorded stresses with the average indicates that the stresses do not vary across the section as a plane, so in determining the maximum bending stresses, the difference between the largest stress and the average stress was taken as the bending stress. For example, the lateral bending of the center pile of Fig. 28 was taken as the difference between —115 psi and the average of —102 psi, or —13 psi, which is 12.7 percent of the axial load in the column. This eccentric bending was to the south. The longitudinal bending of the center pile was taken as the difference between —120 psi, which is the largest stress, and the average of —102 psi, which is 18 psi, or 17.7 percent of the axial load. This eccentric bending was to the west.

The lateral bending in the piles and columns of the four bridges tested under the various diesel and steam locomotives is shown as a percentage of the axial stress in the pile or column (see Figs. 112 to 119, incl). It can be seen from these diagrams that the lateral bending in the piles was quite large, especially in the Chicago & North Western bridge, where bending as large as 96 percent was recorded in the north pile under a Mikado-type locomotive at about 30 mph (see Fig. 114). There does not appear to be any general relation between locomotive speed and lateral bending, although in a few piles, such as the west pile of the Missouri Pacific bridge 131, Fig. 115, the lateral bending increases quite definitely with an increase in locomotive speed. The exact cause or loading condition to produce these bending stresses is not known, but any uneven bearing of the slab on the concrete pile cap would produce bending in the cap, with resulting lateral bending in the pile. Of course, a lateral force is transmitted from the locomotive wheels to the bents, but it will be shown later than this force is usually vibrating, and these forces have been reported separately.

The longitudinal bending in the piles and columns of the four bridges tested under the diesel and steam locomotives is shown as a percentage of the axial stress in the pile or column (see Figs. 120 to 130, incl.). The majority of the values shown on these diagrams was secured under the normal operation of the trains; however, the use of the special test train during the testing of the Missouri Pacific bridges permitted the determination of the longitudinal bending effects resulting from a hard service application of the brakes. The longitudinal bending effects resulting from the application of the brakes on the test train are shown on Figs. 124 and 125 by the open squares, just as the train comes to a stop on the bridge or at a locomotive speed of 0 mph, and the values shown are the bending stresses resulting from the eccentricity of load on the pile plus the bending stresses resulting from the locomotive braking. It can be seen that the longitudinal bending resulting from the test train coming to a stop due to braking is considerably greater than those produced by the eccentricity of load under the normal train operation, but the longitudinal bending produced by the test train braking at the higher speeds is about the same as that produced by the normal train operation. More data on the effects of train braking are presented under "Lateral and Longitudinal Forces."

A study of Figs. 120 to 130, incl., indicates that there is no general relation between locomotive speed and longitudinal bending in the piles. The exact causes of the bending is not known, but it could be the result of the slabs in one span bearing near the edge of the cap, with the slabs of the adjoining span bearing closer to the center of the cap.

LONGITUDINAL AND LATERAL FORCES

The testing of the two long trestles on the Missouri Pacific with the special test train afforded an opportunity to secure data on the bending stresses in the piles resulting from a train crossing the bridge at various speeds under normal operating conditions, compared to the bending stresses produced by the same train crossing the bridge with the brakes applied. In addition, tests were made to determine the bending stresses in the piles resulting from stopping the train over the test bent by a hard service application of the brakes, and then accelerating the train as rapidly as possible to determine the tractive effects of the drivers. In making these longitudinal force tests, the gages were placed on the piles of bents 39 and 40 of bridge 131, and bents 25 and 29 of bridge 637, with the gages located near the ground line, as shown on Figs. 12 and 14. In addition to the gages on the piles, gages were also placed longitudinally on the webs of the rails at the neutral axis, as shown on Figs. 12 and 14, to determine any longitudinal forces carried by the rails.

The general character of the stresses produced in the piles and rails by stopping the train on the bridge by a hard service application of the brakes on the test train is shown on Fig. 131. The general elevation of the north approach of the Missouri Pacific bridge 131 is shown at the top of the diagram, with a Mountain-type locomotive, six hopper cars and caboose shown on the bridge in the position where they stopped. The gages were located on the piles of bent 39 as shown by Sec. C–C, and on the rails over bent 37, Sec. A–A, and bent 42, Sec. B–B. The traces shown on this diagram were reproduced from the oscillogram secured for one of these test runs. The upper two traces, with gages B5 and B6 located on the two rails over bent 37, indicate that the rails started carrying longitudinal stresses when the brakes were first applied, and that these stresses kept increasing until the forward movement of the train stopped. As soon as the train stopped, the compressive stresses in the rails were released, but it can be seen that the structure continued to vibrate at a low frequency for some time. It can be seen from the trace of gage B5 that this rail returned to about its original position, but that the rail having gage B6 went into slight tension after the structure stopped vibrating. A maximum compressive stress of 2000 psi was recorded in each rail web. Thus, assuming uniform distribution of stress over the entire cross section of the 112-lb rail, a total longitudinal force of 44,000 lb is being carried by the rails for this particular run.

The two lower traces on Fig. 131 were obtained from gages located on the center pile of bent 39, as shown by Sec. C–C, and it can be seen that their action was similar to that of the rails, except that as soon as the first wheel came onto the span between bents 39 and 40, the piles started taking vertical load as well as longitudinal load. However, the magnitude of the stress in the piles resulting from the stopping of the train can be determined by drawing a mean line through the residual oscillations and measuring the distance between the maximum trace deflection at the instant the train stopped and the mean line. For the particular run shown on Fig. 131, the north side of the pile, gage A3, was stressed in bending to 60 psi compression by the braking force, and the south side was stressed to 60 psi tension. By using the average bending stress in the three piles and considering the bent fixed at the top of the concrete collar at the ground line, and at the bottom of the cap, it was determined that bent 39 was carrying a longitudinal force of 5100 lb.

The magnitude of the longitudinal bending stresses in the piles of the various bents recorded under the diesel and steam locomotives crossing over the bridges under normal operating conditions previously discussed and shown in Figs. 120 to 130, incl. are believed to be the result of eccentric loading of the piles. It is apparent that the application of a longitudinal force, such as that produced by the braking of a train, would either increase or decrease the bending stresses in the piles, depending upon the direction of the eccentric bending. To determine whether the application of the brakes on the test train actually increased or decreased the bending stresses in the piles, the forces required to produce the bending stresses measured under the two operating conditions were calculated and are shown in Figs. 132 and 133 for the test trains on the Missouri Pacific bridges. For example, the longitudinal force values shown by the open and solid circles on Fig. 132 were calculated using the bending stresses in the piles secured under normal operation of the test train over the bridge, while those shown by the open and solid triangles were calculated from the bending stresses secured with the test train crossing the bridge at the speeds indicated, but having the brakes applied just before reaching the test bents. It can be seen that there is very little difference in the longitudinal forces between the two methods of operation, except at the lower speeds where there is some indication of an increase in the longitudinal force with the test train braking. The longitudinal force values shown by the solid squares at a zero speed were secured with the test train stopping on the bridge over the test bent, as explained previously. It can be seen from Fig. 132 that the maximum longitudinal force carried by bents 39 and 40 was slightly over 6 kips, compared with the AREA design specification force of 35 kips. However, it should be kept in mind that the rails were carrying longitudinal forces as large as 44 kips.

A study of the oscillograms secured under the test trains with the gages on the piles of the Missouri Pacific bridges indicated that the locomotive was producing a sinusoidal lateral force on the bent at a frequency of about 3.3 vps, as shown by the typical oscillogram on Fig. 26. The effect of this lateral force is to bend the pile about an axis parallel to the track, with a resulting tension on one side of the pile and a simultaneous compression on the other side. It can be seen from Fig. 26 that at any particular time, such as that shown by the right vertical line, the gages on the east side of the piles, B1, B5 and B9, indicate tensions, while those on the west side, B3, B7 and B11, indicate compression. The bending stresses in the piles were determined by drawing the upper and lower envelope curves through the peaks of the oscillations and then drawing the "mean stress curve" for each trace, as shown on Fig. 26. The maximum lateral bending stress or semi-amplitude for each pile can then be determined as shown.

The lateral forces required to produce the measured lateral bending stresses in the piles were calculated on the assumption that the bent was acting as a rigid frame, with the piles fixed at the top of the collar at the ground line and with the concrete cap encasing the top of the piles acting as part of the frame. The lateral forces determined from the bending stresses in bents 5A and 25 produced by the test trains on the Missouri Pacific bridges are shown on Figs. 132 and 133. It can be seen that the maximum lateral force was 6 kips, compared with an AREA design force of 20 kips.

CONCRETE TENSILE STRAINS

The tensile strains in the concrete were measured simultaneously with the tensile strains in the reinforcement bars as shown by the location of the gages on Figs. 2, 8, 14 and 16 for the four bridges tested. As explained previously under the discussion of static stresses, the recorded stresses were appreciably lower than the calculated static stresses, with an explanation that the section was acting monolithically with the concrete carrying part of the tensile stresses.

The relation between the measured tensile strains in the concrete and in the reinforcing bars in the four bridges tested is shown on the four diagrams of Fig. 134 for a full range of speed up to about 100 mph. The ordinate on each of these diagrams is the ratio of the strain in the concrete to the strain in the reinforcement. Accordingly, a ratio of 1 indicates that the strains are the same, while a ratio of 0.5 indicates that the strain in the concrete was only 50 percent of that in the reinforcement. A study of Fig. 134 indicates that in some of the slabs the strains in the concrete and reinforcement were about the same, while in others the strain in the concrete was considerably lower than the strain in the reinforcement. For example, there was good comparison between the concrete and reinforcement strains in the north slab of the Chicago & North Western bridge, but the concrete strains in the south slab were only about 40 percent of the reinforcement strains. It is interesting to note that this variation in ratios between the north and south slab is reflected in the recorded static stresses, as shown in Table 2. In this table, the recorded static stresses in the reinforcing bars of the south slab were somewhat smaller than those recorded in the north slab.

It can be seen from the diagrams on Fig. 134 that the ratios of the strains in the concrete and reinforcement are about the same for all locomotive speeds, so that this composite action can be relied upon, to some degree, under dynamic loading as well as under static loading of the structure.

CONCLUSIONS

The tests on these four concrete bridges afforded an opportunity to measure and compare the static and dynamic effects produced by the passage of diesel and steam locomotives over the same spans at various speeds. The conclusions stated in this report must be considered as applying to these bridges only; the final conclusions pertaining to the behavior of concrete bridges under railroad loading must await further tests on this type of structure.

From the data as found from these tests, it seems logical to conclude that:

1. The concrete and reinforcing bars are acting partially as a composite section, with the concrete carrying part of the tensile stresses. Full interaction between the concrete and reinforcement does not exist, as the concrete tensile strains varied from about 40 to 90 percent of the reinforcement tensile strains.
2. The concrete curbs are acting as part of the section.
3. The stresses in the tensile reinforcing bars are only about 20 percent of those calculated for the same loading by AREA design specification.

4. The impact percentages exceed the AREA design values by a considerable amount as a result of the low static stresses, but the impact stresses are appreciably smaller than those predicated by AREA design rules.
5. A poorly supported rail joint near the center of the span increases the impact stresses appreciably.
6. The use of ½-in rubber-fabric pads under regular steel tie plates did not reduce the impact stresses in the slabs.
7. The recorded lateral forces are smaller than those predicated by AREA design specification.
8. Only small longitudinal forces are transmitted to the structure when the brakes are applied to a fast-moving train.
9. Maximum longitudinal effects on the structure are produced when the train is stopped on the span by the application of the brakes.
10. The total longitudinal force produced when the train is stopped on the span exceeds that specified by AREA specifications. Of the total force, the greater part is carried by the rails.

ACKNOWLEDGMENT

The Committee on Impact and Bridge Stresses is indebted to the officers of the Chicago & North Western Railway, the Missouri Pacific Railroad, and the Grand Trunk Western Railroad for their cooperation in conducting these tests.

TABLE I

RATING OF TEST LOCOMOTIVES

RAILROAD	LOCOMOTIVES		C.&N.W.RY.	M.P.R.R.		G.T.W.R.R.
	TYPE & CLASS	NUMBER	19'-3½ R.C. SLAB SPAN	BR. NO. 131	BR. NO. 637	38'-11¾ R.C. SLAB SPAN
				19'-0 R.C. SLAB SPAN		
C.&N.W.RY. (FIG. 19)	MIKADO 2-8-2 CLASS "J"	2533-2597	E 49.6			
	3-AXLE DIESELS	5005-5006	E 36.1			
	2-AXLE DIESELS	4067-4071	E 33.3			
M.P.R.R.	MIKADO 2-8-2 (FIG. 20)	1264-1279		E 49.3		
		1301		E 48.4		
		1405-1526			E 56.1	
		1537-1553			E 54.5	
	MOUNTAIN 4-8-2 (FIG. 21)	5308-5316			E 45.6	
		5322-5324			E 48.2	
		5337		E 50.6		
	PACIFIC 4-6-2 (FIG. 21)	6001			E 47.8	
		6613-6625			E 53.0	
	2-AXLE DIESELS (FIG. 22)	301-320		E 32.1	E 32.1	
		577-614		E 35.0	E 35.0	
		1513-1557 *			E 31.8	
	3-AXLE DIESELS (FIG. 22)	7004-7019			E 37.6	
		8003-8009			E 34.6	
G.T.W.R.R. (FIG. 23)	NORTHERN 4-8-4 CLASS U-3	6312-6336				E 57.1
	2-AXLE DIESELS CLASS V-1	9006-9027				E 36.6

* T.&P.RY. LOCOMOTIVES

TABLE 2
CHICAGO AND NORTH WESTERN RAILWAY BRIDGE TESTS
19'-3½ R.C. SPLIT SLAB SPAN - BALLASTED FLOOR
COMPARISON OF RECORDED AND CALCULATED STATIC STRESS IN SLABS

SLAB	LOCOMOTIVE		TOP OF CONCRETE CURB					TOP OF CONCRETE SLAB					BOTTOM REINFORCING BARS				
			RECORDED STRESS	CALCULATED STRESS CONCRETE NOT TAKING TENSION	CALCULATED STRESS CONCRETE TAKING TENSION	STRESS FACTOR		RECORDED STRESS	CALCULATED STRESS CONCRETE NOT TAKING TENSION	CALCULATED STRESS CONCRETE TAKING TENSION	STRESS FACTOR		RECORDED STRESS	CALCULATED STRESS CONCRETE NOT TAKING TENSION	CALCULATED STRESS CONCRETE TAKING TENSION	STRESS FACTOR	
	CLASS	NUMBER															
COL. 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
SOUTH	2 AXLE DIESELS	4067											+512			0.69	
		4071	-105			0.51		-99			0.80		+537			0.73	
		4069		-418	-207		0.55		-164	-124		0.93	+612	+3340	+737	0.83	0.77
		4070	-105			0.51		-125			1.01		+612			0.83	
		4069	-132			0.64		-123			0.99		+550			0.75	
NORTH		4067											+562			0.76	
		4071	-141			0.68		-119			0.96		+612			0.83	
		4069		-418	-207		0.80		-164	-124		0.99	+700	+3340	+737	0.95	0.89
		4070	-190			0.92		-135			1.09		+737			1.00	
		4069	-166			0.80		-115			0.93		+662			0.90	
SOUTH	3 AXLE DIESELS	5005	-79			0.35		-100			0.75		+662			0.83	
		5006	-72	-452	-225	0.32	0.34	-101	-177	-134	0.75	0.75	+637	+3615	+797	0.80	0.79
		5006											+625			0.78	
		5006											+587			0.74	
NORTH		5005	-147			0.65		-116			0.87		+812			1.02	
		5006	-147	-452	-225	0.65	0.65	-128	-177	-134	0.95	0.91	+850	+3615	+797	1.07	1.02
		5006											+812			1.02	
		5006											+775			0.97	
SOUTH	CLASS "J"	2552	-151			0.39		-163			0.71		+912			0.66	
		2550		-780	-387		0.37		-306	-230		0.68	+875	+6250	+1375	0.64	0.63
		2501	-132			0.34		-149			0.65		+837			0.61	
		2394											+812			0.59	
NORTH		2552	-220			0.57		-160			0.70		+1125			0.82	
		2550		-780	-387		0.56		-306	-230		0.67	+1050	+6250	+1375	0.76	0.73
		2501	-208			0.54		-148			0.64		+1012			0.74	
		2394											+825			0.60	

NOTE: STRESSES ARE GIVEN IN PSI., WHERE (+) INDICATES TENSION AND (–) COMPRESSION
STRESS FACTOR, AS GIVEN, IS THE RATIO OF RECORDED TO CALCULATED STRESS, ASSUMING CONCRETE TAKING TENSION
E_s=30,000,000 PSI. E_c=5,000,000 PSI. (ULTIMATE STRENGTH AT 28 DAYS = 5,000 PSI.) n=6.0

TABLE 3

CHICAGO & NORTH WESTERN RAILWAY BRIDGE TESTS

BENT NO. 4 - 19'-3½ & 18'-2 R.C. SPLIT SLAB SPANS – BALLASTED FLOOR

COMPARISON OF RECORDED AND CALCULATED DIRECT STATIC STRESSES IN PILES

LOCOMOTIVE		SOUTH PILE				CENTER PILE				NORTH PILE			
		RECORDED	CALCULATED	STRESS FACTOR		RECORDED	CALCULATED	STRESS FACTOR		RECORDED	CALCULATED	STRESS FACTOR	
CLASS	NO.				AVER.				AVER.				AVER.
COL. 1	2	3	4	5	6	7	8	9	10	11	12	13	14
2-AX. DIESELS	4067	149	77	1.93	1.86	77	82	0.94	0.77	74	70	1.06	0.88
	4069	137		1.78		48		0.59		49		0.70	
3-AX. DIESELS	5006	164	78	2.10	1.97	60	83	0.72	0.67	57	71	0.80	0.75
	5006	143		1.83		51		0.62		49		0.69	
CLASS "J"	2550	222	114	1.95	1.75	96	121	0.79	0.67	68	103	0.66	0.62
	2394	177		1.55		67		0.55		59		0.57	

NOTE: STRESSES IN PILES ARE COMPRESSIVE AND GIVEN IN PSI.
STRESS FACTOR, AS GIVEN, IS THE RATIO OF RECORDED TO CALCULATED STRESS.
E_s = 30,000,000 PSI. E_c = 5,000,000 PSI. (ULTIMATE STRENGTH AT 28 DAYS = 5,000 PSI.) n = 6

TABLE 4
MISSOURI PACIFIC RAILROAD BRIDGE TESTS
BRIDGE NO 131-19'-0 R.C. SPLIT SLAB SPAN – BALLASTED FLOOR
COMPARISON OF RECORDED AND CALCULATED STATIC STRESSES IN SLABS

SLAB	LOCOMOTIVE		TOP OF CONCRETE CURB					TOP OF CONCRETE SLAB					TOP REINFORCING BARS					BOTTOM REINFORCING BARS				
			RECORDED STRESS	CALCULATED STRESS		STRESS FACTOR		RECORDED STRESS	CALCULATED STRESS		STRESS FACTOR		RECORDED STRESS	CALCULATED STRESS		STRESS FACTOR		RECORDED STRESS	CALCULATED STRESS		STRESS FACTOR	
	CLASS	NO		CONCRETE NOT TAKING TENSION	CONCRETE TAKING TENSION				CONCRETE NOT TAKING TENSION	CONCRETE TAKING TENSION				CONCRETE NOT TAKING TENSION	CONCRETE TAKING TENSION				CONCRETE NOT TAKING TENSION	CONCRETE TAKING TENSION		
COL. 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
EAST	2 AXLE DIESELS	312		-291	-166		0.44	-56	-96	-90	0.62	0.80	-287	-272	-459	0.63	0.68	+635	+2582	+650	0.98	0.92
		315						-75			0.83							+650			1.00	
		514		-314	-179			-90	-104	-98	0.92			-295	-496			+610	+2796	+704	0.87	
		519	-79			0.44		-87			0.89		-358			0.72		+611			0.87	
		616		-292	-166			-68	-97	-90	0.76			-274	-460			+585	+2595	+654	0.90	
WEST		312		-291	-166		0.36		-96	-90		0.96	-467	-272	-459	1.02	0.90	+560	+2582	+650	0.86	0.92
		315						-113			1.26							+685			1.05	
		514		-314	-179			-90	-104	-98	0.92			-295	-496			+660	+2796	+704	0.94	
		519	-64			0.36		-84			0.86		-383			0.77		+550			0.79	
		616		-292	-166			-71	-97	-90	0.79			-274	-460			+635	+2595	+654	0.97	
EAST	MOUNTAIN TYPE 4-8-2	5337	-109	-459	-261	0.42	0.48	-122	-152	-142	0.86	0.90	-660	-431	-724	0.91	0.96	+957	+3850	+970	0.99	1.01
								-143			1.01							+1006			1.04	
								-116			0.82							+1020			1.05	
			-109			0.42		-124			0.87		-600			0.83		+856			0.88	
			-128			0.49		-140			0.99		-785			1.08		+1025			1.06	
			-154			0.59		-134			0.94		-750			1.04		+1015			1.05	
								-116			0.82		-688			0.95		+900			0.93	
													-675			0.93		+1060			1.09	
WEST		5337	-120	-459	-261	0.46	0.48	-121	-152	-142	0.85	0.98	-742	-431	-724	1.02	1.18	+950	+3850	+970	0.98	1.05
								-161			1.13							+906			0.94	
								-139			0.98							+917			0.95	
			-113			0.43		-118			0.83		-767			1.06		+908			0.94	
			-146			0.56		-137			0.96		-967			1.33		+1080			1.11	
			-120			0.46		-165			1.16		-950			1.31		+1075			1.11	
													-858			1.18		+1025			1.06	
													-850			1.17		+1230			1.27	

NOTE: STRESSES ARE GIVEN IN PSI., WHERE (+) INDICATES TENSION AND (-) COMPRESSION
STRESS FACTOR AS GIVEN IS THE RATIO OF RECORDED TO CALCULATED STRESS ASSUMING CONCRETE TAKING TENSION
E_s = 30,000,000 PSI, E_c = 4,500,000 PSI. (ULTIMATE STRENGTH IN 28 DAYS = 4500 PSI.) n = 6.7

TABLE 5

MISSOURI PACIFIC RAILROAD BRIDGE TESTS

BRIDGE NO. 131
- BENT 5A – 18'-0 AND 19'-0 R.C. SPLIT SLAB SPANS – BALLASTED FLOOR
- BENT 39 – 24'-0 AND 27'-0 W.F. BEAM SPANS } BALLASTED TIMBER FLOOR
- BENT 40 – 27'-0 W.F. BEAM SPANS } BALLASTED TIMBER FLOOR

COMPARISON OF RECORDED AND CALCULATED DIRECT STATIC STRESSES IN PILES

BENT NO.	LOCOMOTIVE TYPE & NO.	EAST PILE				CENTER PILE				WEST PILE			
		RECORDED	CALCULATED	STRESS FACTOR	AVER.	RECORDED	CALCULATED	STRESS FACTOR	AVER.	RECORDED	CALCULATED	STRESS FACTOR	AVER.
COL. 1	2	3	4	5	6	7	8	9	10	11	12	13	14
5A	MOUNTAIN TYPE 4-8-2 NO. 5337	62	82	0.76	0.74	91	159	0.57	0.57	67	82	0.82	0.84
		58		0.71		86		0.54		60		0.73	
		63		0.77		97		0.61		71		0.87	
		60		0.73		91		0.57		77		0.94	
39		94	106	0.89	0.78	124	182	0.68	0.60	106	106	1.00	1.07
		80		0.75		96		0.53		114		1.08	
		72		0.68		100		0.55		116		1.09	
		86		0.81		110		0.61		112		1.06	
		82		0.77		114		0.63		118		1.11	
40		126	119	1.06	0.93	105	187	0.56	0.55	82	119	0.68	0.68
		93		0.78		97		0.52		78		0.66	
		112		0.94		99		0.53		82		0.69	
		103		0.87		99		0.53		76		0.64	
		118		0.99		110		0.59		88		0.74	

NOTE: STRESSES IN PILES ARE COMPRESSIVE AND GIVEN IN PSI.
STRESS FACTOR AS GIVEN IS THE RATIO OF RECORDED TO CALCULATED STRESS
E_s = 30,000,000 PSI. E_c = 4,500,000 PSI. (ULTIMATE STRENGTH AT 28 DAYS = 4,500 PSI.) n = 6.7

TABLE 6
MISSOURI PACIFIC RAILROAD BRIDGE TESTS
BRIDGE NO 637 – 19'-0 R.C. SPLIT SLAB SPAN – BALLASTED FLOOR
COMPARISON OF RECORDED AND CALCULATED STATIC STRESS IN SLABS

SLAB	LOCOMOTIVE CLASS	LOCOMOTIVE NUMBER	TOP OF CONCRETE CURB: RECORDED STRESS	CALCULATED STRESS, CONCRETE NOT TAKING TENSION	CALCULATED STRESS, CONCRETE TAKING TENSION	STRESS FACTOR		TOP OF CONCRETE SLAB: RECORDED STRESS	CALCULATED STRESS, CONCRETE NOT TAKING TENSION	CALCULATED STRESS, CONCRETE TAKING TENSION	STRESS FACTOR		TOP REINFORCING BARS: RECORDED STRESS	CALCULATED STRESS, CONCRETE NOT TAKING TENSION	CALCULATED STRESS, CONCRETE TAKING TENSION	STRESS FACTOR		BOTTOM REINFORCING BARS: RECORDED STRESS	CALCULATED STRESS, CONCRETE NOT TAKING TENSION	CALCULATED STRESS, CONCRETE TAKING TENSION	STRESS FACTOR	
COL 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
EAST	2 AXLE DIESELS	307	-90	-286	-163	0.55	0.49	-80	-95	-89	0.90	0.94	-475	-268	-452	1.05	1.08	+645	+2542	+640	1.01	0.96
		314						-98			1.10							+650			1.02	
		578	-90	-312	-177	0.51		-90	-103	-97	0.93		-500	-291	-492	1.02		+625	+2778	+698	0.91	
		1546*	-64	-285	-161	0.40		-71	-95	-88	0.81		-525	-266	-448	1.17		+575	+2525	+636	0.90	
WEST		307	-79	-296	-169	0.47	0.44	-69	-97	-91	0.76	0.80	-442	-278	-466	0.95	1.11	+580	+2622	+660	0.88	0.84
		314						-86			0.95							+575			0.87	
		578	-75	-322	-183	0.41		-68	-107	-99	0.69		-442	-303	-508	0.87		+480	+2862	+722	0.67	
		1546*	-71	-294	-167	0.43		-70	-98	-90	0.78		-700	-276	-462	1.51		+600	+2605	+656	0.92	
EAST	3 AXLE DIESELS	7009	-94	-337	-192	0.49	0.50	-93	-111	-104	0.89	0.91	-600	-316	-530	1.13	1.12	+730	+2992	+752	0.97	0.98
		7014	-98			0.51		-96			0.93		-592			1.12		+750			0.99	
WEST		7009	-90	-348	-198	0.46	0.48	-80	-115	-108	0.74	0.79	-533	-326	-546	0.98	1.15	+590	+3080	+776	0.76	0.86
		7014	-98			0.50		-91			0.84		-716			1.31		+740			0.95	
EAST	MIKADO TYPE 2-8-2	1405	-124	-502	-286	0.43	0.43	-120	-166	-156	0.77	0.76	-758	-472	-791	0.96	0.97	+1000	+4460	+1123	0.89	0.89
		1460	-113	-510	-290	0.39		-129	-168	-157	0.82			-479	-802			+940	+4530	+1139	0.83	
		1493	-120	-494	-282	0.43		-127	-163	-153	0.83		-783	-465	-777	1.01		+955	+4400	+1106	0.86	
		1547		-485	-276				-161	-151			-725	-455	-765	0.95		+980	+4310	+1091	0.90	
													-700			0.92		+940			0.86	
													-875			1.14		+1140			1.04	
													-750			0.98		+1015			0.93	
													-625			0.82		+970			0.89	
		1550	-131			0.47		-124			0.82		-750			0.98		+1030			0.94	
		1561	-109	-477	-272	0.40		-83	-158	-148	0.56		-692	-448	-743	0.93		+840	+4240	+1066	0.79	
WEST		1405	-113	-518	-296	0.38	0.41	-98	-172	-160	0.61	0.69	-775	-488	-815	0.95	0.87	+925	+4600	+1161	0.80	0.77
		1460	-143	-526	-298	0.48		-139	-174	-162	0.86			-490	-828			+1010	+4670	+1170	0.86	
		1493	-128	-510	-290	0.44		-105	-169	-157	0.67		-808	-479	-803	1.00		+905	+4540	+1140	0.79	
		1547		-501	-286				-167	-155			-550	-470	-790	0.70		+770	+4450	+1139	0.68	
													-600			0.76		+765			0.67	
													-825			1.04		+980			0.86	
													-600			0.76		+825			0.73	
													-600			0.76		+900			0.79	
		1550	-113			0.40		-99			0.64		-758			0.96		+840			0.74	
		1561	-101	-493	-280	0.36		-100	-164	-152	0.66		-675	-464	-767	0.88		+845	+4380	+1102	0.77	
EAST	MOUNTAIN TYPE 4-8-2	5308	-101	-406	-231	0.44	0.46	-109	-135	-126	0.87	0.77	-667	-382	-639	1.04	1.01	+800	+3610	+910	0.88	0.94
		5323	-116	-431	-245	0.47		-88	-143	-133	0.66		-658	-404	-678	0.97		+950	+3820	+965	0.99	
WEST		5308	-101	-420	-239	0.42	0.41	-99	-139	-130	0.76	0.76	-650	-394	-661	0.98	0.97	+640	+3730	+941	0.68	0.75
		5323	-98	-445	-253	0.39		-104	-147	-137	0.76		-667	-418	-700	0.95		+795	+3945	+997	0.81	
EAST	PACIFIC TYPE 4-6-2	6001	-105	-427	-243	0.43	0.42	-101	-142	-132	0.77	0.76	-738	-400	-672	1.10	1.09	+750	+3790	+955	0.79	0.79
		6618	-113	-472	-268	0.42		-108	-156	-147	0.74		-813	-444	-744	1.09		+845	+4200	+1056	0.80	
WEST		6001	-83	-441	-251	0.33	0.36	-90	-146	-136	0.66	0.68	-608	-412	-694	0.88	0.89	+635	+3910	+985	0.65	0.70
		6618	-105	-488	-278	0.38		-104	-162	-151	0.69		-692	-460	-770	0.90		+820	+4340	+1092	0.75	

NOTE: STRESSES ARE GIVEN IN PSI., WHERE (+) INDICATES TENSION AND (–) COMPRESSION
STRESS FACTOR, AS GIVEN, IS THE RATIO OF RECORDED TO CALCULATED STRESS, ASSUMING THAT CONCRETE TAKES TENSION
E_s = 30,000,000 PSI. E_c = 4,500,000 PSI. (ULTIMATE STRENGTH AT 28 DAYS = 4,500 PSI.) n = 6.7
*) T. & P. R.R. DIESEL LOCOMOTIVE

TABLE 7

MISSOURI PACIFIC RAILROAD BRIDGE TESTS

BRIDGE NO. 637 {BENT 25 – 19'-0 – R.C. SPLIT SLAB SPANS / BENT 29 – 16'-0 & 18'-0 – R.C. SPLIT SLAB SPANS} BALLASTED FLOOR

COMPARISON OF RECORDED AND CALCULATED DIRECT STATIC STRESSES IN PILES

BENT NO.	LOCOMOTIVE TYPE & NO.	EAST PILE				CENTER PILE				WEST PILE			
		RECORDED	CALCULATED	STRESS FACTOR	AVER.	RECORDED	CALCULATED	STRESS FACTOR	AVER.	RECORDED	CALCULATED	STRESS FACTOR	AVER.
COL. 1	2	3	4	5	6	7	8	9	10	11	12	13	14
25	MIKADO TYPE 2-8-2 NO. 1547	63		0.69		97		0.55					
		66		0.73		93		0.53					
		57	91	0.63	0.71	87	175	0.50	0.53		91		
		71		0.78		95		0.54					
29		72		0.85		73		0.45		55		0.65	
		64		0.75		75		0.46		56		0.66	
		62	85	0.73	0.78	89	163	0.55	0.48	47	85	0.55	0.62
		68		0.80		80		0.49		57		0.67	
		66		0.78		77		0.47		47		0.55	

NOTE: STRESSES IN PILES ARE COMPRESSIVE AND GIVEN IN PSI.
STRESS FACTOR AS GIVEN IS THE RATIO OF RECORDED TO CALCULATED STRESS
E_s=30,000,000 PSI. E_c=4,500,000 PSI. (ULTIMATE STRENGTH AT 28 DAYS =4,500 PSI.) n = 6.7

TABLE 9

GRAND TRUNK WESTERN RAILROAD BRIDGE TESTS

PIER 3 – 33'-7$\frac{1}{2}$ & 38'-11$\frac{3}{4}$ R.C. SLAB SPANS – CONTINUOUS – CONCRETE FLOOR

COMPARISON OF RECORDED AND CALCULATED DIRECT STATIC STRESSES IN COLUMNS

LOCATION	LOCOMOTIVE TYPE & NO.	COLUMN NO. 2				COLUMN NO. 3				COLUMN NO. 4			
		RECORDED	CALCULATED	STRESS FACTOR	AVER.	RECORDED	CALCULATED	STRESS FACTOR	AVER.	RECORDED	CALCULATED	STRESS FACTOR	AVER.
COL. 1	2	3	4	5	6	7	8	9	10	11	12	13	14
CONCRETE	NORTHERN TYPE 4-8-4 NO. 6332	10		0.83		61		0.62		48		0.61	
		13		1.08		61		0.62		46		0.58	
		10	12	0.83	0.95	59	99	0.60	0.62	46	79	0.58	0.58
		14		1.17		59		0.60		45		0.57	
		10		0.83		64		0.65		45		0.57	
REINFORCING BARS						462		0.66		375		0.67	
						537		0.77		425		0.76	
			86			462	700	0.66	0.71	287	560	0.51	0.70
						500		0.71		450		0.80	
						525		0.75		412		0.74	

NOTE: STRESSES IN COLUMNS ARE COMPRESSIVE AND GIVEN IN PSI.
STRESS FACTOR AS GIVEN IS THE RATIO OF RECORDED TO CALCULATED STRESS
E_s=30,000,000 PSI. E_c=4,275,000 PSI. (ULTIMATE STRENGTH AT 28 DAYS =4,275 PSI.) n = 7

TABLE 8
GRAND TRUNK WESTERN RAILROAD BRIDGE TESTS
$33'\text{-}7\frac{1}{2}$ AND $38'\text{-}11\frac{3}{4}$ R.C. SLAB SPANS - (CONTINUOUS) - CONCRETE FLOOR
COMPARISON OF RECORDED AND CALCULATED STATIC STRESSES IN SLABS

Span	Train	Locomotive Class	Locomotive No.	Near ℄ Span – Top of Concrete Slab – Recorded Stress	Near ℄ Span – Top of Concrete Slab – Calculated Stress – Concrete Not Taking Tension	Near ℄ Span – Top of Concrete Slab – Calculated Stress – Concrete Taking Tension	Near ℄ Span – Top of Concrete Slab – Stress Factor		Near ℄ Span – Bottom Reinforcing Bars – Recorded Stress	Near ℄ Span – Bottom Reinforcing Bars – Calculated Stress – Concrete Not Taking Tension	Near ℄ Span – Bottom Reinforcing Bars – Calculated Stress – Concrete Taking Tension	Near ℄ Span – Bottom Reinforcing Bars – Stress Factor		At Pier – Bottom of Concrete Slab – Recorded Stress	At Pier – Bottom of Concrete Slab – Calculated Stress – Concrete Not Taking Tension	At Pier – Bottom of Concrete Slab – Calculated Stress – Concrete Taking Tension	At Pier – Bottom of Concrete Slab – Stress Factor		At Pier – Top Reinforcing Bars – Recorded Stress	At Pier – Top Reinforcing Bars – Calculated Stress – Concrete Not Taking Tension	At Pier – Top Reinforcing Bars – Calculated Stress – Concrete Taking Tension	At Pier – Top Reinforcing Bars – Stress Factor	
COL. 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
END SPAN – SPAN 4 $33'\text{-}7\frac{1}{2}$ C. TO C. BEARING ON ℄ TRACK	W. B. ON W. B. TRACK	2 AXLE DIESELS	9012	−67	−145	−105	0.64	0.57	+425	+3080	+697	0.61	0.66	−68	−200	−120	0.57	0.66	+450	+4390	+824	0.55	0.62
			9014	−54			0.52		+433			0.62		−78			0.65		+525			0.64	
			9011	−70			0.67		+458			0.66		−81			0.67						
			9014	−47			0.45		+508			0.73		−91			0.76		+550			0.67	
	E. B. ON W. B. TRACK	NORTHERN TYPE 4-8-4	6332	−105	−218	−158	0.67	0.66	+700	+4610	+1040	0.67	0.69	−120	−289	−173	0.69	0.73	+825	+6590	+1240	0.66	0.70
				−104			0.66		+700			0.67		−126			0.73		+825			0.66	
				−103			0.65		+767			0.74		−134			0.77		+850			0.69	
				−108			0.68		+742			0.71		−128			0.74		+850			0.69	
				−104			0.66		+708			0.68		−127			0.73		+950			0.77	
INTERMEDIATE SPAN – SPAN 3 $38'\text{-}11\frac{3}{4}$ C. TO C. PIERS ON ℄ TRACK	W. B. ON W. B. TR.	2 AX. DIESEL	9023	−66	−121	−87	0.76	0.76	+384	+2560	+579	0.66	0.70	−77	−197	−118	0.65	0.69	+575	+4380	+823	0.70	0.70
				−67			0.77		+425			0.73		−85			0.72		+575			0.70	
	EAST BOUND TRAINS ON WEST BOUND TRACK	NORTHERN TYPE 4-8-4	6332	−108	−236	−171	0.63	0.63	+958	+4990	+1130	0.85	0.85	−151	−289	−173	0.87	0.81	+975	+6620	+1240	0.79	0.76
				−110			0.64		+975			0.86		−154			0.89		+1050			0.85	
				−95			0.56		+950			0.84		−126			0.73		+900			0.73	
				−108			0.63		+950			0.84		−133			0.77		+900			0.73	
				−102			0.60		+983			0.87		−142			0.82		+1075			0.87	
				−119			0.69		+1033			0.91		−143			0.83		+975			0.79	
				−120			0.70		+975			0.86		−136			0.79		+950			0.77	
				−95			0.56		+934			0.83		−139			0.80		+825			0.67	
				−115			0.67		+884			0.78		−134			0.77		+800			0.64	

NOTE: STRESSES ARE GIVEN IN PSI, WHERE (+) INDICATES TENSION AND (−) COMPRESSION
STRESS FACTOR, AS GIVEN, IS THE RATIO OF RECORDED STRESS TO CALCULATED STRESS, ASSUMING CONCRETE TAKING TENSION
$E_s = 30{,}000{,}000$ PSI. $E_c = 4{,}275{,}000$ PSI. (ULTIMATE STRENGTH AT 28 DAYS = 4,275 PSI) $n = 7$

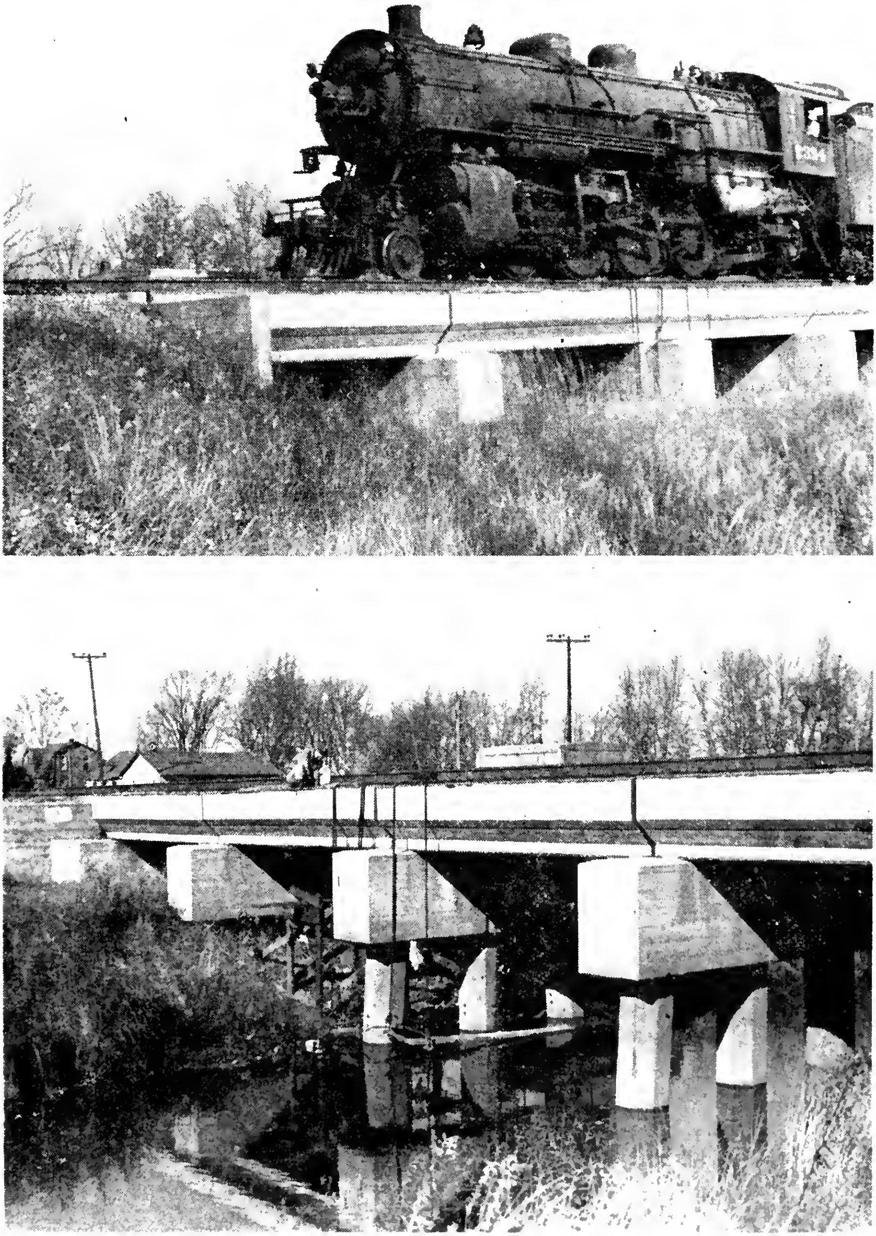


Fig. 1—General views of reinforced concrete pile trestle near Adams, Wis.

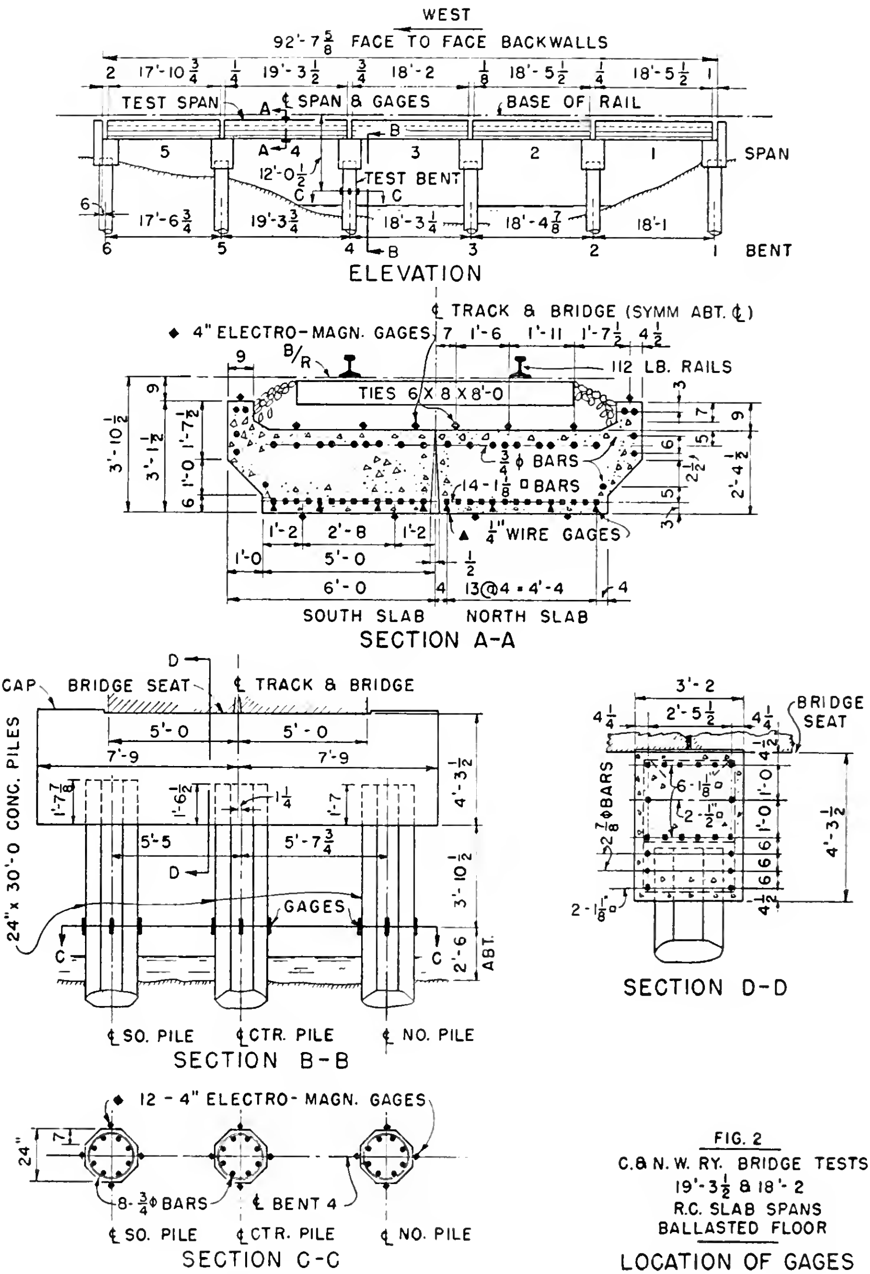


FIG. 2
C.& N. W. RY. BRIDGE TESTS
19'-3 1/2 & 18'-2
R.C. SLAB SPANS
BALLASTED FLOOR
LOCATION OF GAGES

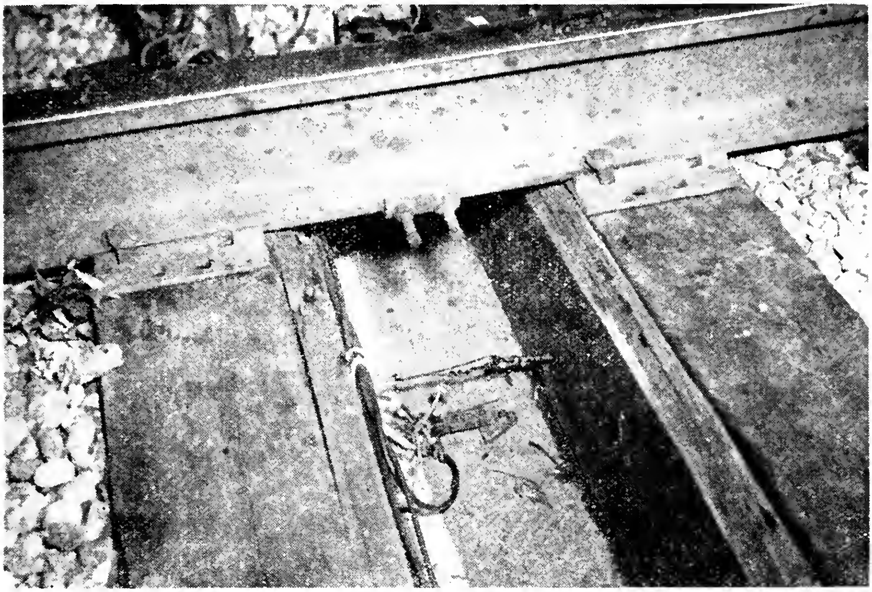


Fig. 3—Electro-magnetic gage on top of reinforced concrete slab between ties.

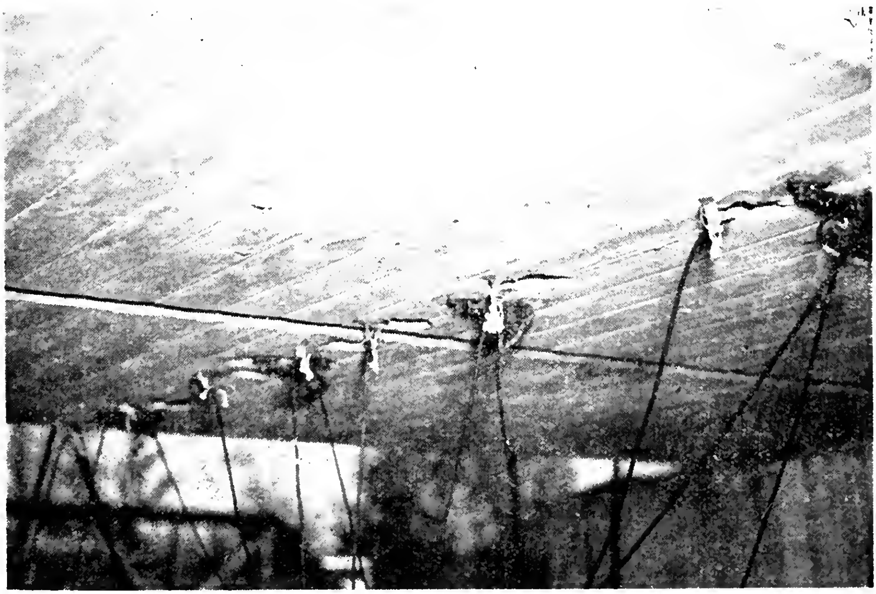


Fig. 4—General view of SR4 wire gages on reinforcing bars and electro-magnetic gages on concrete on bottom of slab.

Fig. 5—Cutting out concrete covering on reinforcing bars.

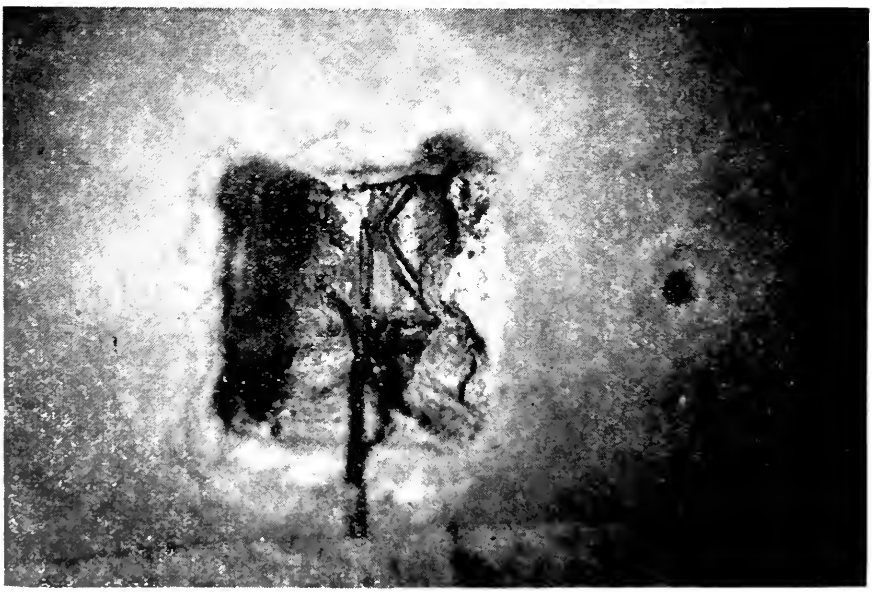


Fig. 6—SR4 wire gage on reinforcing bar.

Fig. 7—General views of reinforced concrete pile trestle near Rochelle, La.

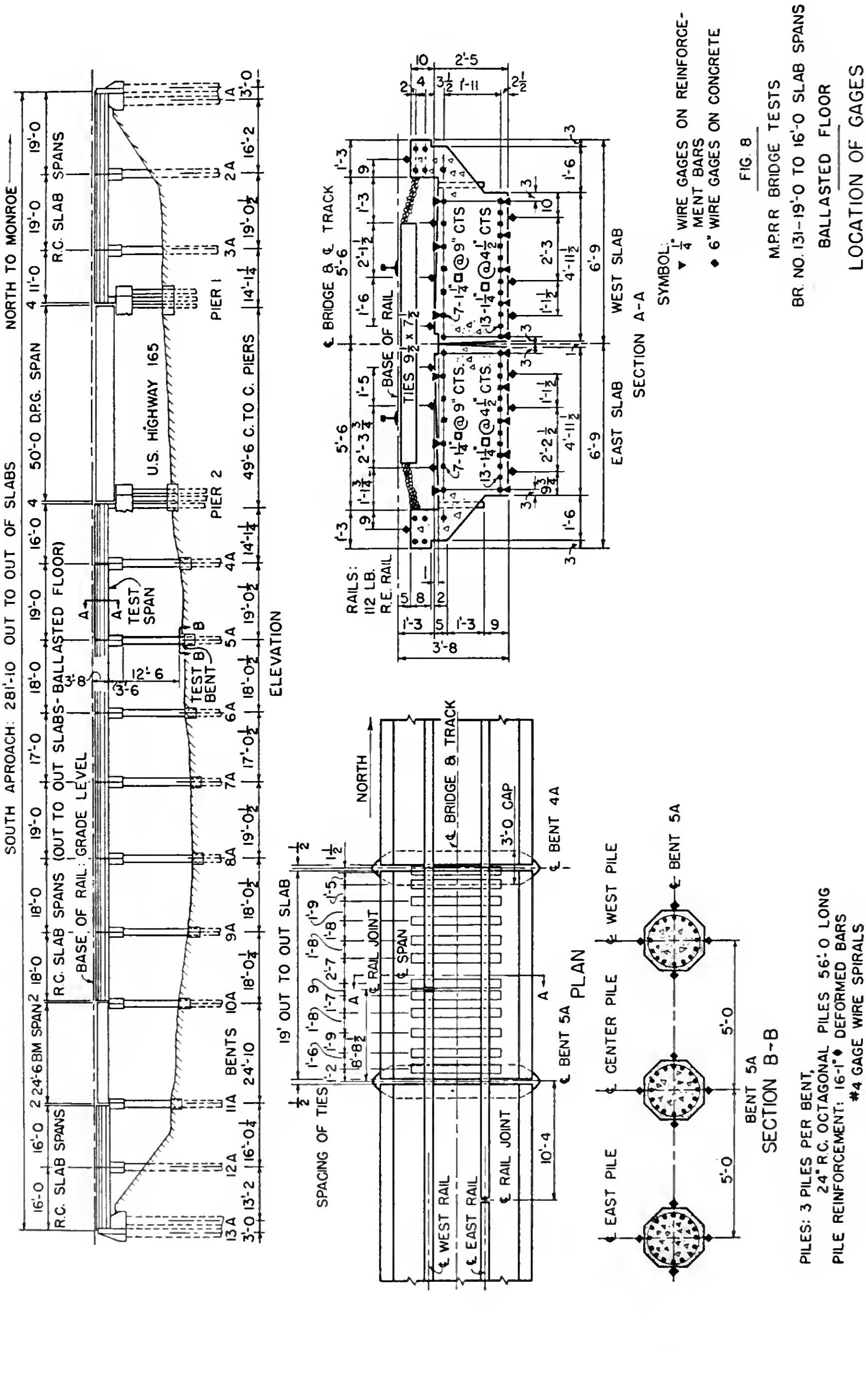


FIG. 8
M.P.R.R. BRIDGE TESTS
BR. NO. 131-19'-0 TO 16'-0 SLAB SPANS
BALLASTED FLOOR
LOCATION OF GAGES

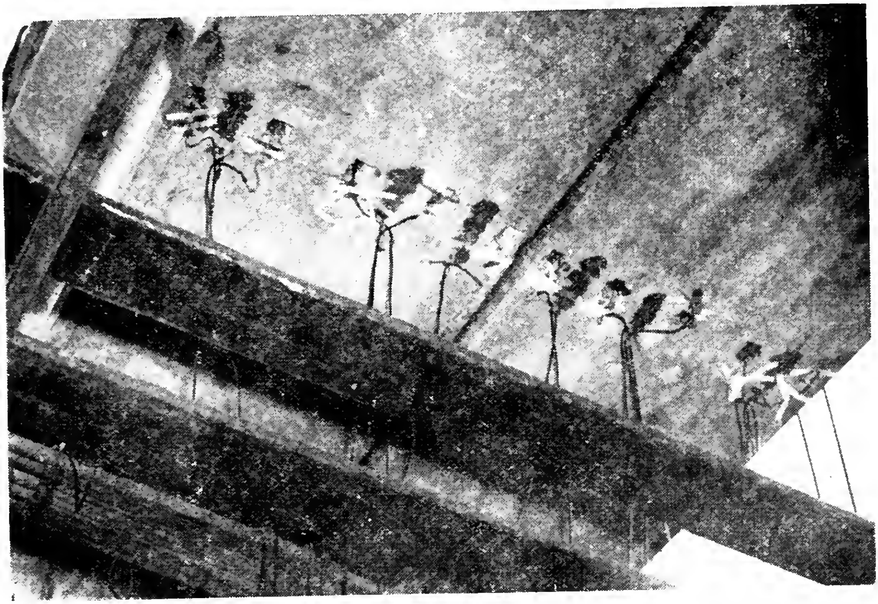


Fig. 9—General view of SR4 wire gages on concrete and reinforcing bars at bottom of slab.

Fig. 10—Location of SR4 wire gages on piles.

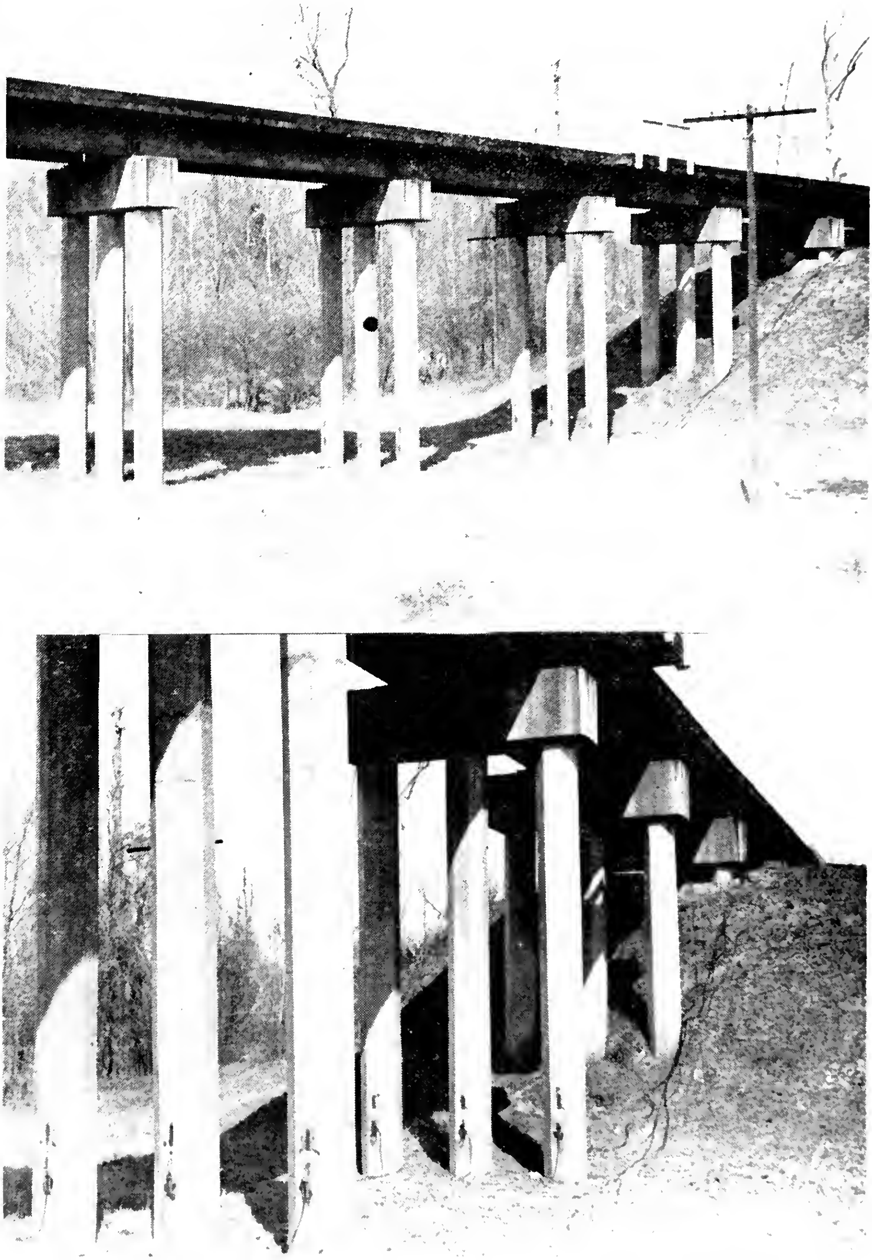
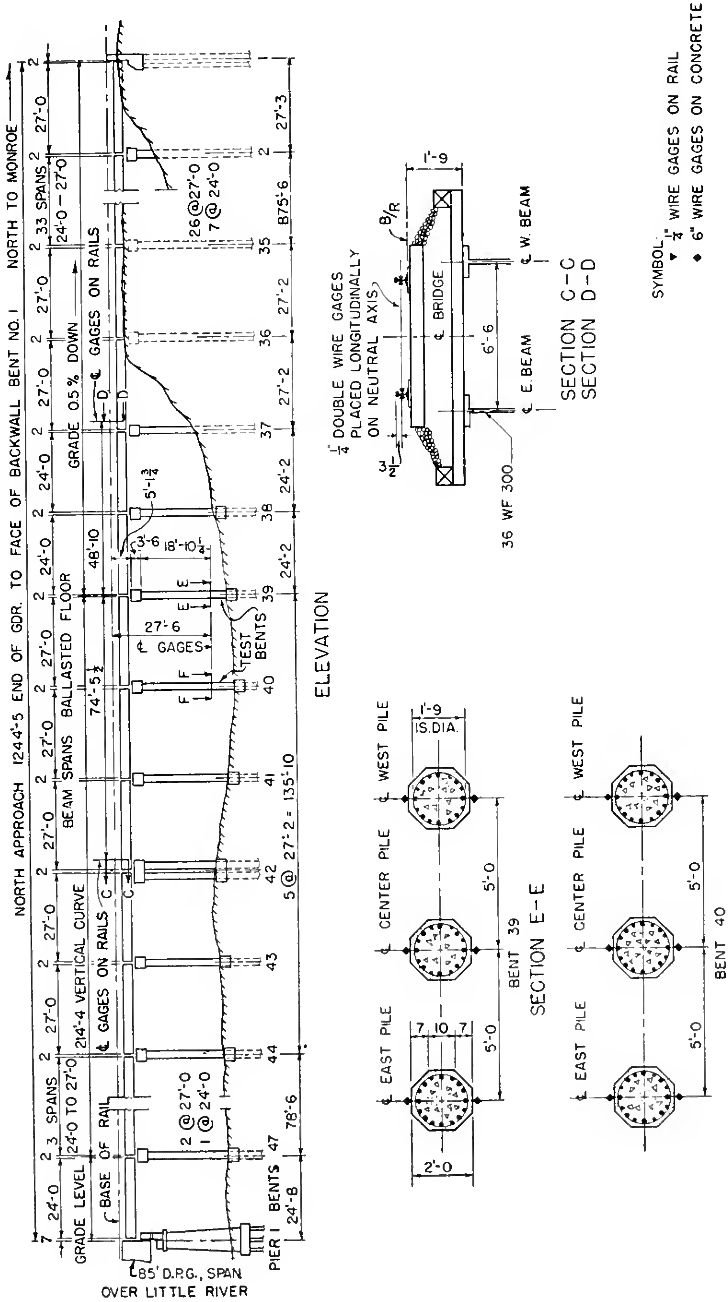


Fig. 11—General views of reinforced concrete pile bents of north approach structure to Bridge 131, near Rochelle, La.



PILES 3 PILES PER BENT
24" R.C. OCTAGONAL PILES, 50'-0 LONG
PILE REINFORCEMENT 16-1" Φ DEFORMED BARS
#4 GAGE WIRE SPIRALS

FIG 12
M.P.R.R BRIDGE TESTS
BR. NO. 131—24'-0 & 27'-0 BEAM SPANS
BALLASTED TIMBER FLOOR
LOCATION OF GAGES

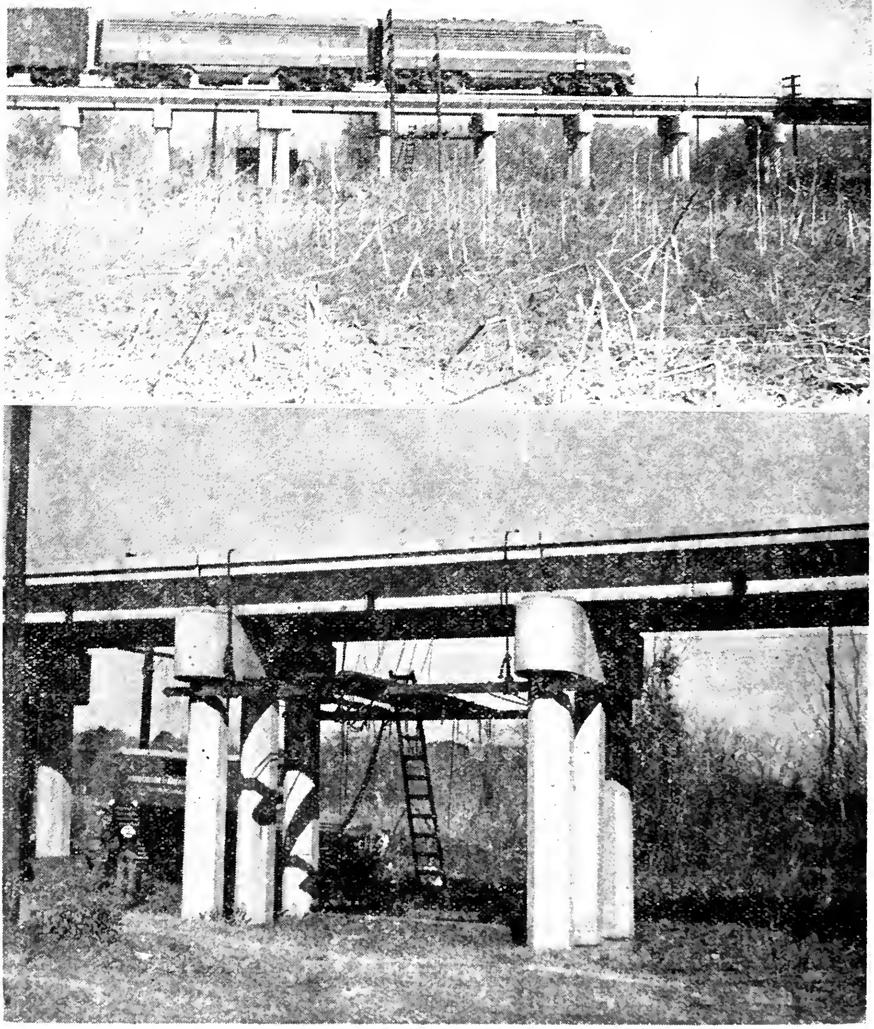
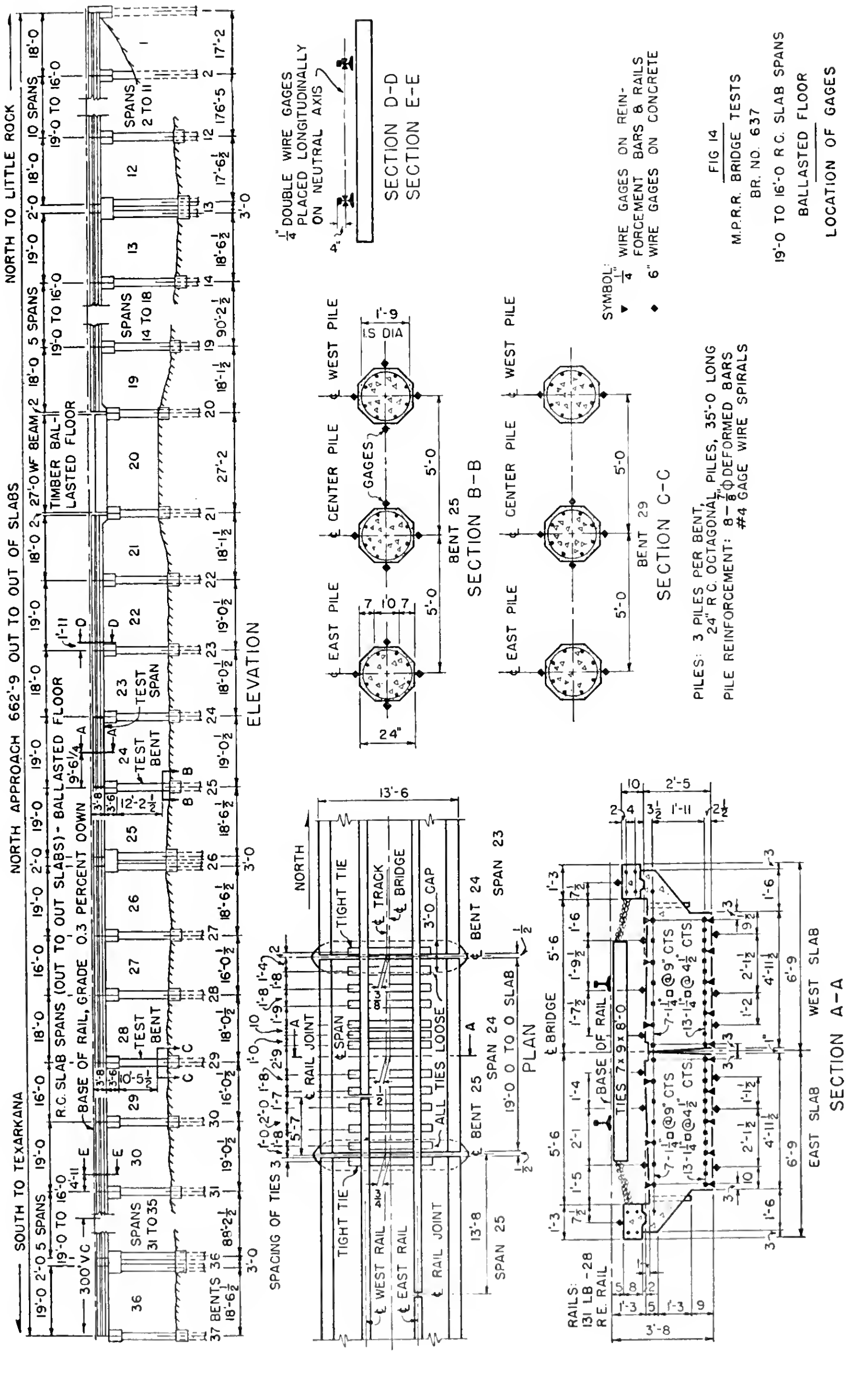


Fig. 13—General views of reinforced concrete pile trestle near Arkadelphia, Ark.


NORTH APPROACH 662'-9 OUT TO OUT OF SLABS
SOUTH TO TEXARKANA
NORTH TO LITTLE ROCK
R.C. SLAB SPANS (OUT TO OUT SLABS) - BALLASTED FLOOR
BASE OF RAIL, GRADE 0.3 PERCENT DOWN
27'-0 WF BEAM TIMBER BALLASTED FLOOR
TEST SPAN
TEST BENT
ELEVATION
SPACING OF TIES
TIGHT TIE
ALL TIES LOOSE
RAIL JOINT
℄ WEST RAIL
℄ EAST RAIL
℄ TRACK
℄ BRIDGE
3'-0 CAP
℄ BENT 24
℄ BENT 25
SPAN 23
SPAN 24 19'-0 O TO O SLAB
SPAN 25
PLAN
EAST PILE
CENTER PILE
WEST PILE
GAGES
BENT 25
SECTION B-B
BENT 29
SECTION C-C
1/4" DOUBLE WIRE GAGES PLACED LONGITUDINALLY ON NEUTRAL AXIS
SECTION D-D
SECTION E-E
PILES: 3 PILES PER BENT, 24" R.C. OCTAGONAL PILES, 35'-0 LONG
PILE REINFORCEMENT: 8-7/8"Φ DEFORMED BARS #4 GAGE WIRE SPIRALS
SYMBOL: 1/4" WIRE GAGES ON REINFORCEMENT BARS & RAILS
6" WIRE GAGES ON CONCRETE
RAILS: 131 LB - 28 R.E. RAIL
BASE OF RAIL
TIES 7 x 9 x 8'-0
EAST SLAB
WEST SLAB
℄ BRIDGE
SECTION A-A
FIG 14
M.P.R.R. BRIDGE TESTS
BR. NO. 637
19'-0 TO 16'-0 R.C. SLAB SPANS
BALLASTED FLOOR
LOCATION OF GAGES

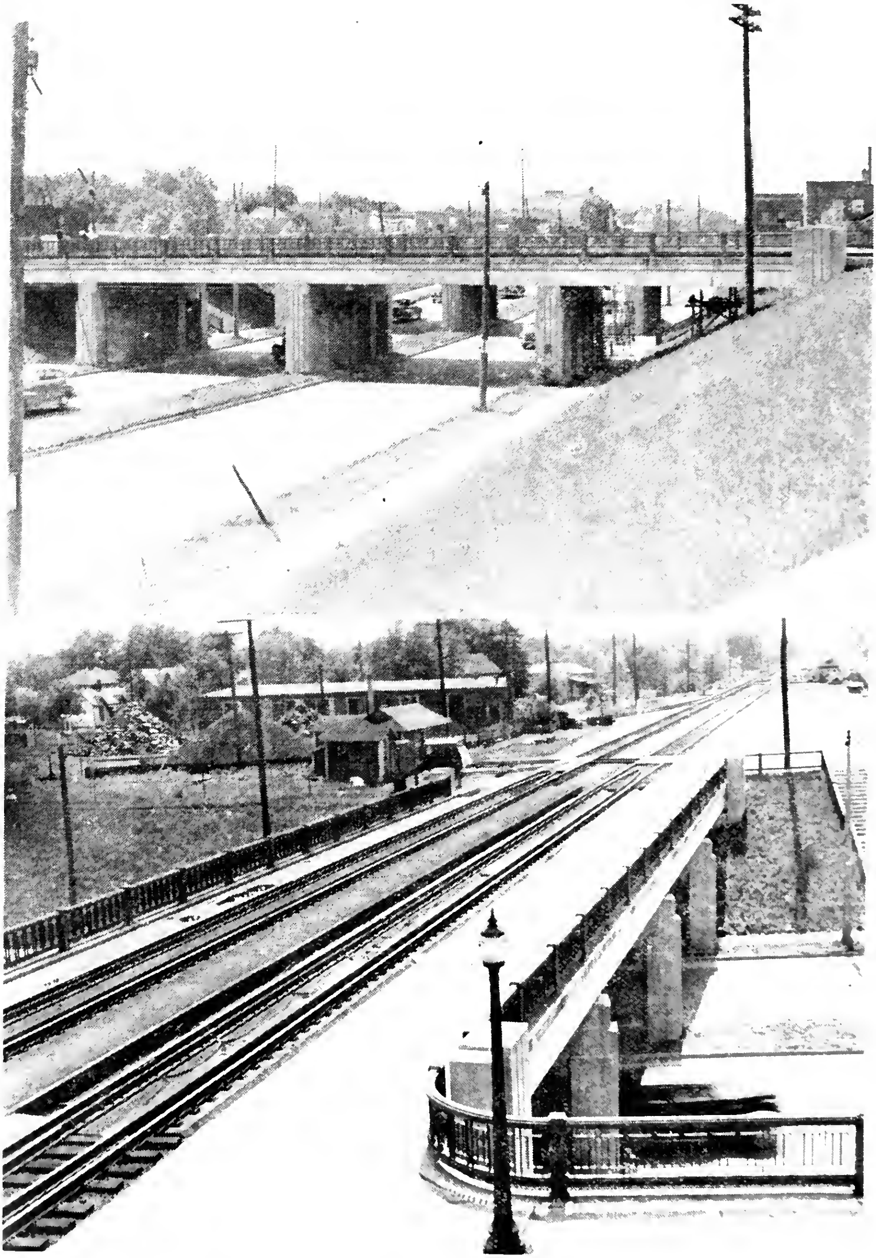


Fig. 15—General views of reinforced concrete continuous span viaduct at Flint, Mich.

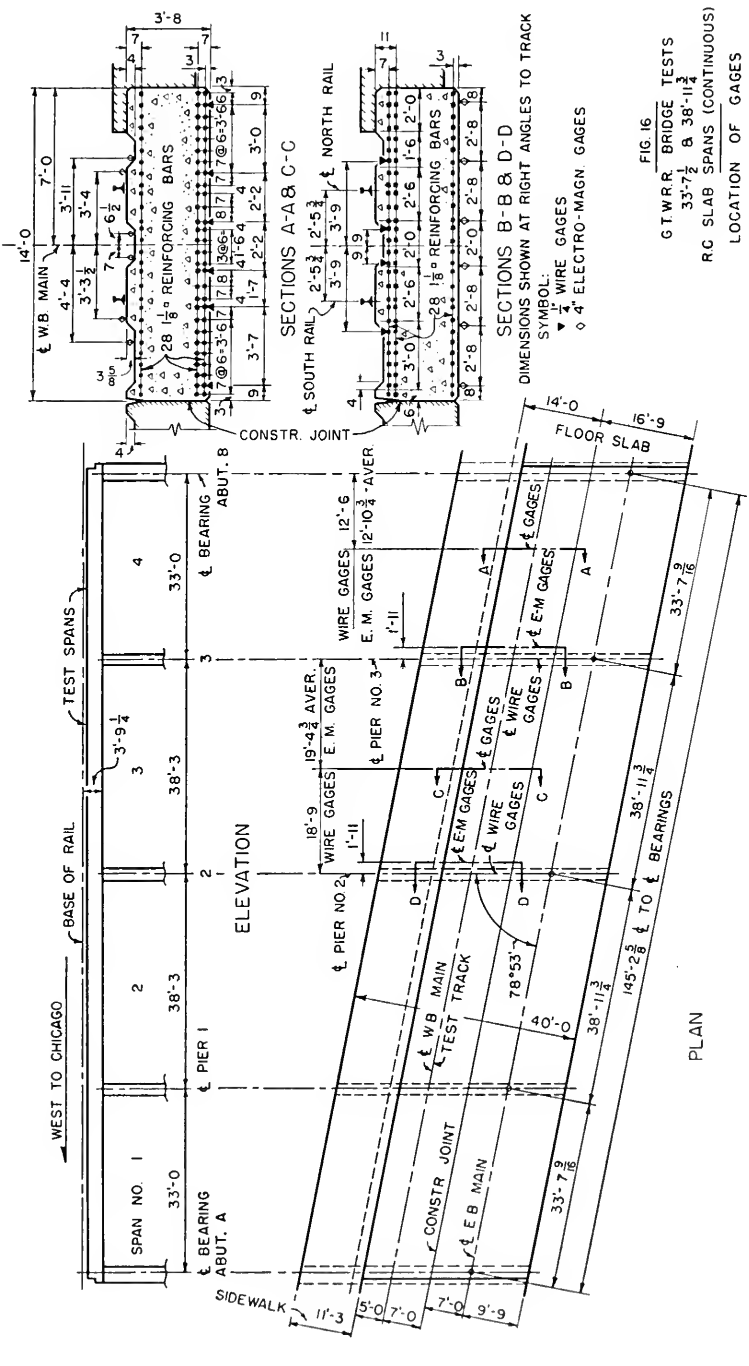


FIG. 16
G.T.W.R.R. BRIDGE TESTS
33'-7½ & 38'-11¾
R.C. SLAB SPANS (CONTINUOUS)
LOCATION OF GAGES

Fig. 17—General views of method of fastening rails to concrete slab, continuous span viaduct at Flint, Mich. The wood shims shown in the lower picture were used to make the tests without rubber pads.

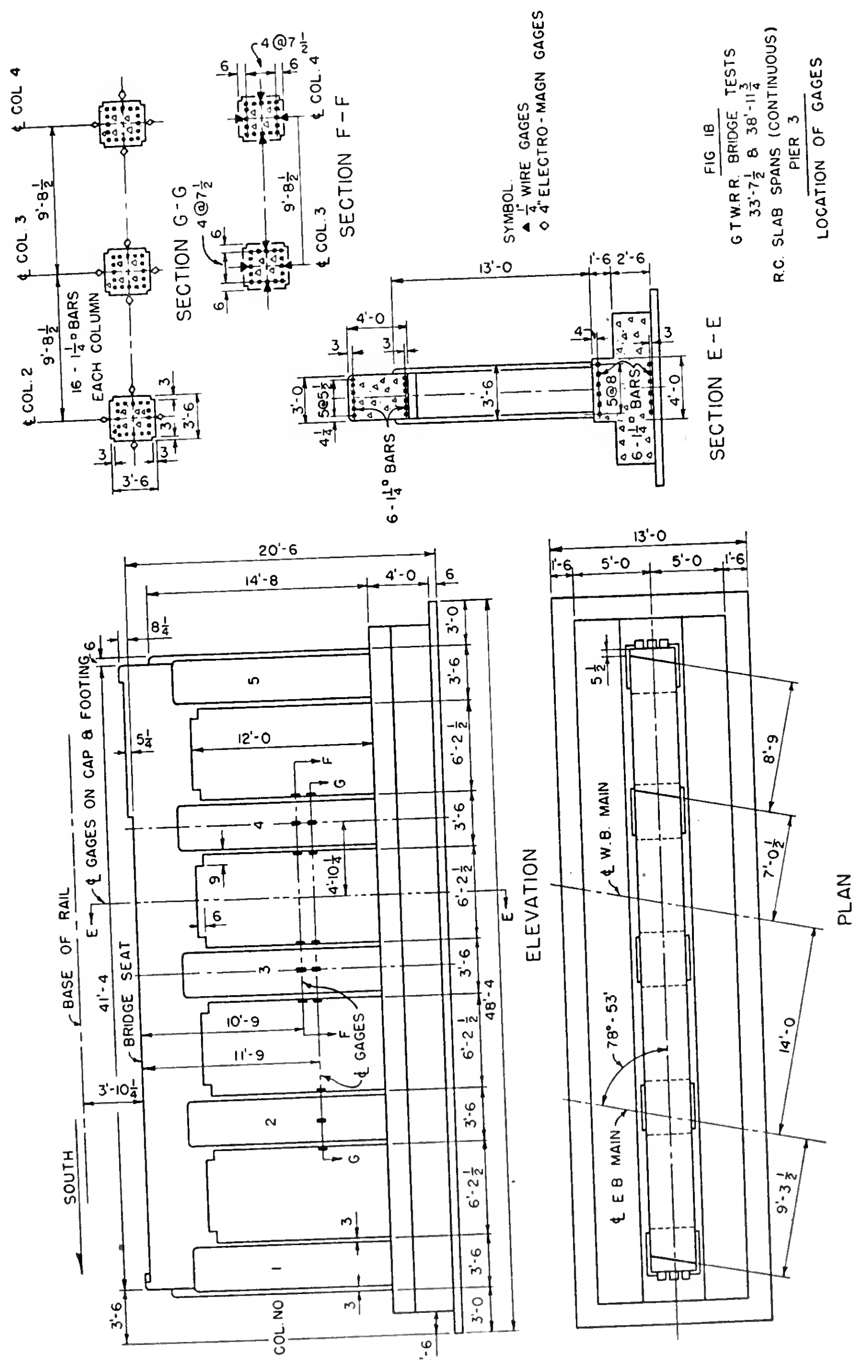


FIG 18
GTW.R.R. BRIDGE TESTS
33'-7½ & 38'-11¾
R.C. SLAB SPANS (CONTINUOUS)
PIER 3
LOCATION OF GAGES

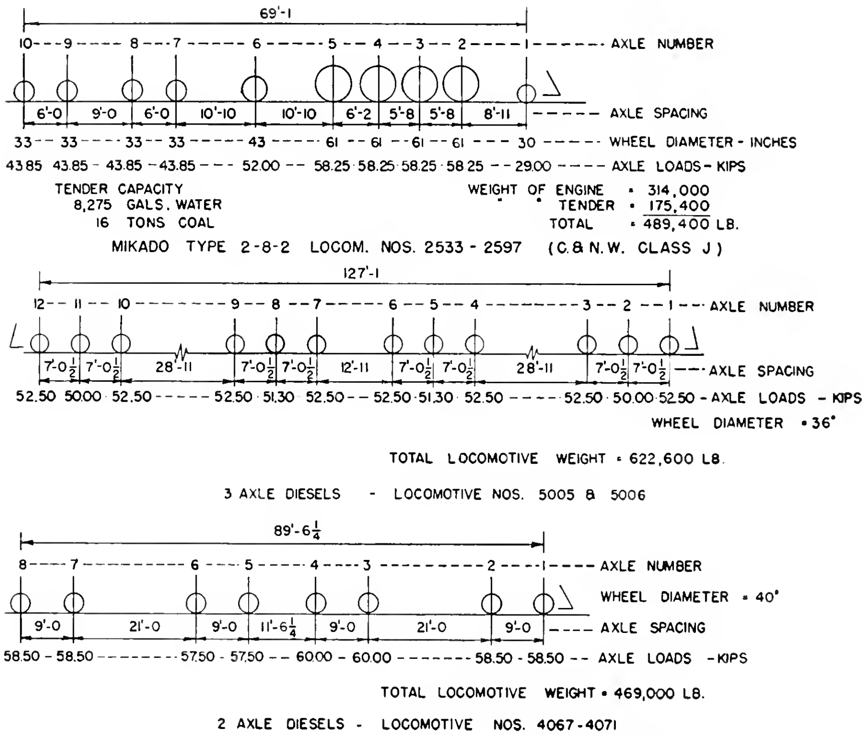


FIG 19 C. & N.W RY. BRIDGE TESTS - LOCOMOTIVE DIAGRAMS

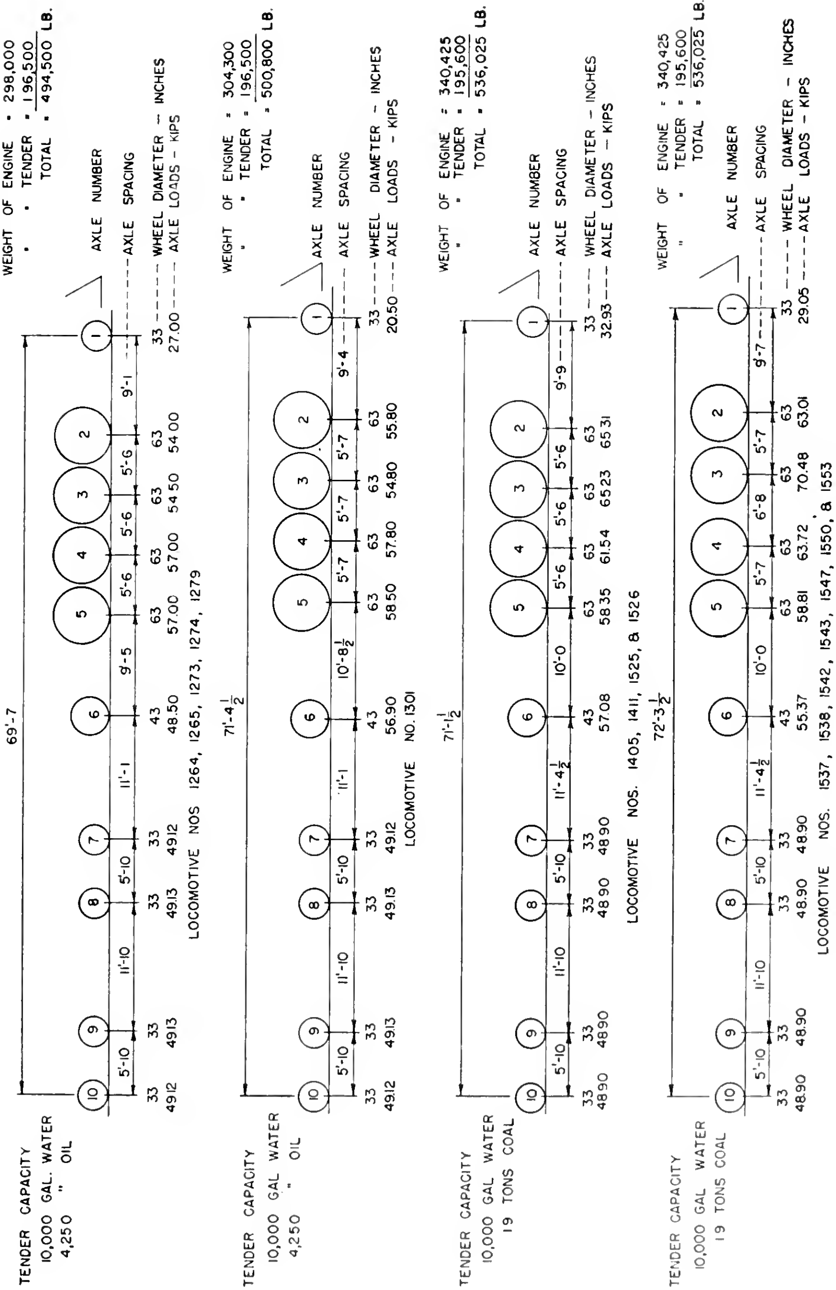


FIG. 20 M.P.RR. BRIDGE TESTS LOCOMOTIVE DIAGRAMS MIKADO TYPE 2-8-2

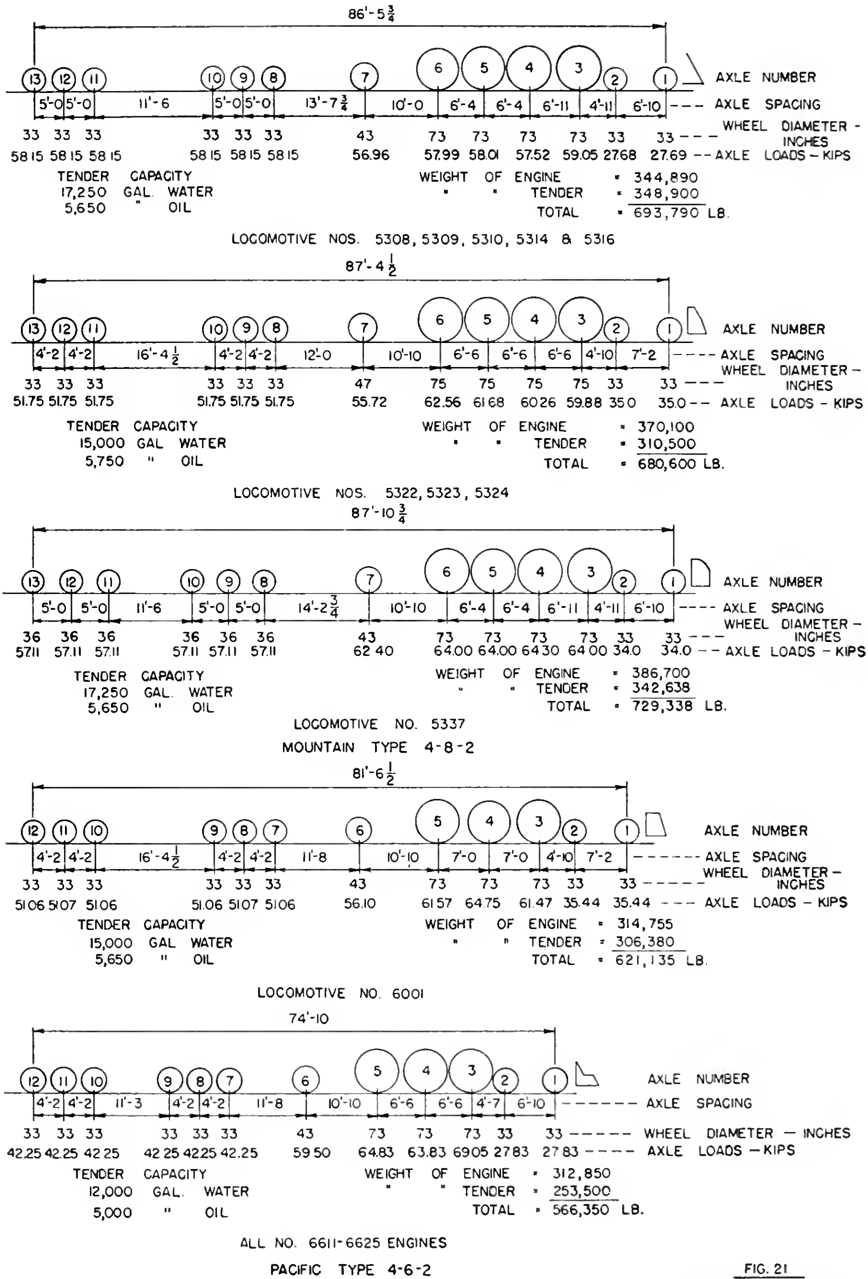


FIG. 21
M.P.R.R. BRIDGE TESTS
LOCOMOTIVE DIAGRAMS
MOUNTAIN TYPE 4-8-2
PACIFIC TYPE 4-6-2

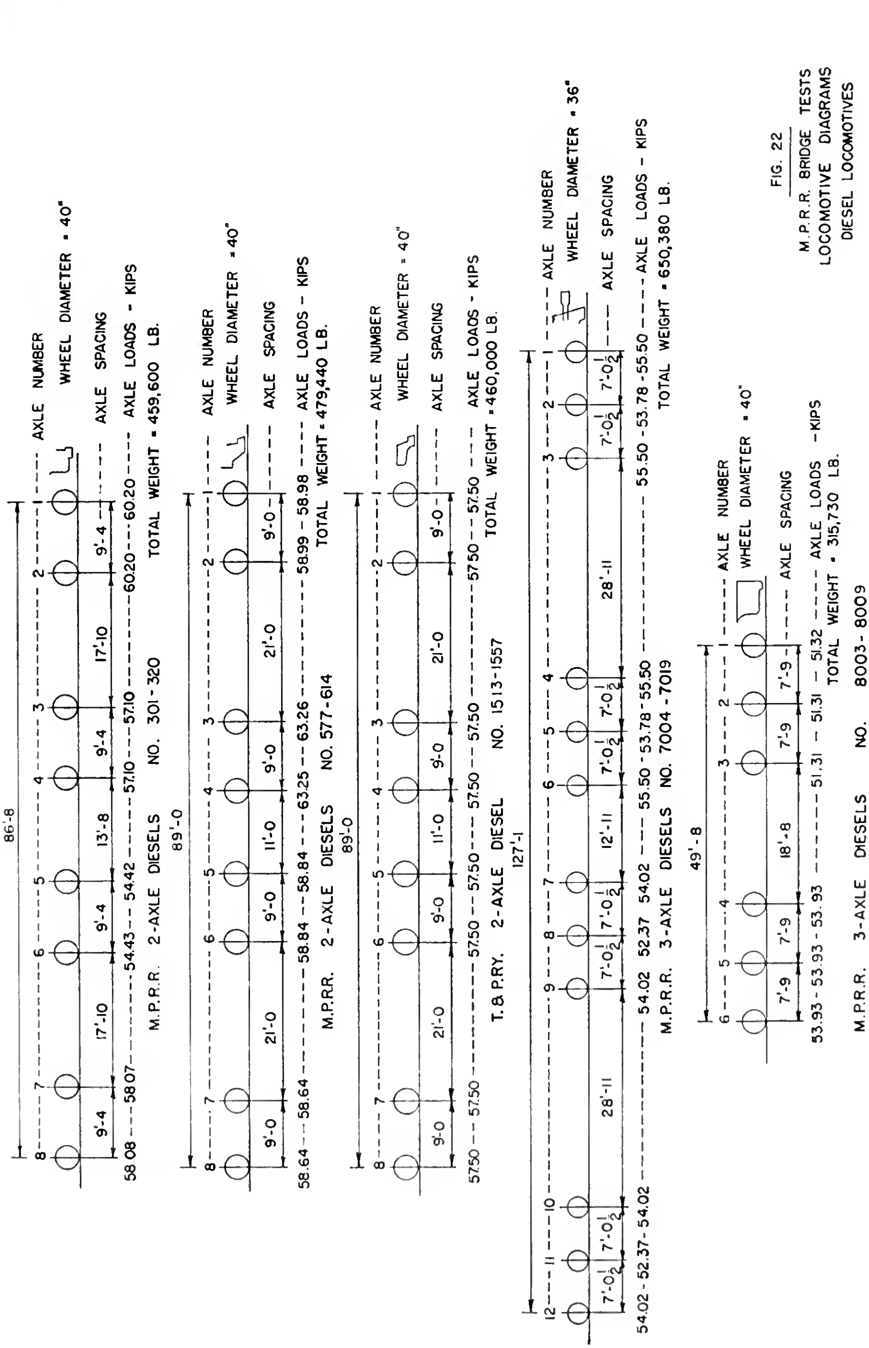


FIG. 22
M.P.R.R. BRIDGE TESTS
LOCOMOTIVE DIAGRAMS
DIESEL LOCOMOTIVES

A

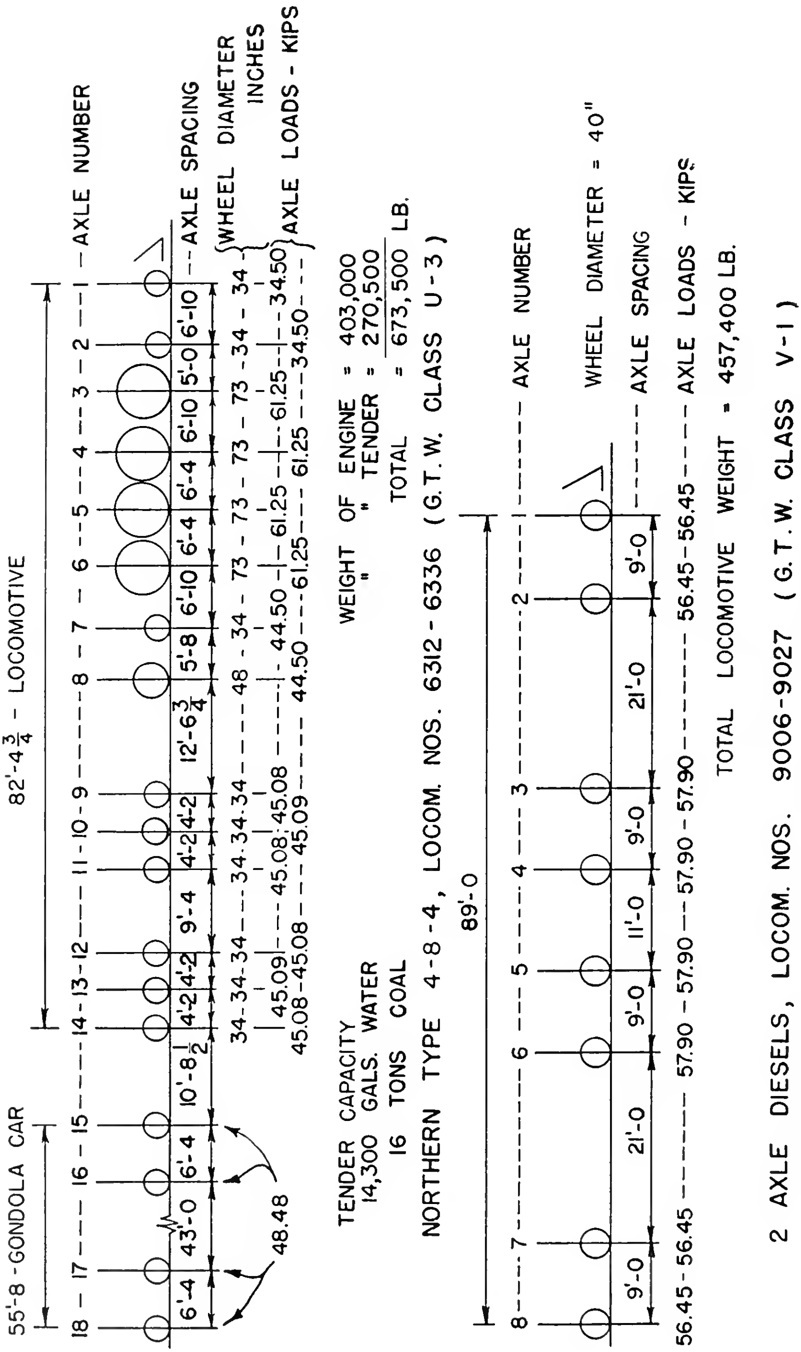
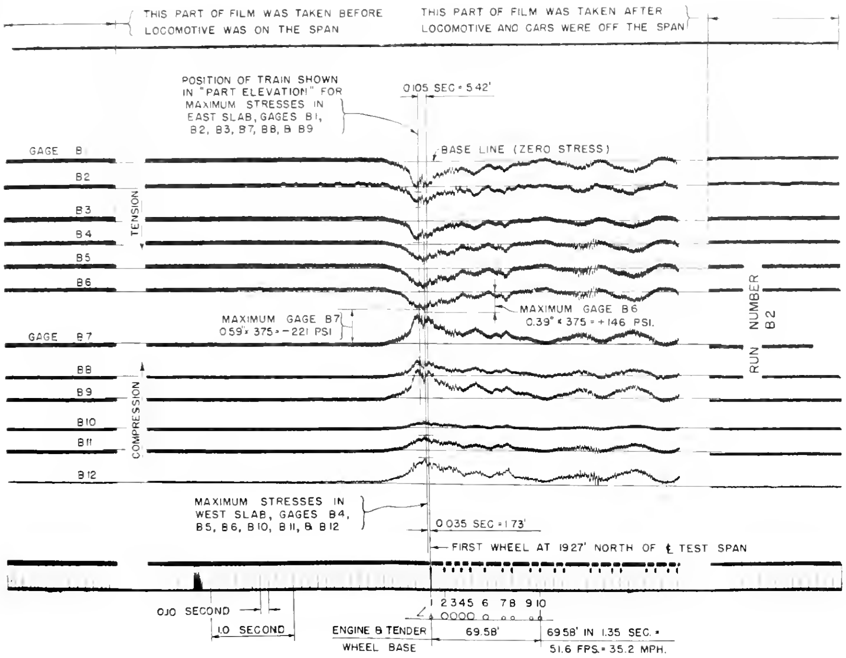
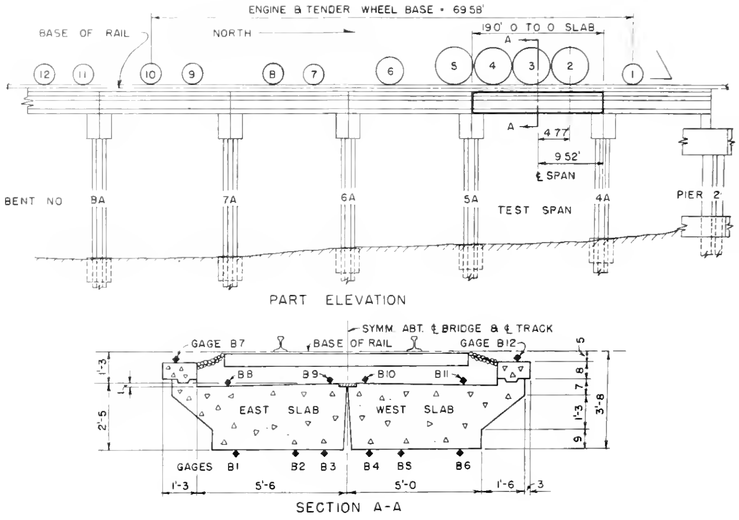


FIG. 23 G.T.W.R.R. BRIDGE TESTS - LOCOMOTIVE DIAGRAMS





SYMBOL:
◆ 6" SR-4 WIRE GAGES

FIG. 24
M. P. R.R. BRIDGE TESTS
BR. NO. 131 - 19'-0 R.C. SLAB SPAN
BALLASTED FLOOR

TYPICAL OSCILLOGRAM
STRESSES IN CONCRETE
LOCOMOTIVE MIKADO TYPE 2-8-2
(M.P. R.R. NO. 1264)

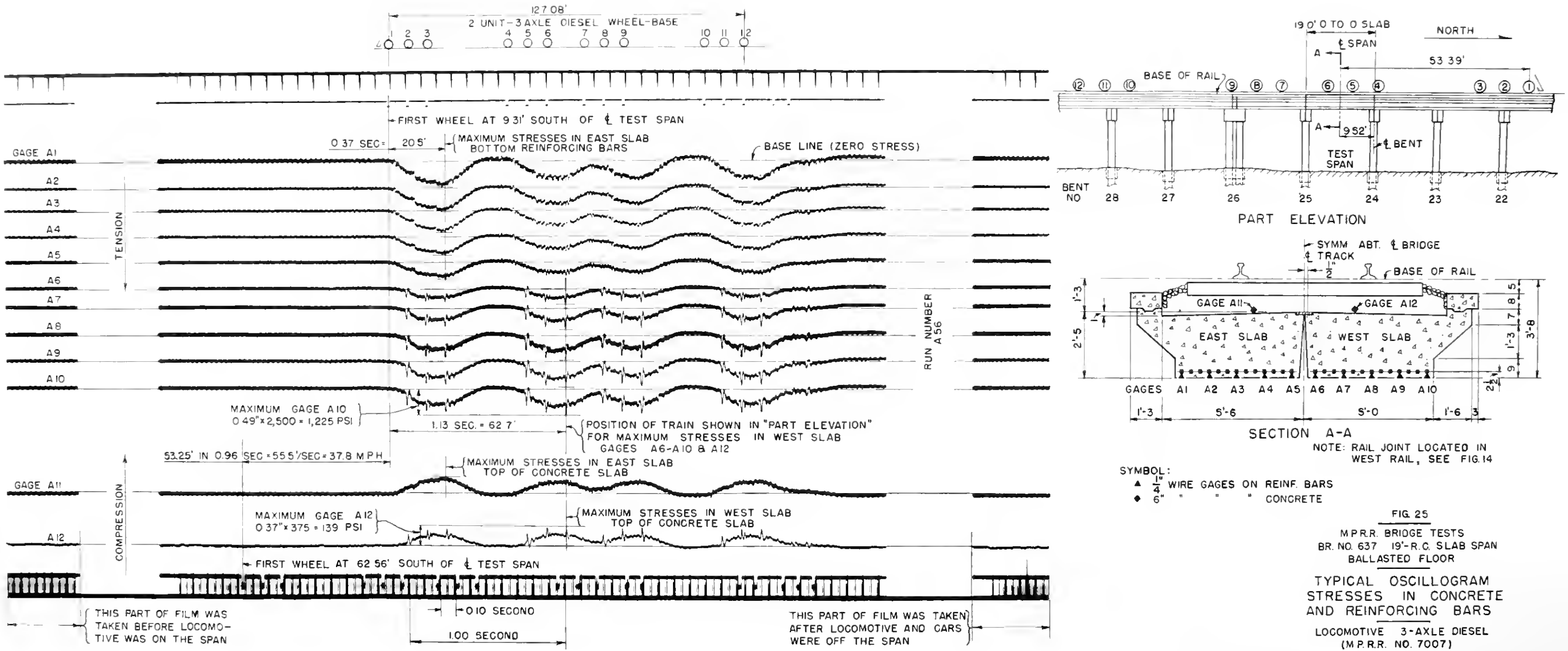


FIG. 25

M.P.R.R. BRIDGE TESTS
BR. NO. 637 19'-R.C. SLAB SPAN
BALLASTED FLOOR

TYPICAL OSCILLOGRAM
STRESSES IN CONCRETE
AND REINFORCING BARS

LOCOMOTIVE 3-AXLE DIESEL
(M.P.R.R. NO. 7007)

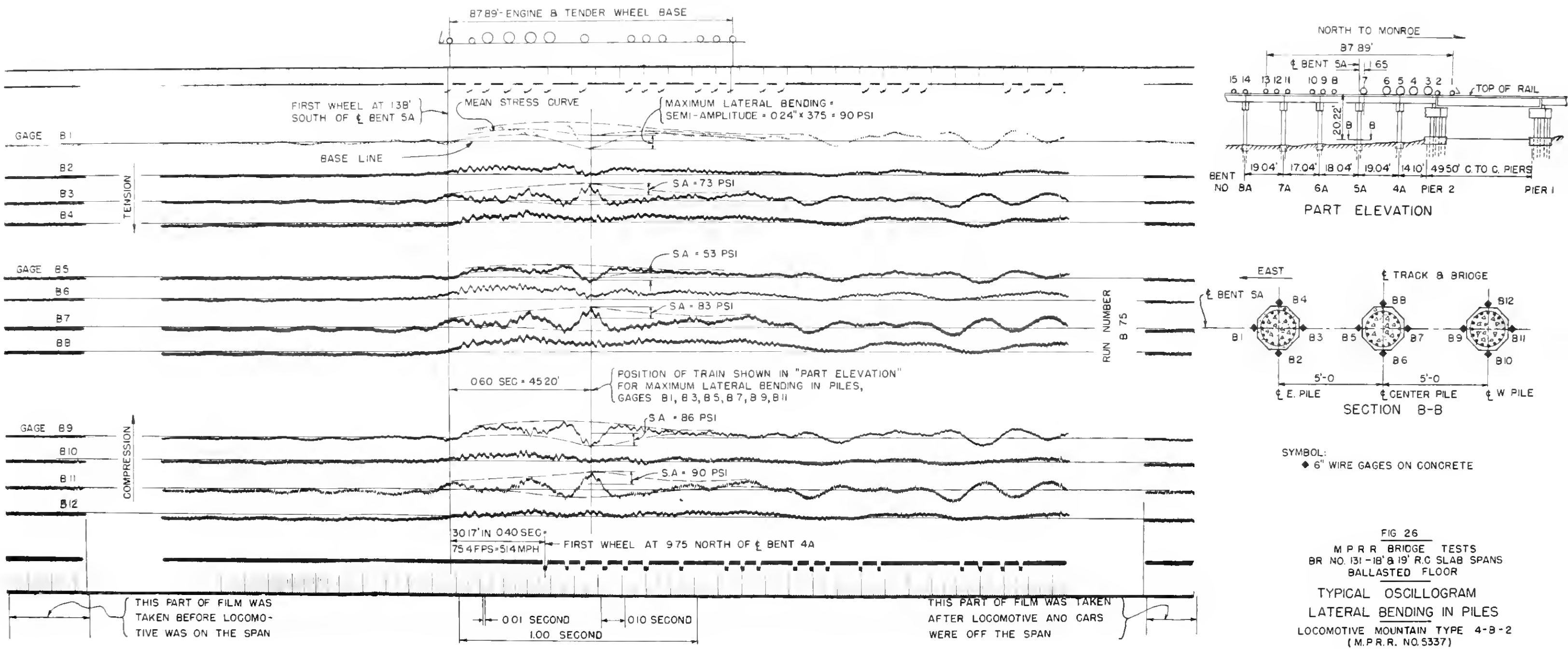
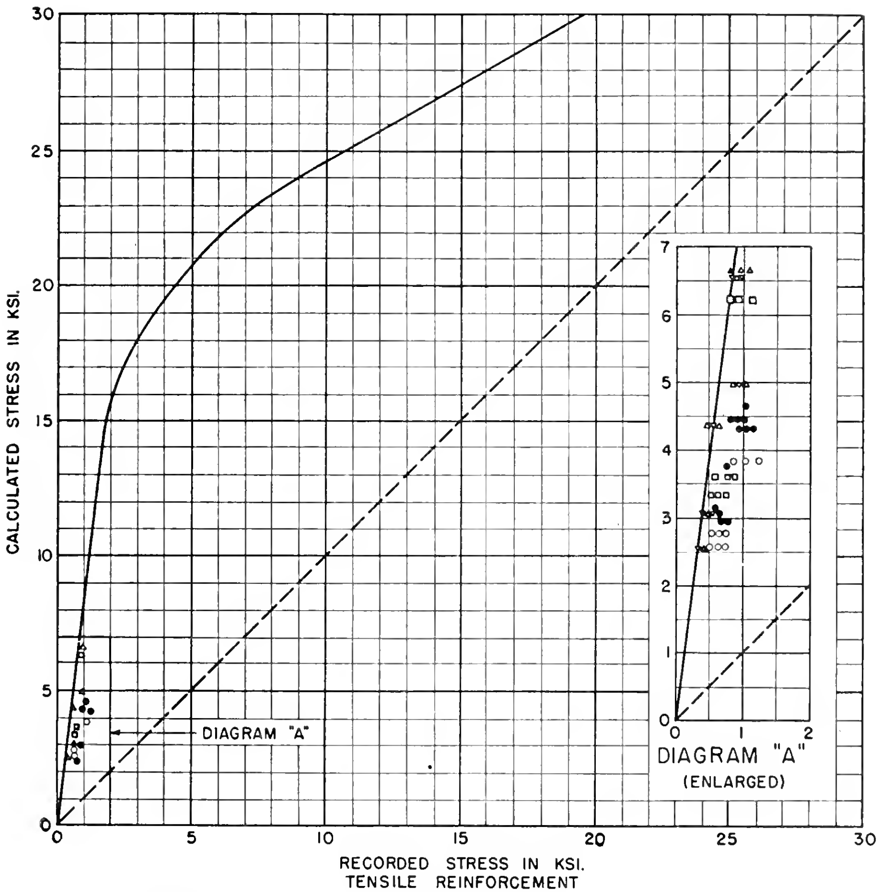


FIG 26
M.P.R.R. BRIDGE TESTS
BR. NO. 131 - 18' & 19' R.C. SLAB SPANS
BALLASTED FLOOR
TYPICAL OSCILLOGRAM
LATERAL BENDING IN PILES
LOCOMOTIVE MOUNTAIN TYPE 4-8-2
(M.P.R.R. NO. 5337)



COMPARISON OF RECORDED & CALCULATED STRESSES IN REINFORCED CONCRETE LABORATORY SPECIMENS

NOTE: CURVE SHOWN IS AVERAGE VALUE OBTAINED ON FIVE DIFFERENT TYPES OF BARS. REFER TO THE JOURNAL OF THE AMERICAN CONCRETE INSTITUTE, OCTOBER AND NOVEMBER 1948, FIG. 14.
ENLARGED DIAGRAM "A" SHOWS RESULTS OF THE TESTS ON FOUR CONCRETE BRIDGES, SEE TABLES 2, 4, 6, AND 8.

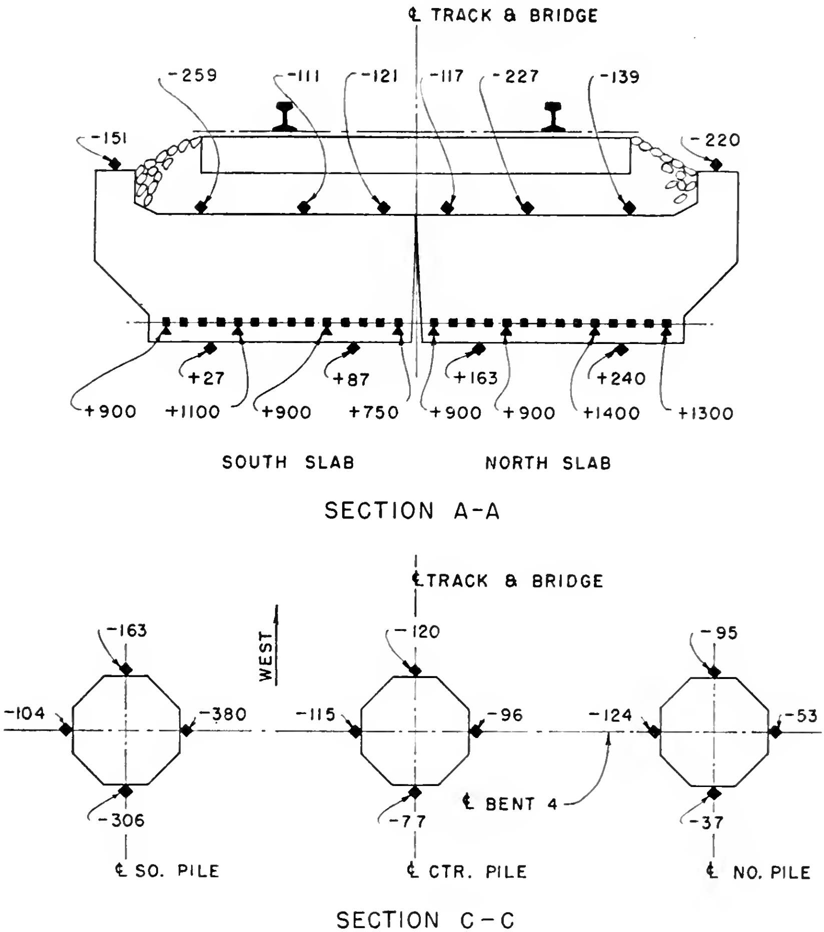
SYMBOL:
- □ C.& N.W. RY. BRIDGE TESTS
- ○ M.P. R.R. BRIDGE TESTS - BRIDGE NO. 131
- ● " " " " " " - " NO. 637
- ▲ G.T.W. R.R. BRIDGE TESTS

FIG. 27

LABORATORY AND FIELD TESTS

COMPARISON OF RECORDED AND CALCULATED STRESSES IN TENSILE REINFORCEMENT

VARIATION OF RECORDED STATIC STRESSES



NOTE:

STRESSES SHOWN ARE IN PSI
+ TENSION
− COMPRESSION
REFER TO FIG. 2 FOR LOCATION OF SECTIONS.

FIG. 28
C. & N. W. RY. BRIDGE TESTS
19'-3½ & 18'-2
R.C. SLAB SPANS
BALLASTED FLOOR
VARIATION OF RECORDED STATIC STRESSES
MIKADO 2-8-2 CLASS J

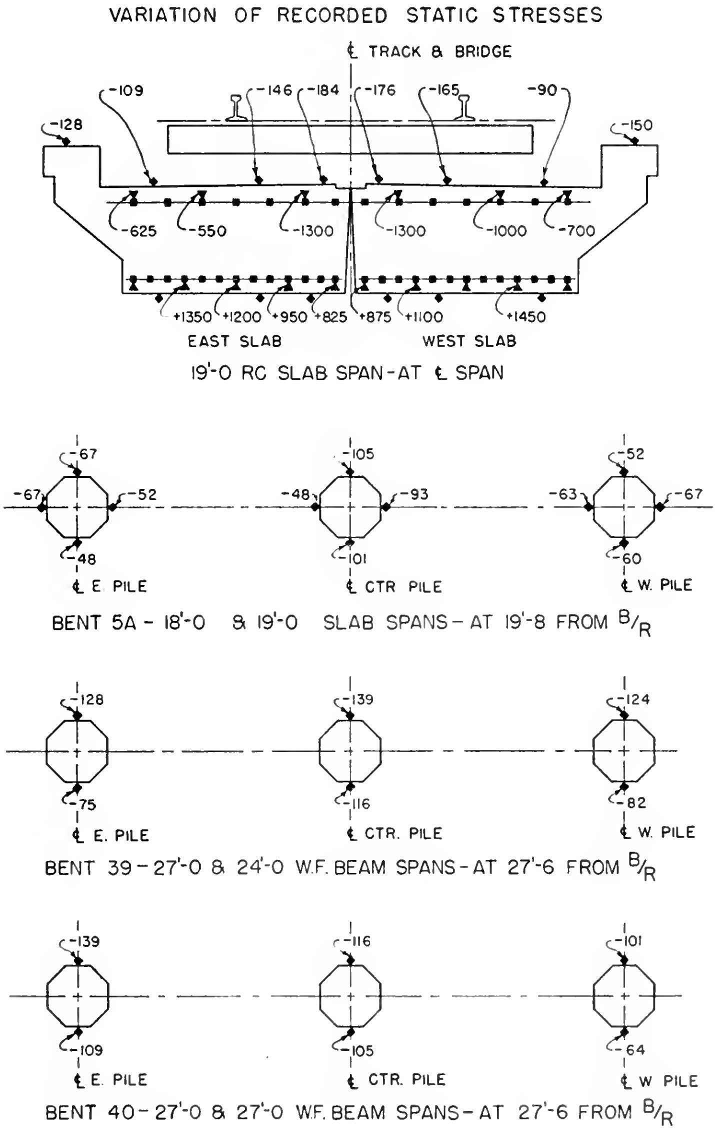


FIG 29
M.P.R.R. BRIDGE TESTS
BR NO 131
R.C. SLAB SPANS &
W.F. BEAM SPANS
BALLASTED FLOOR
VARIATION OF RECORDED
STATIC STRESSES
MOUNTAIN TYPE 4-8-2

NOTE:
STRESSES SHOWN ARE IN PSI
\+ TENSION
\- COMPRESSION

VARIATION OF RECORDED STATIC STRESSES

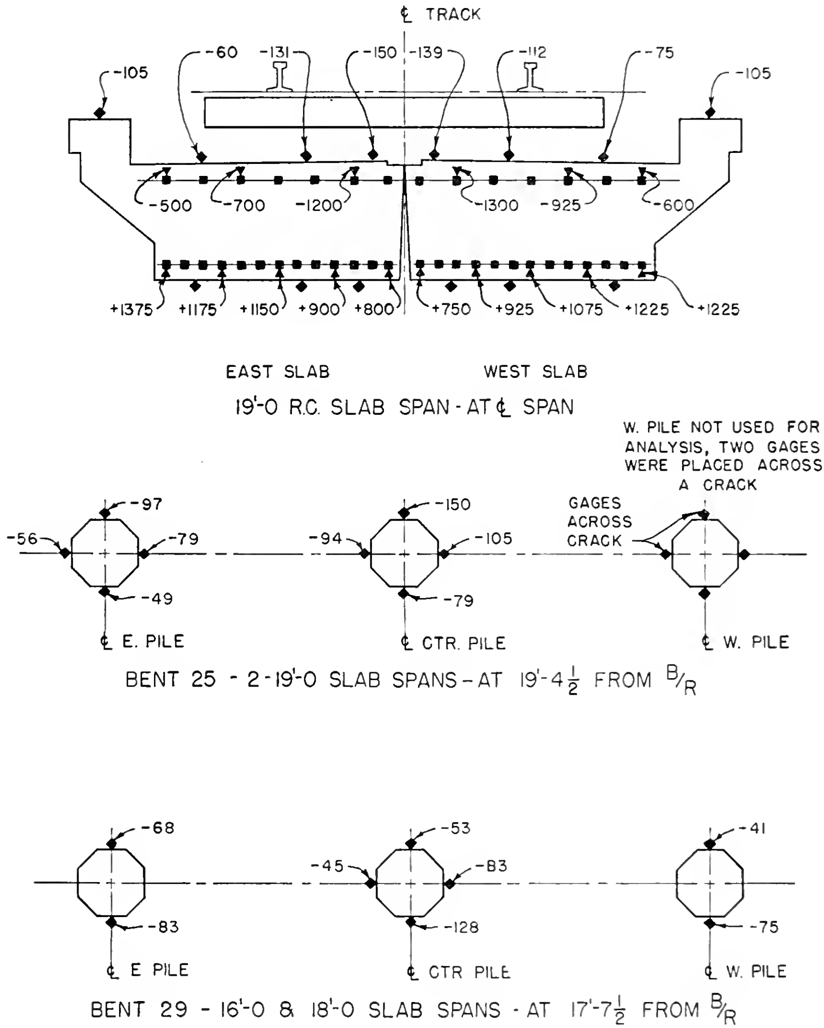


FIG. 30
M.P.R.R. BRIDGE TESTS
BR NO 637
R.C. SLAB SPANS
BALLASTED FLOOR
VARIATION OF RECORDED STATIC STRESSES
MIKADO TYPE 2-8-2

NOTE.
STRESSES SHOWN ARE IN PSI.
+ TENSION
- COMPRESSION

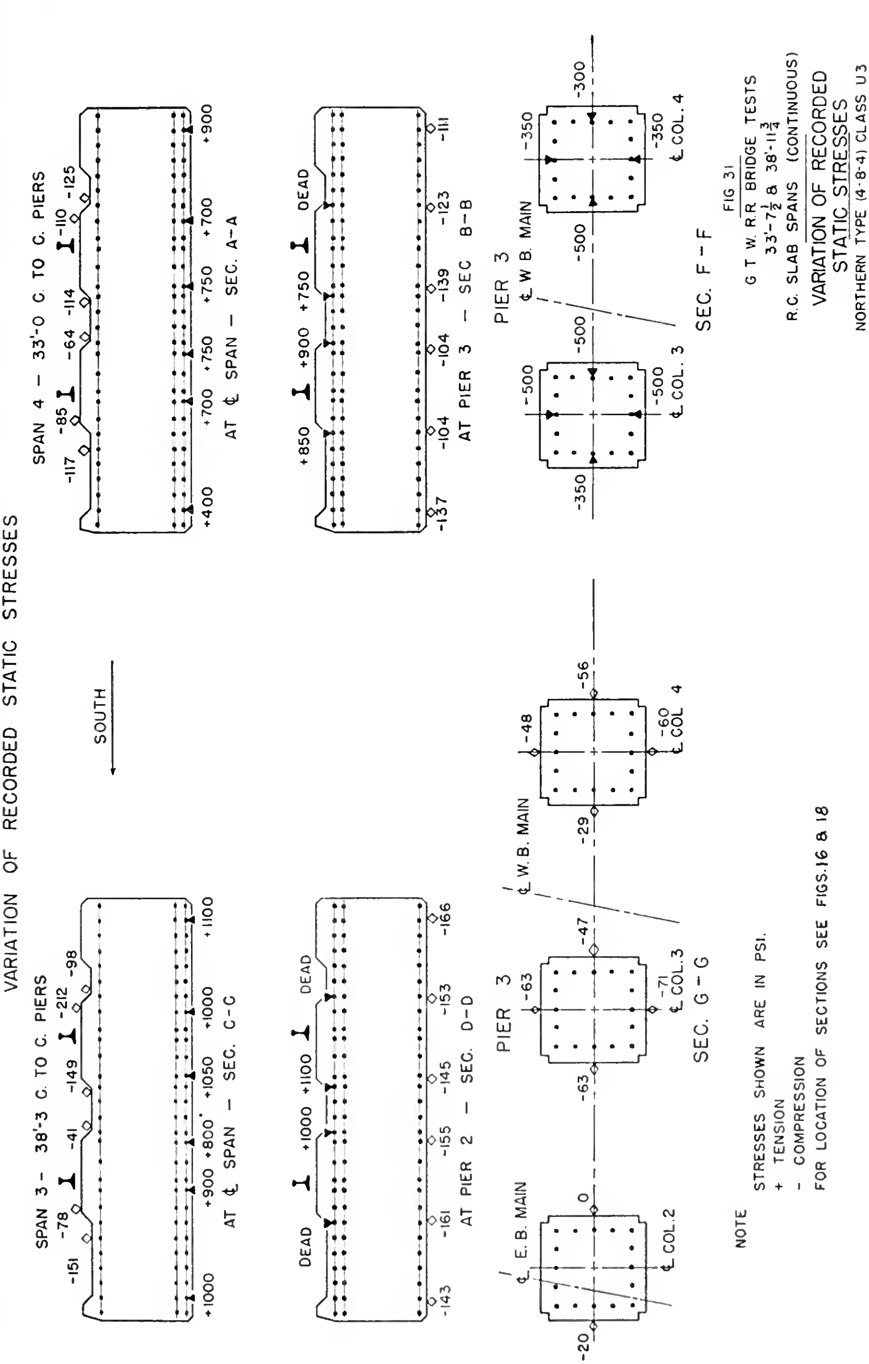


FIG 31
G T W. R.R. BRIDGE TESTS
$33'-7\frac{1}{2}$ & $38'-11\frac{3}{4}$
R.C. SLAB SPANS (CONTINUOUS)
VARIATION OF RECORDED STATIC STRESSES
NORTHERN TYPE (4-8-4) CLASS U3

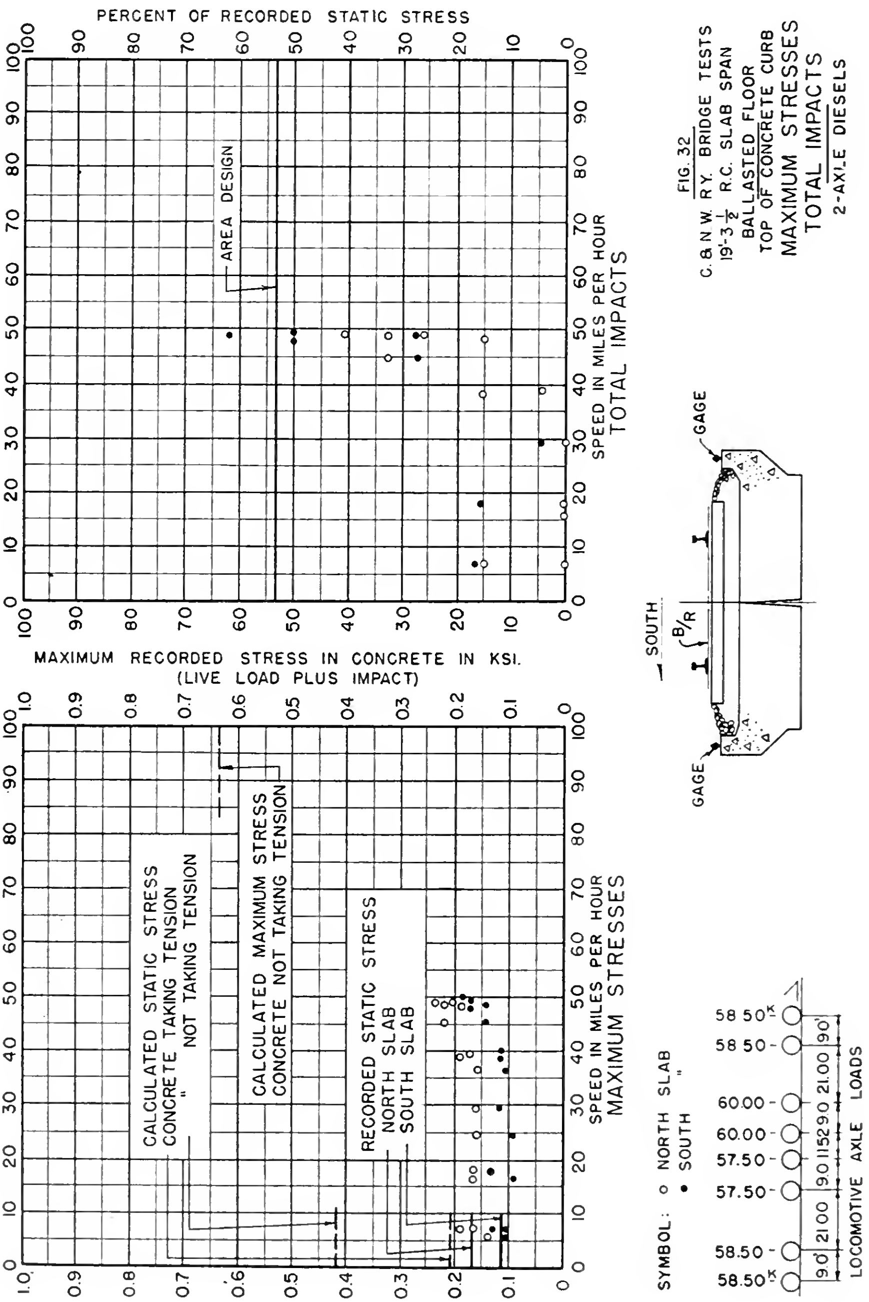


FIG. 32
C. & N.W. RY. BRIDGE TESTS
19'-3 1/2 R.C. SLAB SPAN
BALLASTED FLOOR
TOP OF CONCRETE CURB
MAXIMUM STRESSES
TOTAL IMPACTS
2-AXLE DIESELS

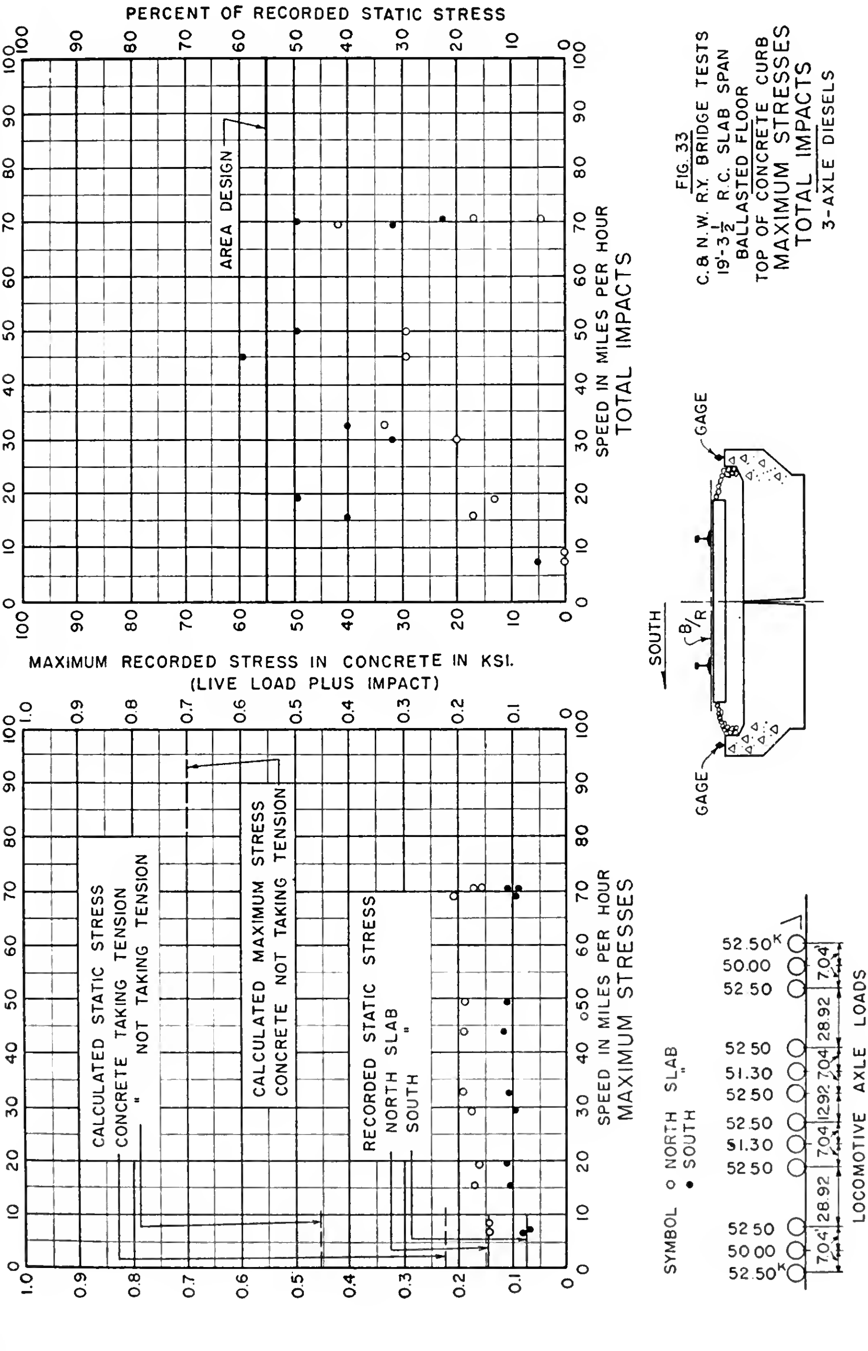


FIG. 33
C.&N.W. RY. BRIDGE TESTS
19'-3½" R.C. SLAB SPAN
BALLASTED FLOOR
TOP OF CONCRETE CURB
MAXIMUM STRESSES
TOTAL IMPACTS
3-AXLE DIESELS

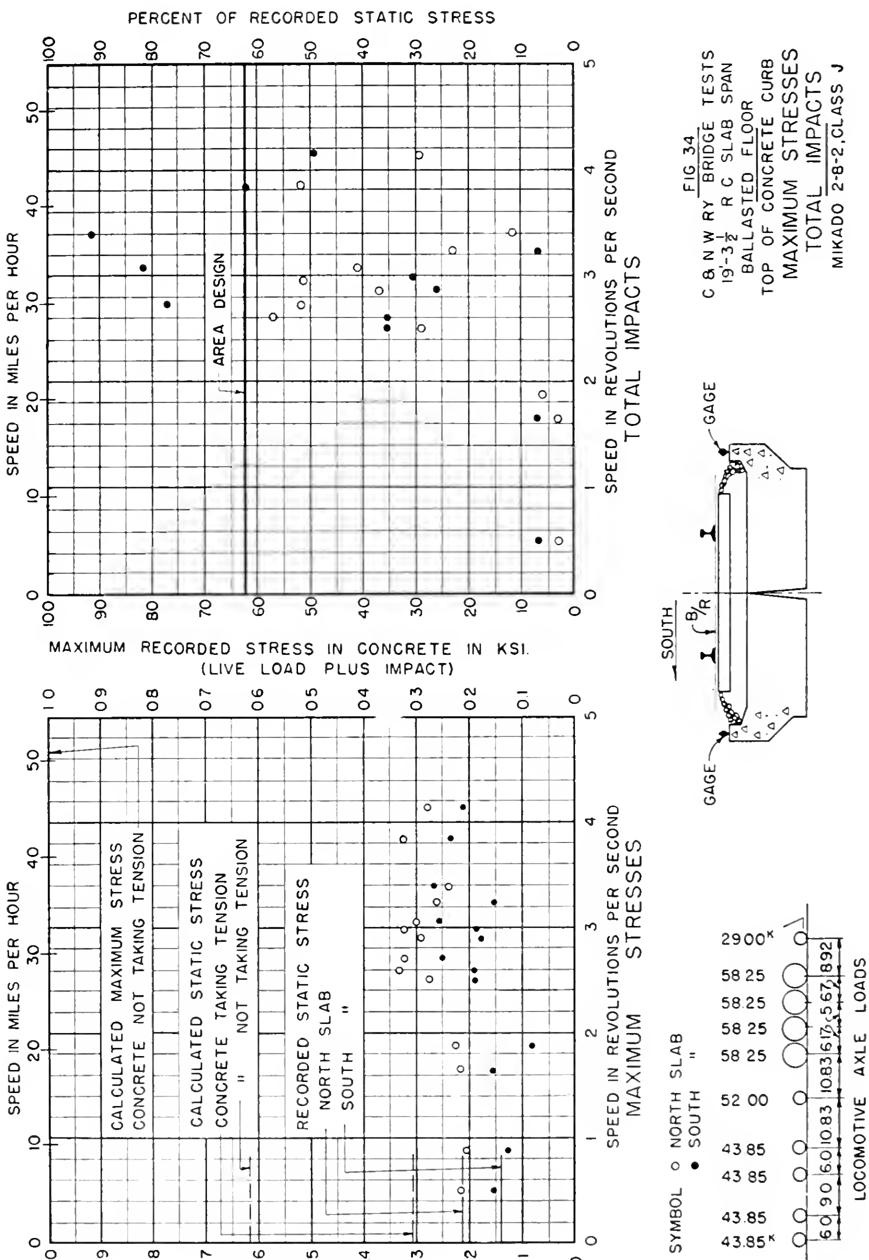


FIG 34
C & N W RY BRIDGE TESTS
19'-3½" R C SLAB SPAN
BALLASTED FLOOR
TOP OF CONCRETE CURB
MAXIMUM STRESSES
TOTAL IMPACTS
MIKADO 2-8-2, CLASS J

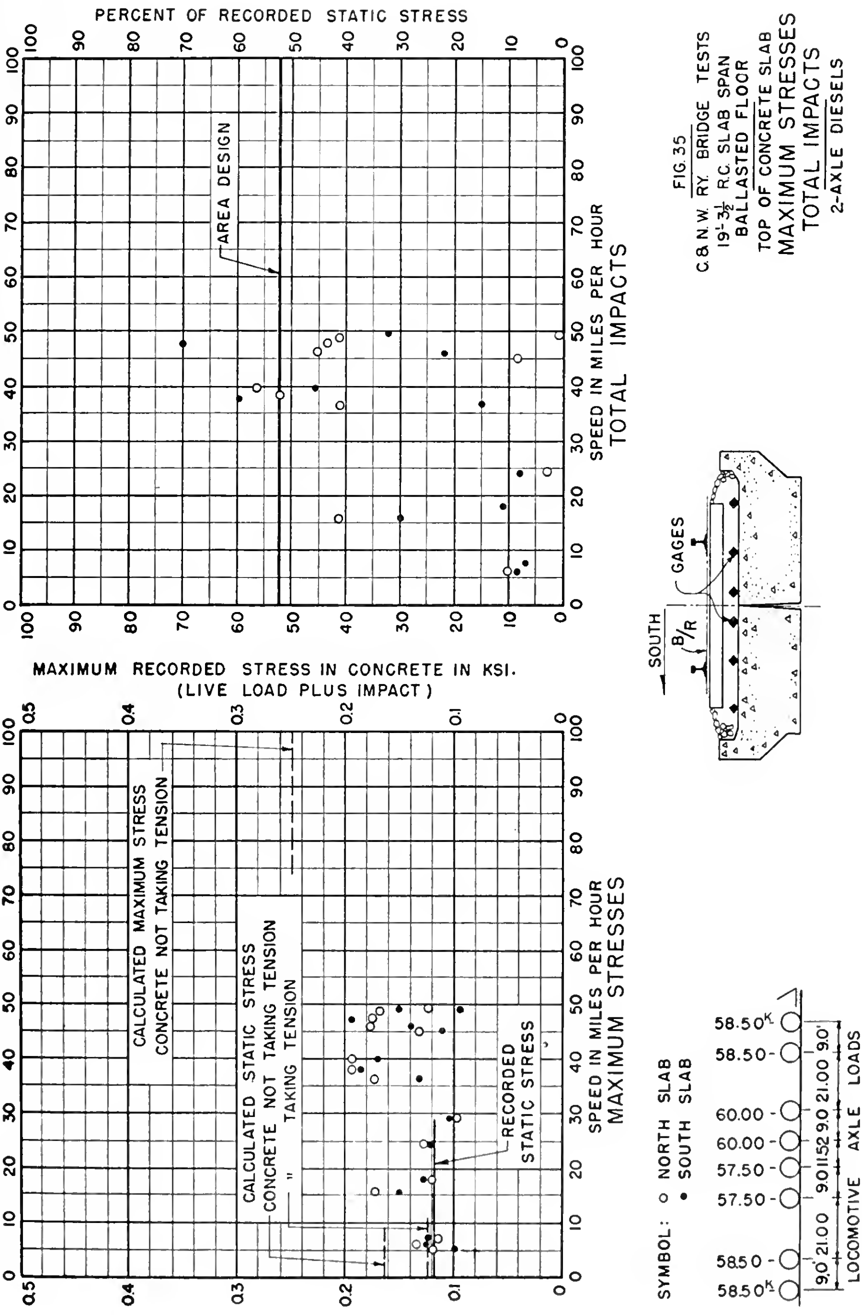


FIG. 35
C.& N.W. RY. BRIDGE TESTS
19'-3½ R.C. SLAB SPAN
BALLASTED FLOOR
TOP OF CONCRETE SLAB
MAXIMUM STRESSES
TOTAL IMPACTS
2-AXLE DIESELS

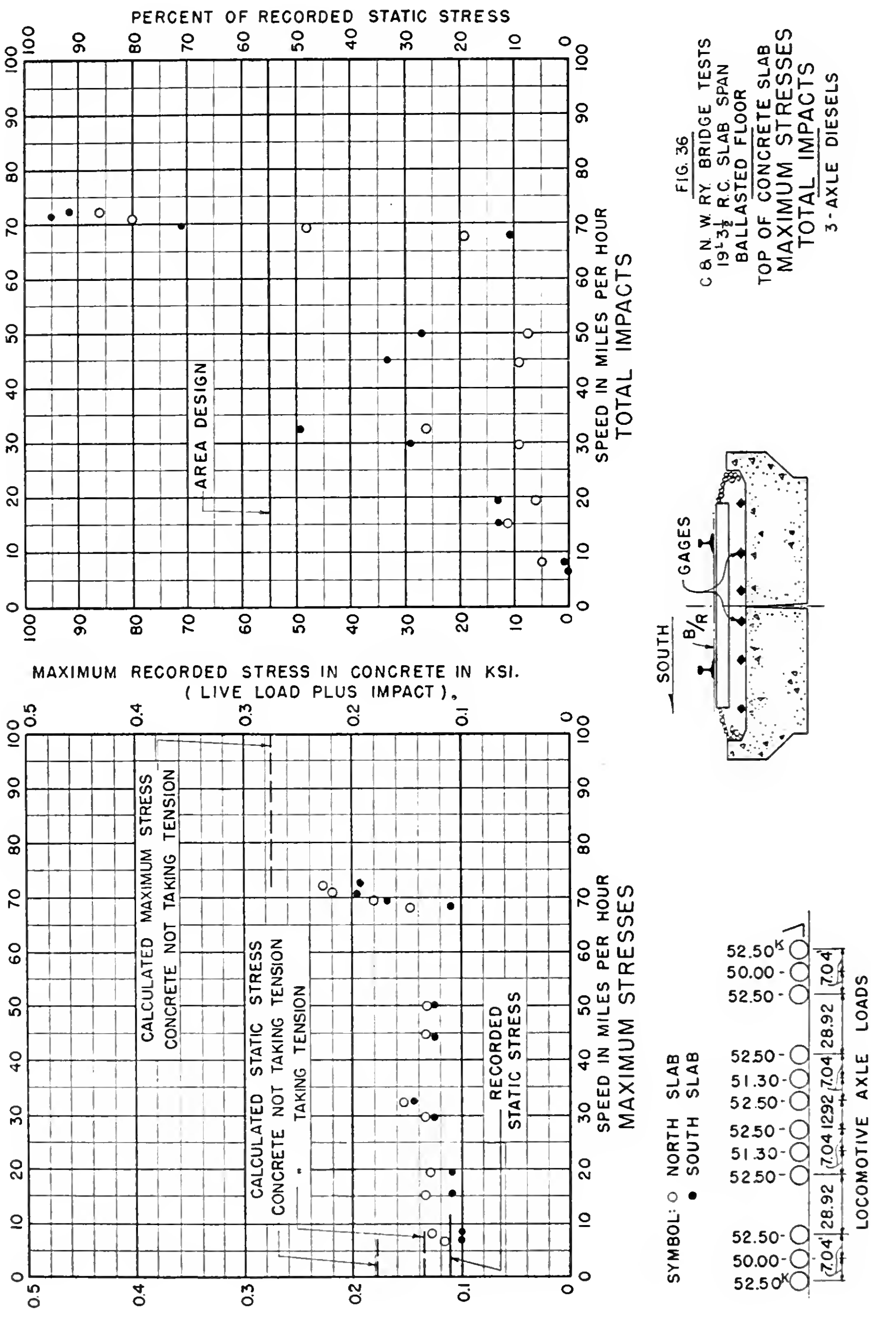


FIG. 36
C & N. W. RY. BRIDGE TESTS
19'-3½" R.C. SLAB SPAN
BALLASTED FLOOR
TOP OF CONCRETE SLAB
MAXIMUM STRESSES
TOTAL IMPACTS
3-AXLE DIESELS

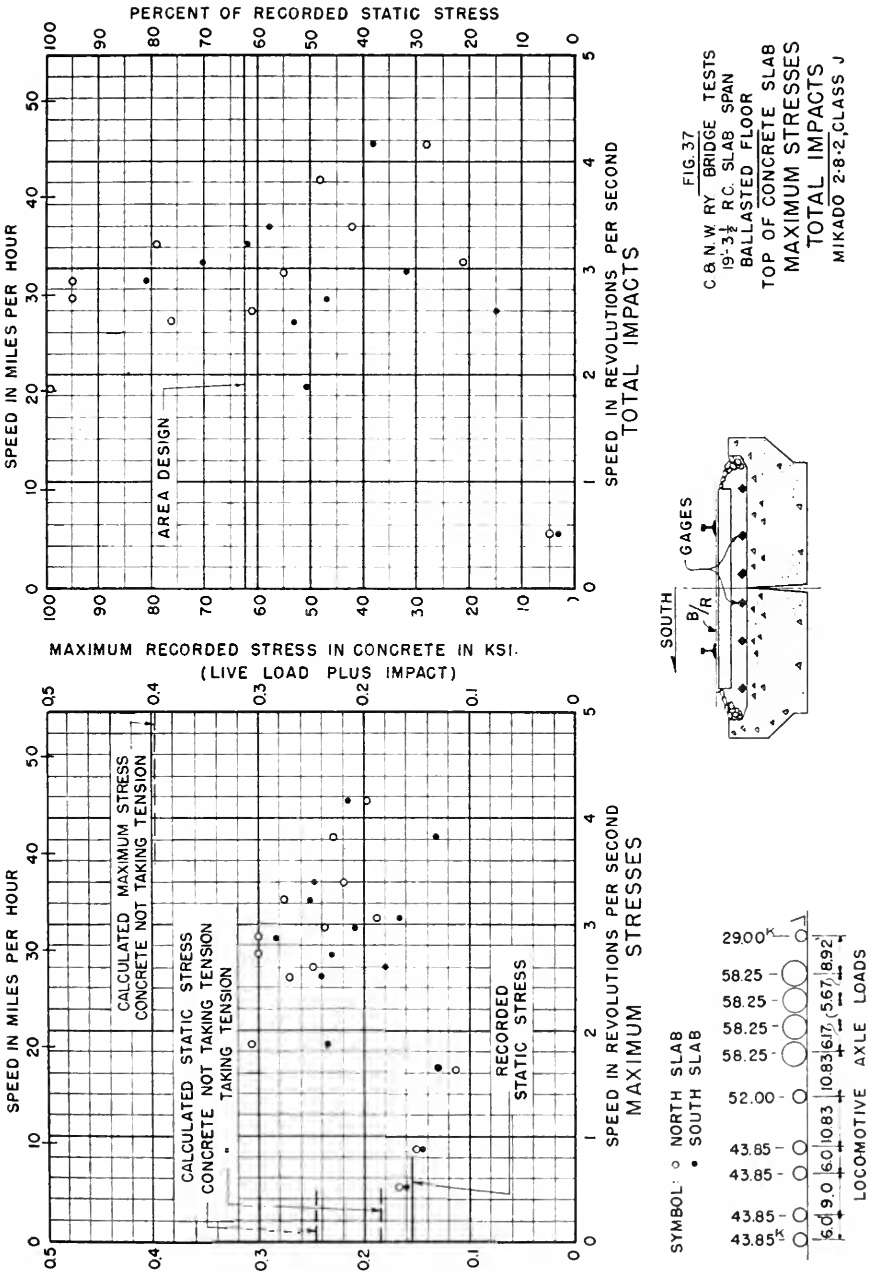


FIG. 37
C & N.W. RY. BRIDGE TESTS
19'-3½" R.C. SLAB SPAN
BALLASTED FLOOR
TOP OF CONCRETE SLAB
MAXIMUM STRESSES
TOTAL IMPACTS
MIKADO 2-8-2, CLASS J

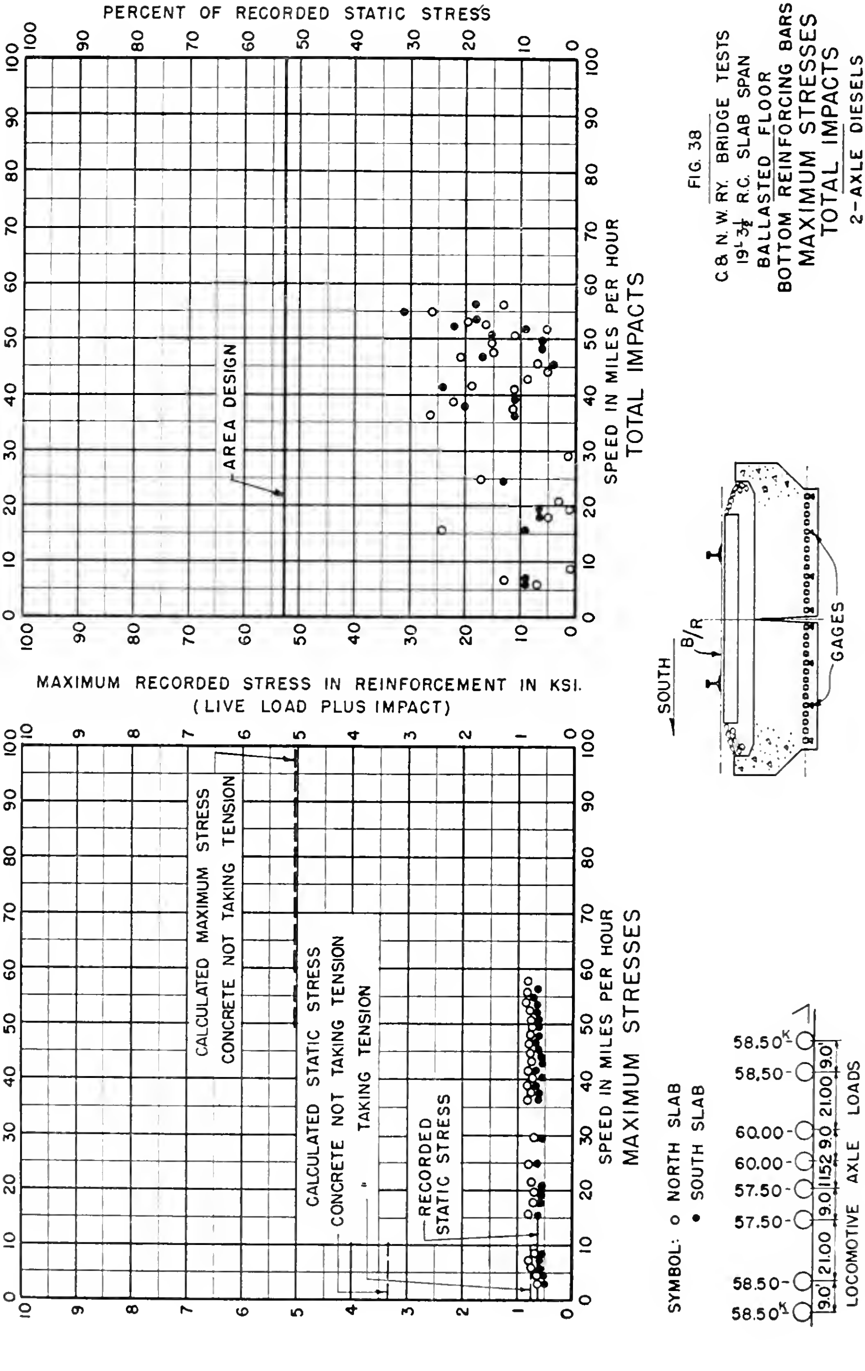


FIG. 38
C.& N.W. RY. BRIDGE TESTS
19'-3½" R.C. SLAB SPAN
BALLASTED FLOOR
BOTTOM REINFORCING BARS
MAXIMUM STRESSES
TOTAL IMPACTS
2-AXLE DIESELS

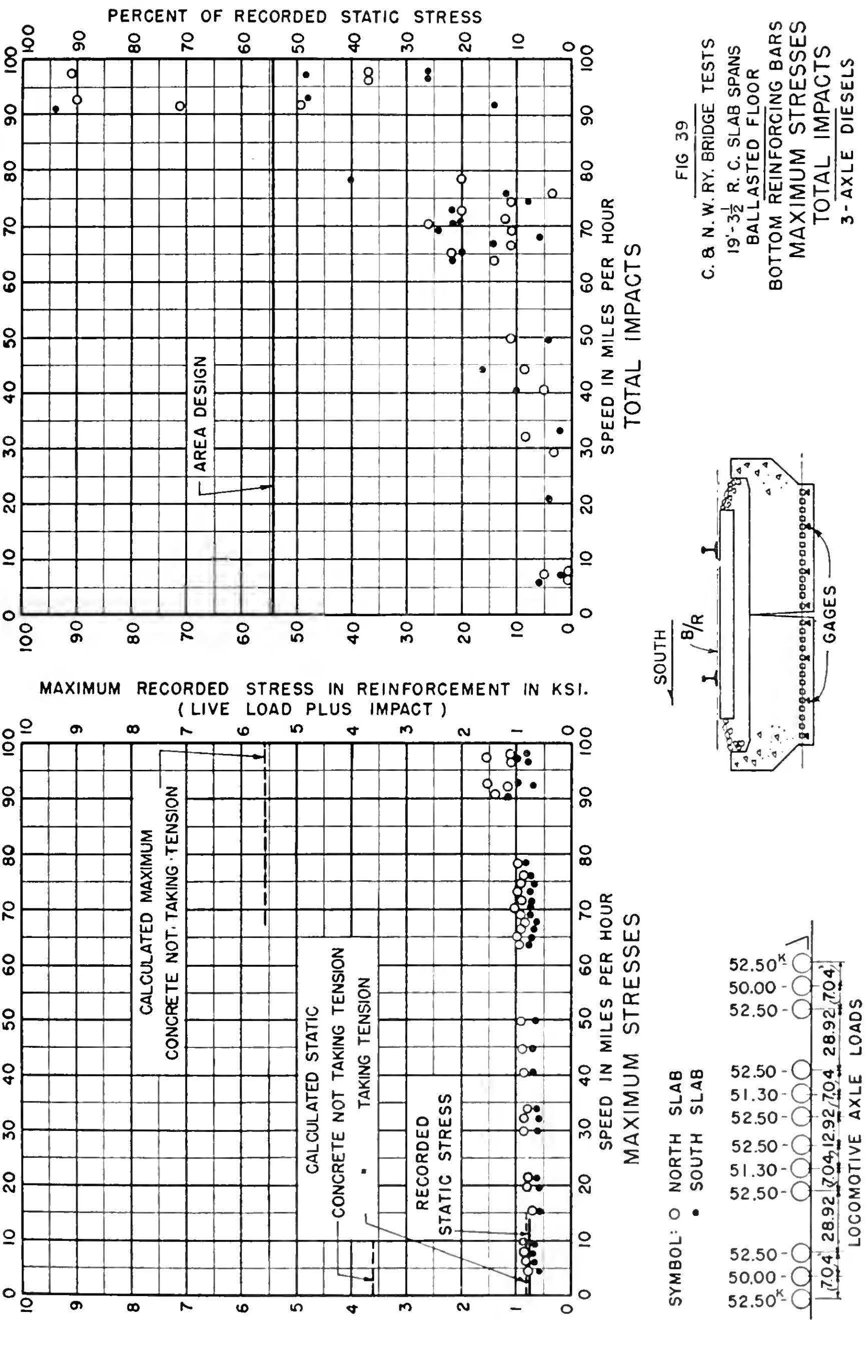


FIG 39

C. & N. W. RY. BRIDGE TESTS

19'-3½ R. C. SLAB SPANS

BALLASTED FLOOR

BOTTOM REINFORCING BARS

MAXIMUM STRESSES

TOTAL IMPACTS

3-AXLE DIESELS

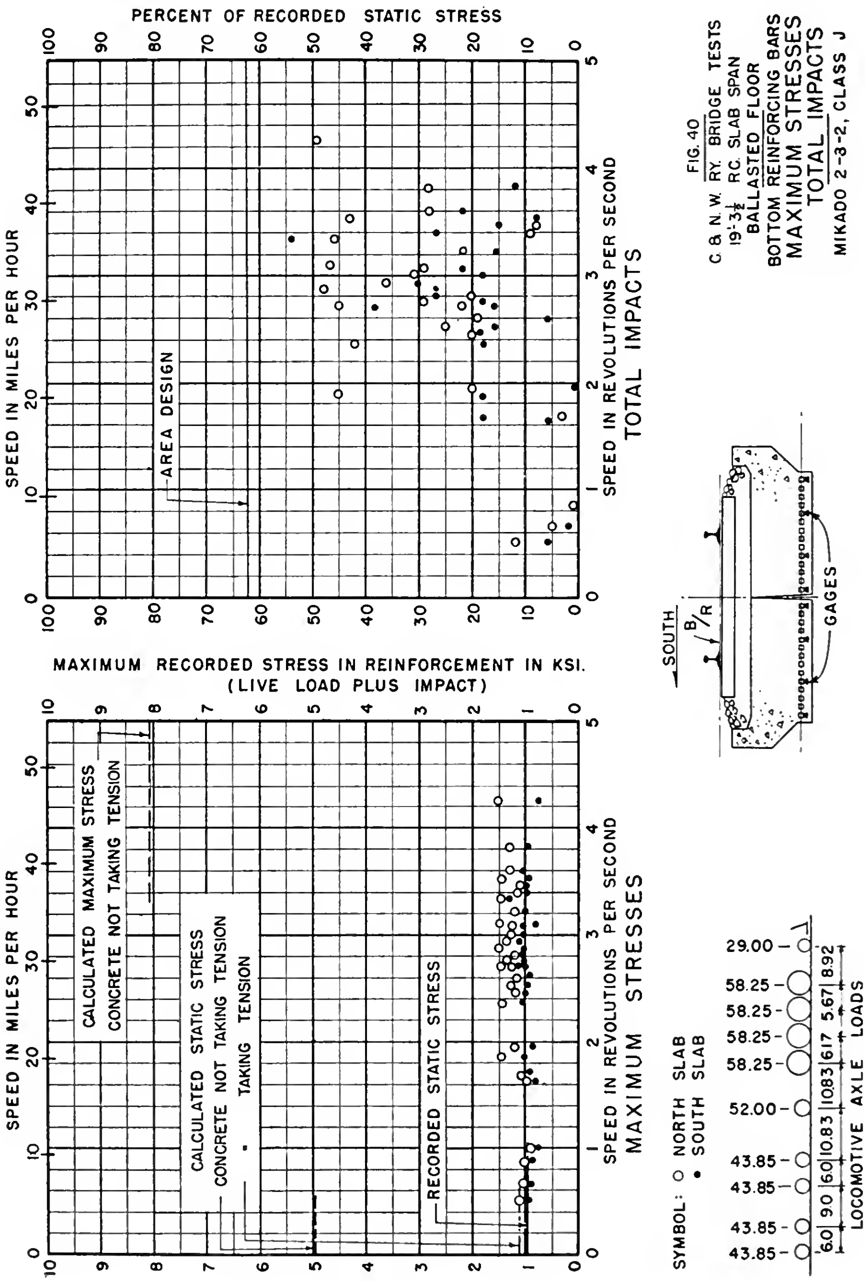


FIG. 40
C. & N. W. RY. BRIDGE TESTS
19'-3½" R.C. SLAB SPAN
BALLASTED FLOOR
BOTTOM REINFORCING BARS
MAXIMUM STRESSES
TOTAL IMPACTS
MIKADO 2-3-2, CLASS J

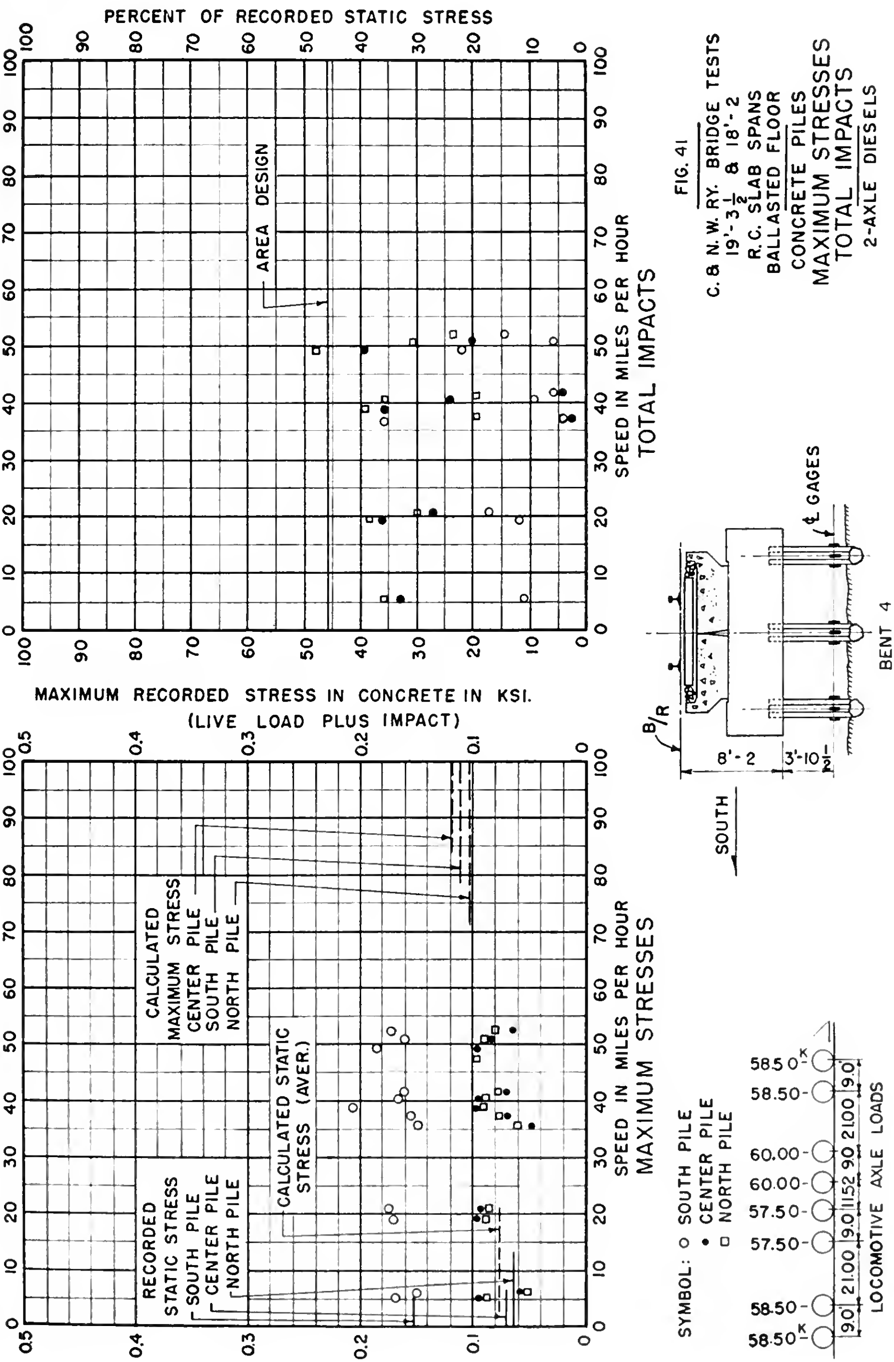


FIG. 41
C. & N. W. RY. BRIDGE TESTS
19'-3½ & 18'-2
R.C. SLAB SPANS
BALLASTED FLOOR
CONCRETE PILES
MAXIMUM STRESSES
TOTAL IMPACTS
2-AXLE DIESELS

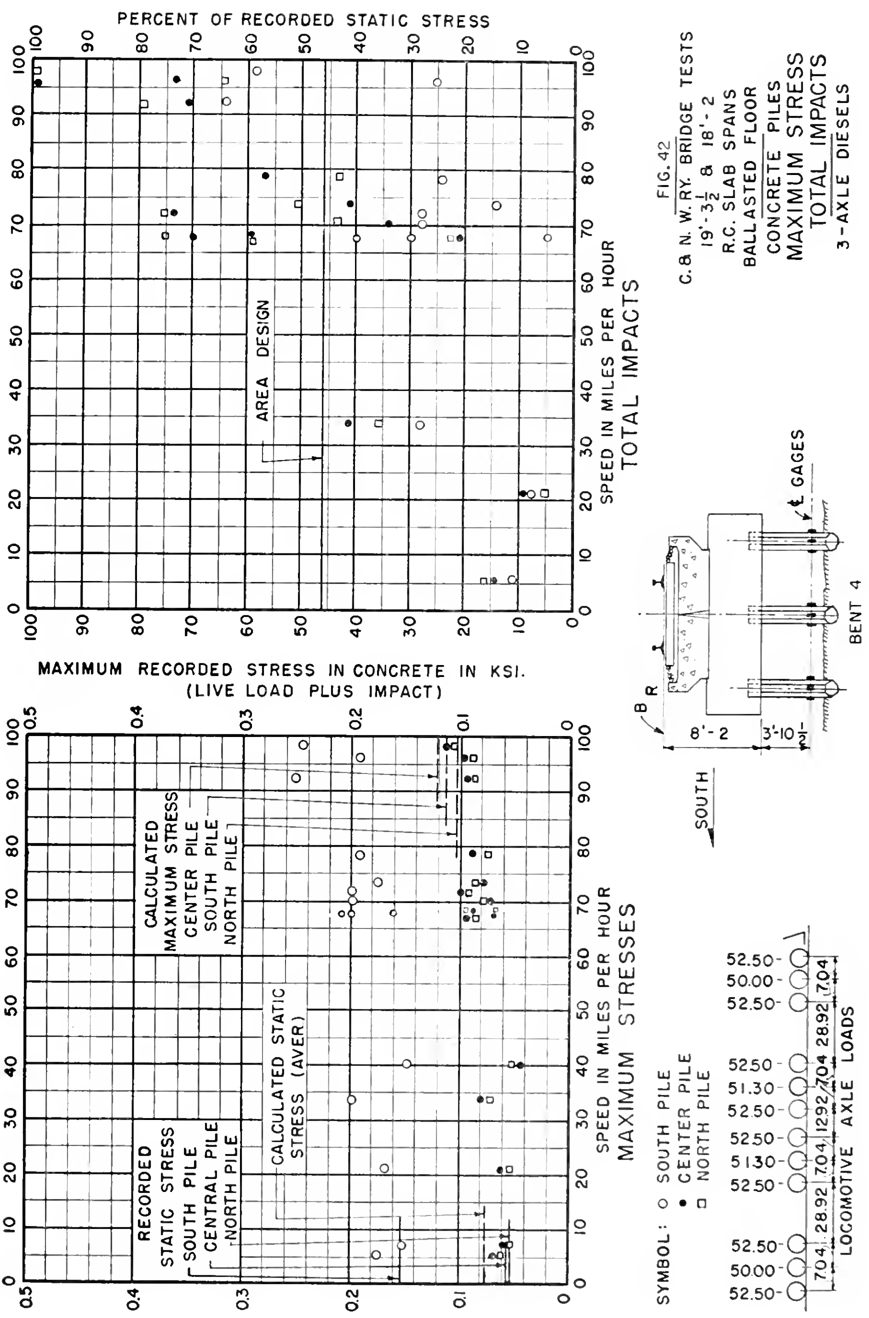


FIG. 42
C.& N. W. RY. BRIDGE TESTS
19'-3½ & 18'-2
R.C. SLAB SPANS
BALLASTED FLOOR
CONCRETE PILES
MAXIMUM STRESS
TOTAL IMPACTS
3-AXLE DIESELS

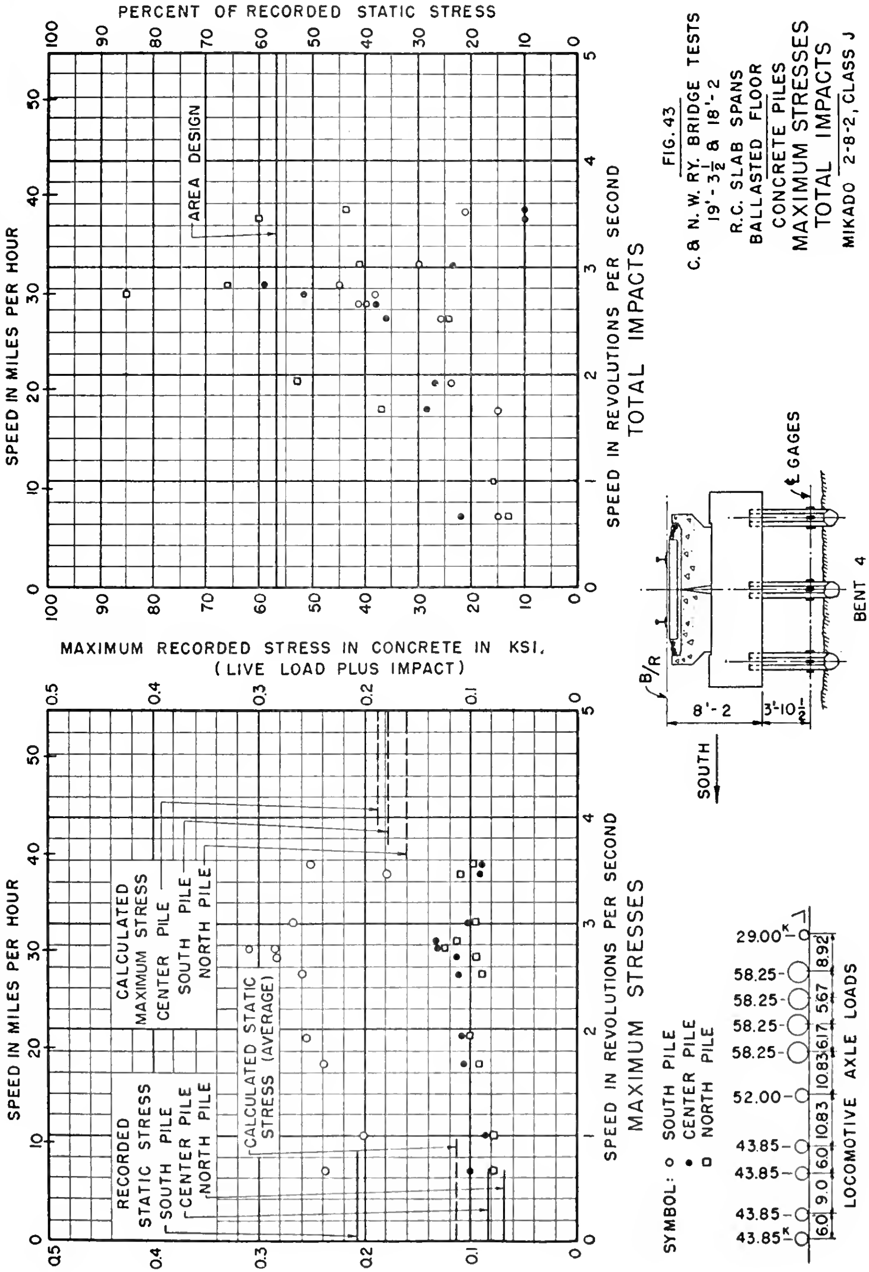


FIG. 43
C. & N. W. RY. BRIDGE TESTS
19'-3½ & 18'-2
R.C. SLAB SPANS
BALLASTED FLOOR
CONCRETE PILES
MAXIMUM STRESSES
TOTAL IMPACTS
MIKADO 2-8-2, CLASS J

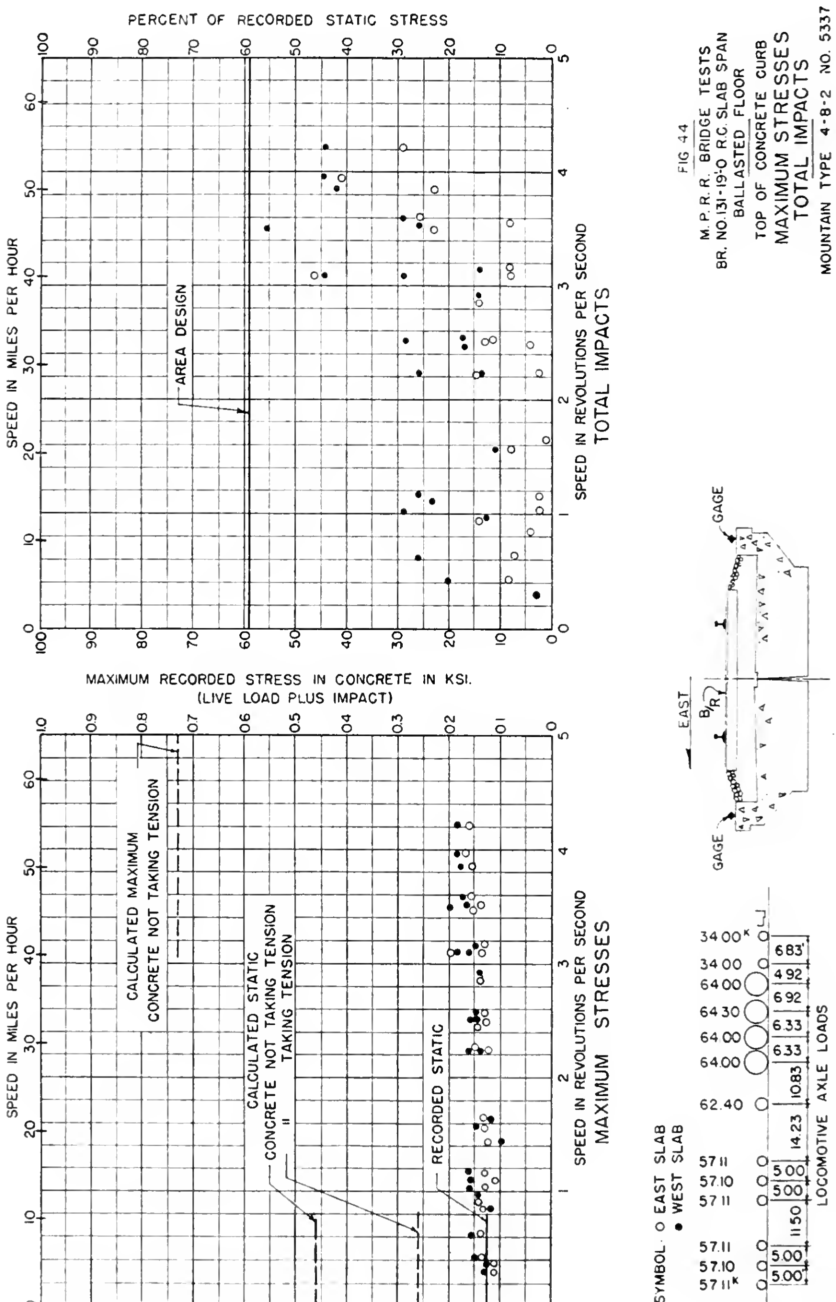


FIG 44
M. P. R. R. BRIDGE TESTS
BR. NO. 131-19'-0 R.C. SLAB SPAN
BALLASTED FLOOR
TOP OF CONCRETE CURB
MAXIMUM STRESSES
TOTAL IMPACTS
MOUNTAIN TYPE 4-8-2 NO. 5337

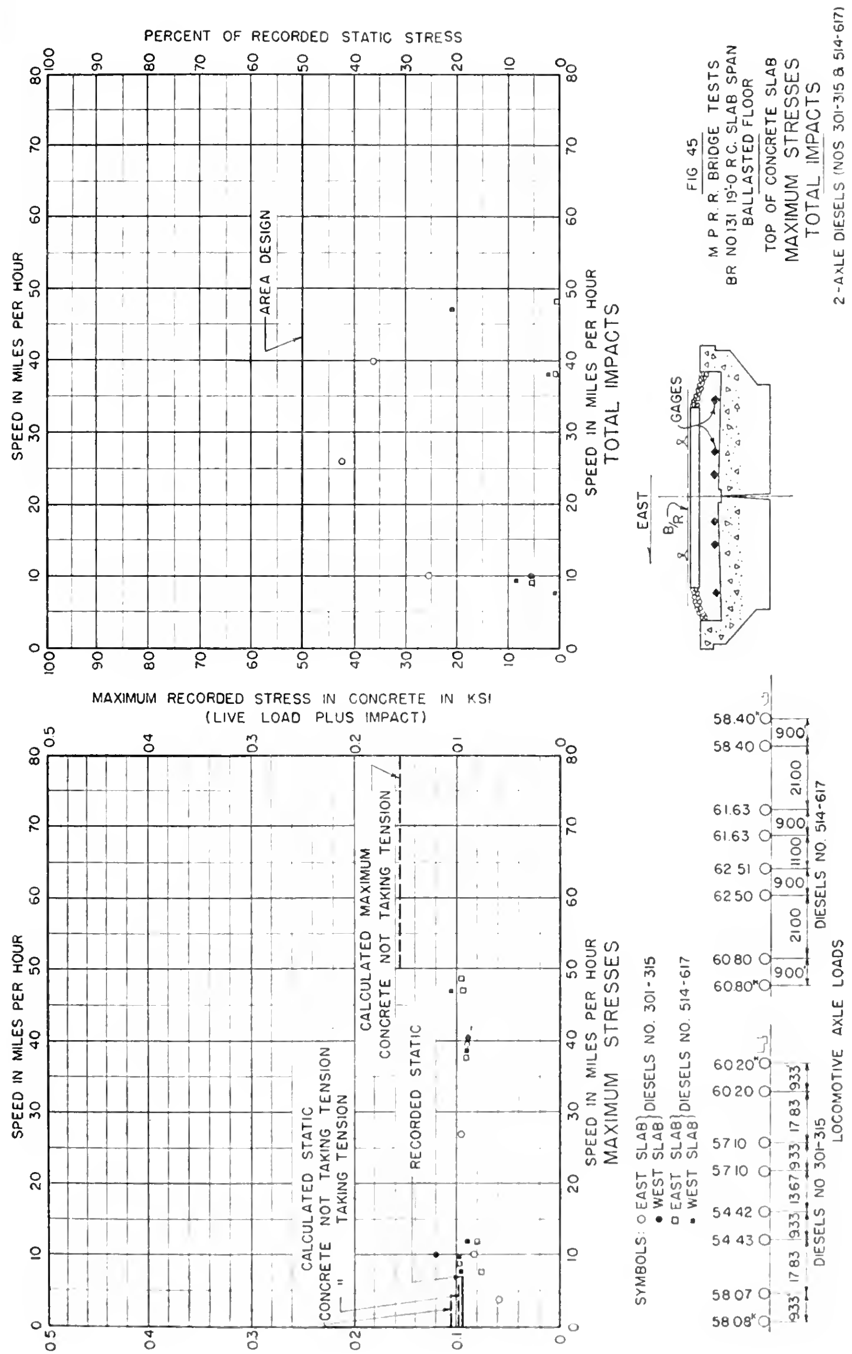


FIG 45
M P R.R. BRIDGE TESTS
BR NO 131 19'-0 R.C. SLAB SPAN
BALLASTED FLOOR
TOP OF CONCRETE SLAB
MAXIMUM STRESSES
TOTAL IMPACTS
2-AXLE DIESELS (NOS 301-315 & 514-617)

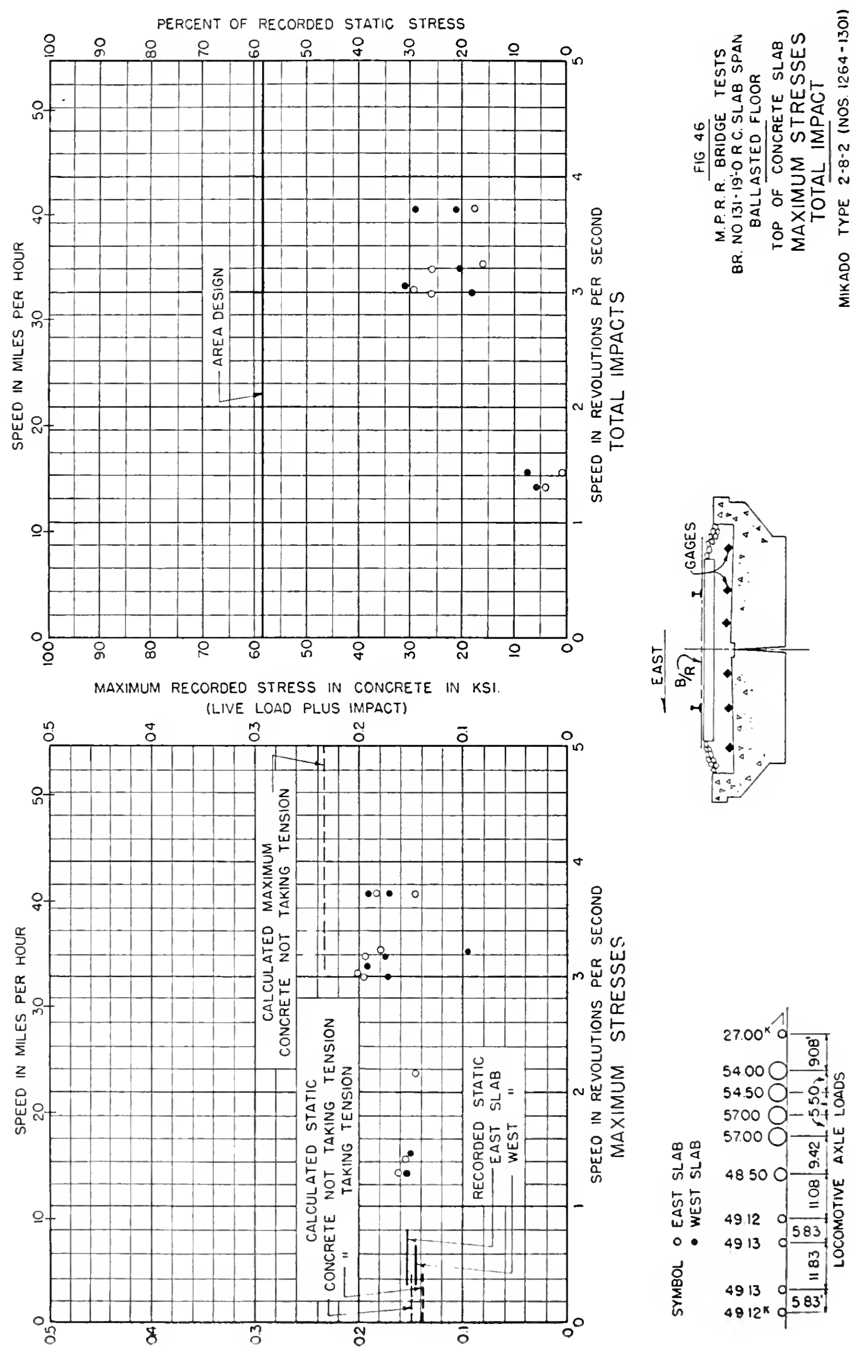


FIG 46
M.P.R.R. BRIDGE TESTS
BR. NO 131-19'-0 R.C. SLAB SPAN
BALLASTED FLOOR
TOP OF CONCRETE SLAB
MAXIMUM STRESSES
TOTAL IMPACT
MIKADO TYPE 2-8-2 (NOS. 1264-1301)
PERCENT OF RECORDED STATIC STRESS
SPEED IN MILES PER HOUR
SPEED IN REVOLUTIONS PER SECOND
TOTAL IMPACTS
AREA DESIGN
MAXIMUM RECORDED STRESS IN CONCRETE IN KSI.
(LIVE LOAD PLUS IMPACT)
CALCULATED MAXIMUM
CONCRETE NOT TAKING TENSION
CALCULATED STATIC
CONCRETE NOT TAKING TENSION
" TAKING TENSION
RECORDED STATIC
EAST SLAB
WEST "
MAXIMUM STRESSES
GAGES
EAST
B/R
SYMBOL ○ EAST SLAB
● WEST SLAB
LOCOMOTIVE AXLE LOADS
27.00K
54.00
54.50
57.00
57.00
48.50
49.12
49.13
49.13
49.12K
9.08'
5.50
9.42
11.08
5.83
11.83
5.83'

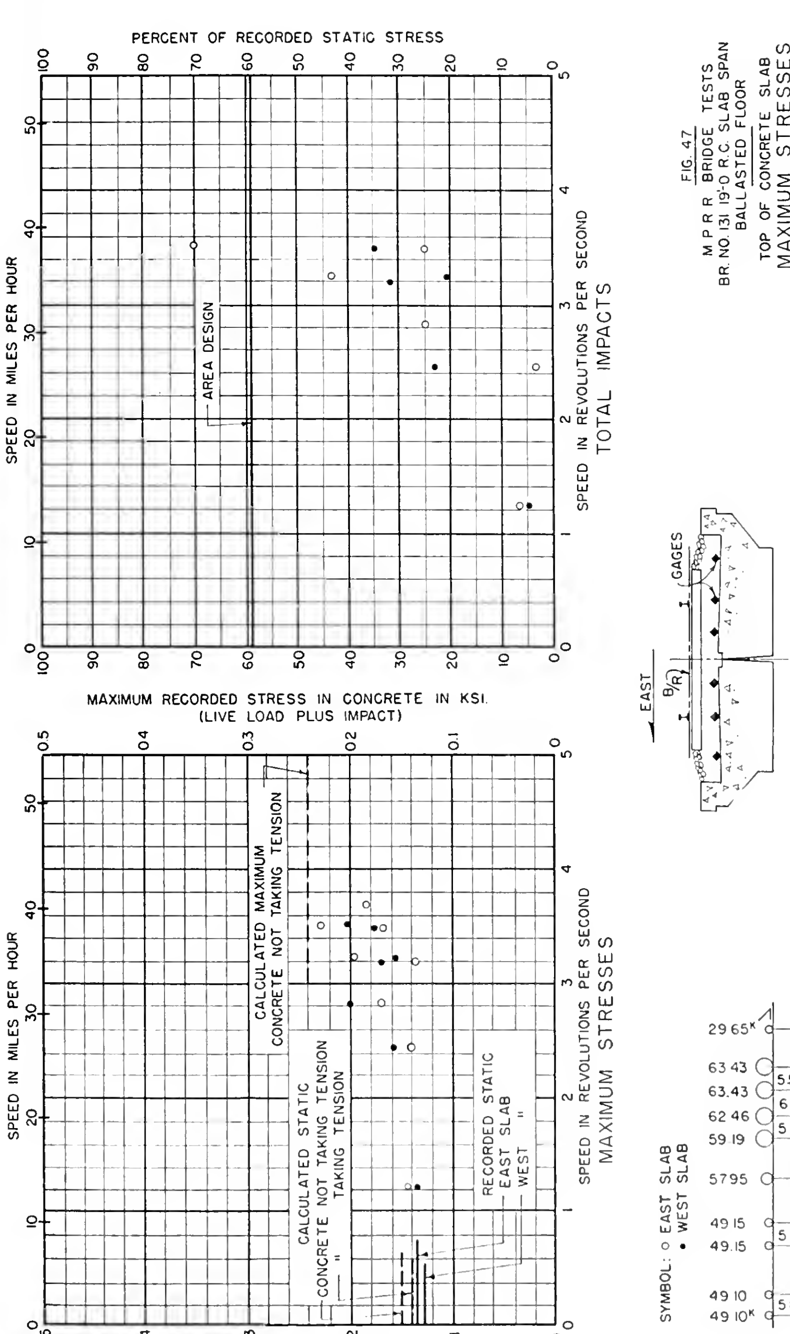


FIG. 47
M P R R BRIDGE TESTS
BR. NO. 131 19'-0 R.C. SLAB SPAN
BALLASTED FLOOR
TOP OF CONCRETE SLAB
MAXIMUM STRESSES
TOTAL IMPACT
MIKADO TYPE 2-8-2 (NOS. 1453-1558)

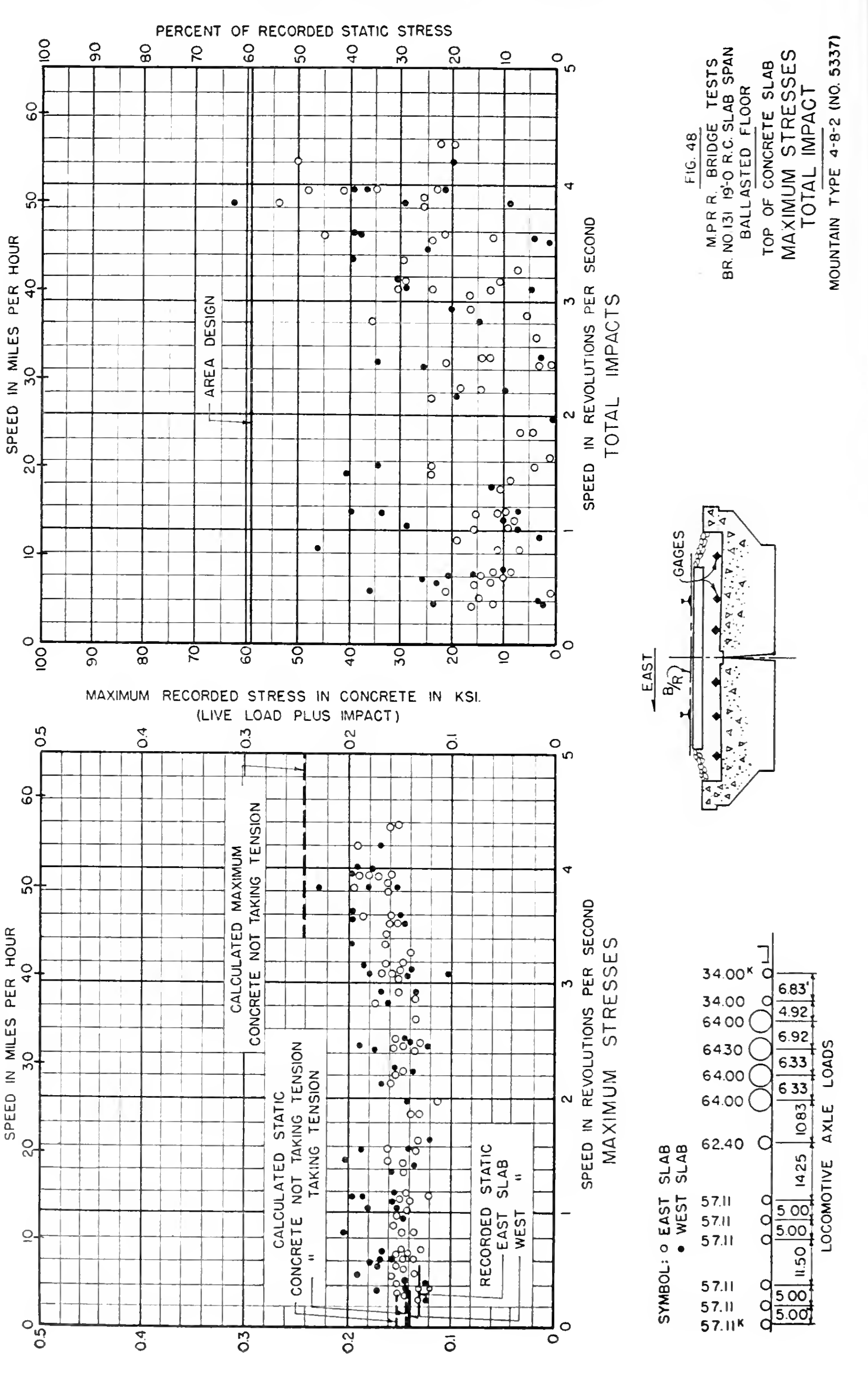


FIG. 48
M.P.R.R. BRIDGE TESTS
BR. NO 131 19'-0 R.C. SLAB SPAN
BALLASTED FLOOR
TOP OF CONCRETE SLAB
MAXIMUM STRESSES
TOTAL IMPACT
MOUNTAIN TYPE 4-8-2 (NO. 5337)

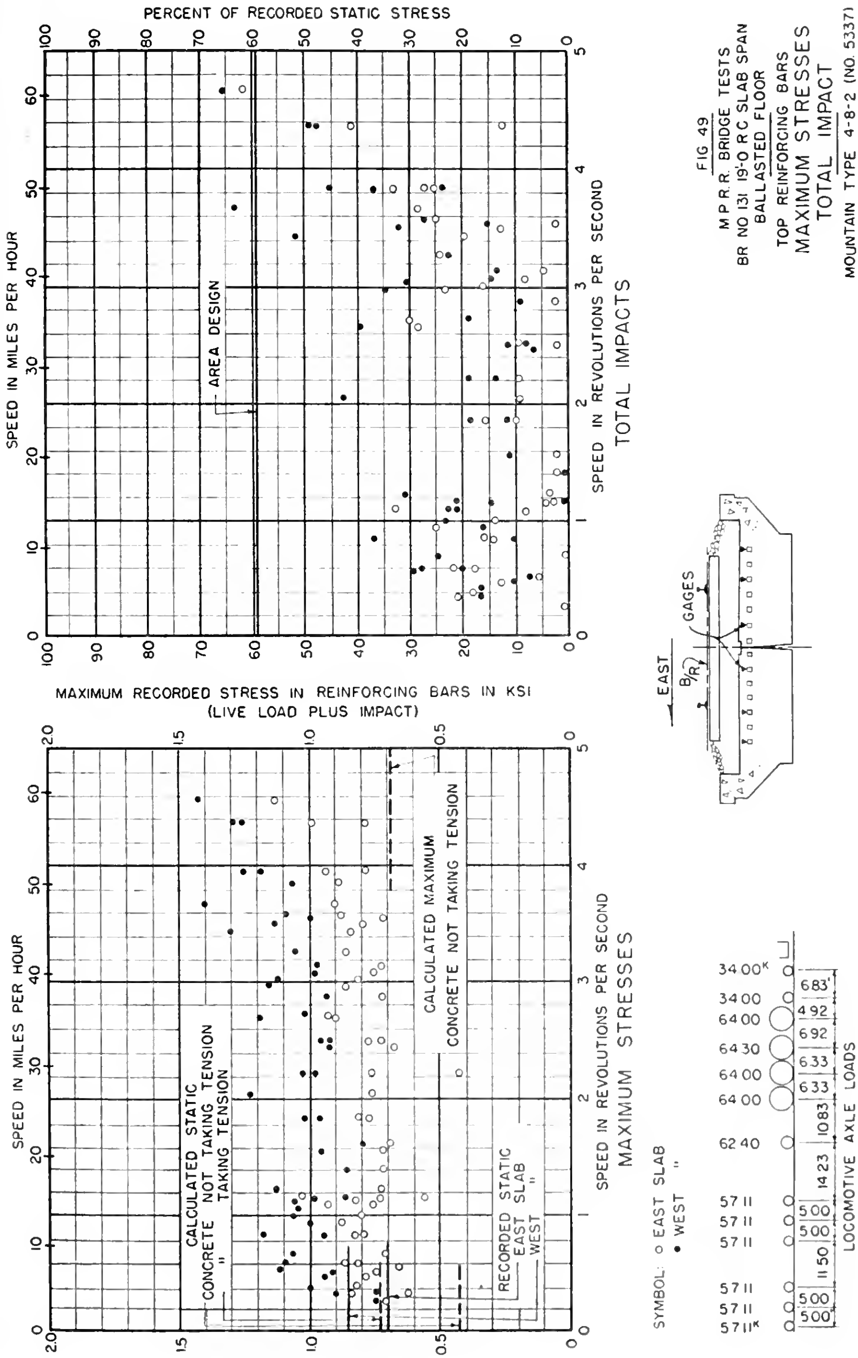


FIG 49
M P R R. BRIDGE TESTS
BR NO 131 19'-0 R C SLAB SPAN
BALLASTED FLOOR
TOP REINFORCING BARS
MAXIMUM STRESSES
TOTAL IMPACT
MOUNTAIN TYPE 4-8-2 (NO. 5337)

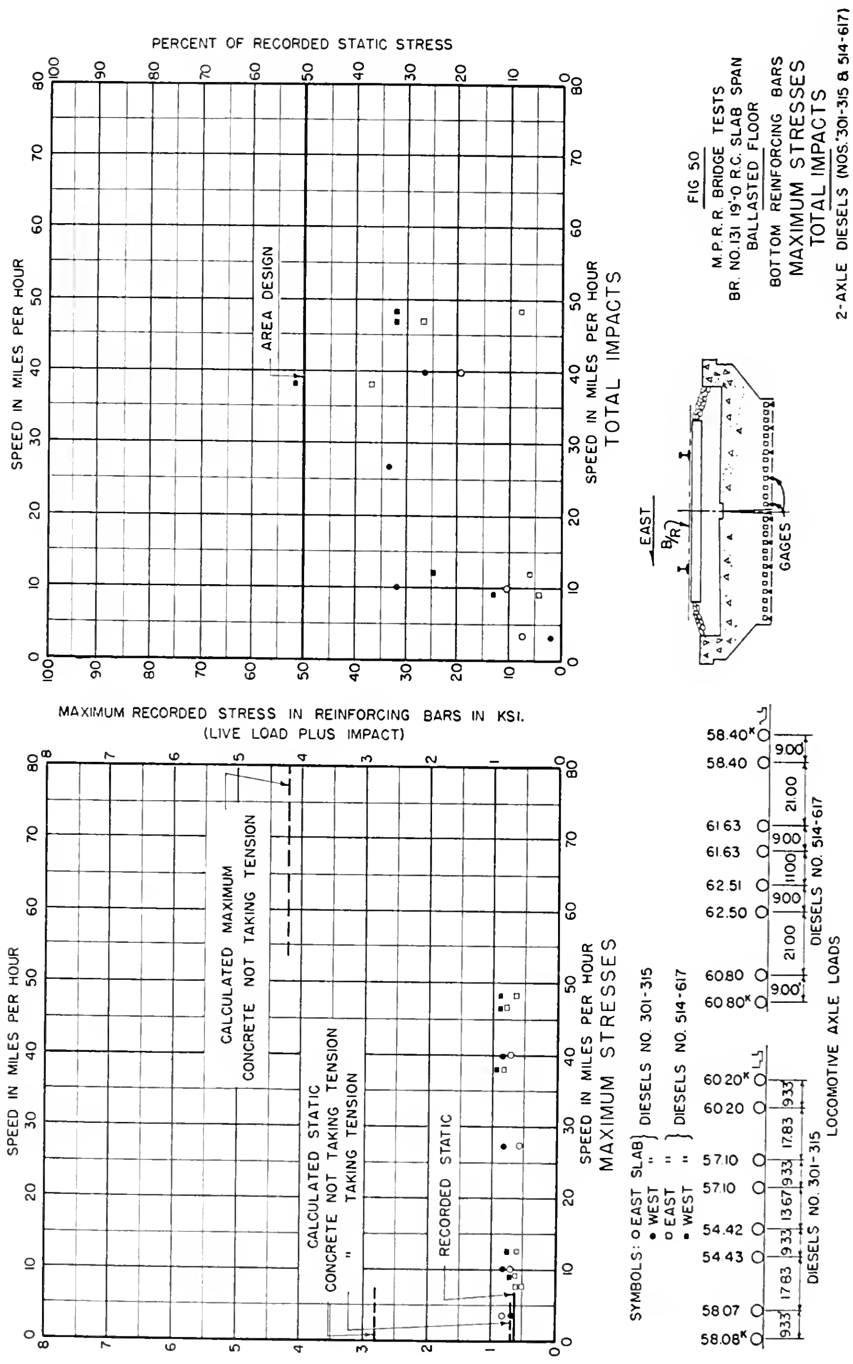


FIG 50
M.P.R.R. BRIDGE TESTS
BR. NO.131 19'-0 R.C. SLAB SPAN
BALLASTED FLOOR
BOTTOM REINFORCING BARS
MAXIMUM STRESSES
TOTAL IMPACTS
2-AXLE DIESELS (NOS. 301-315 & 514-617)

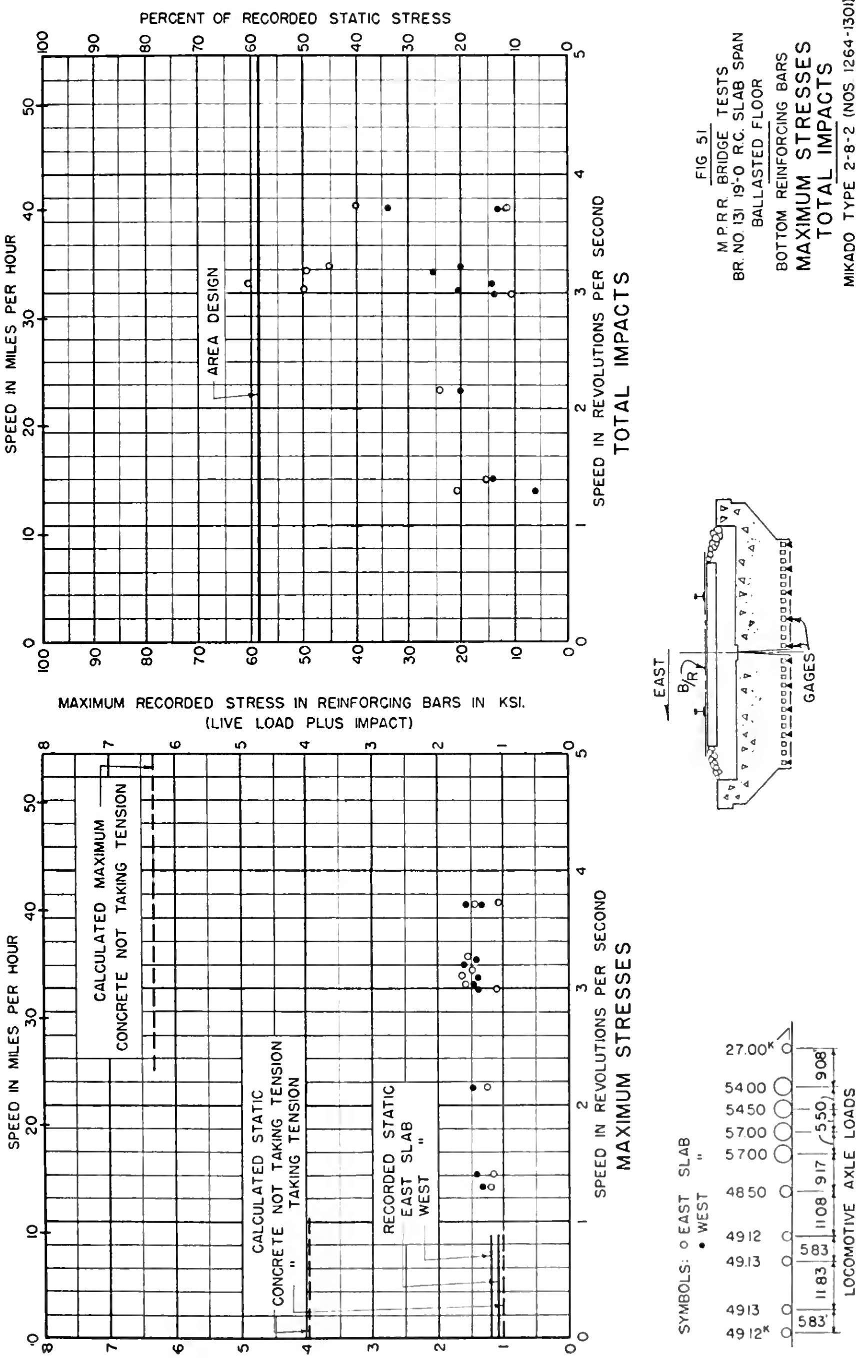


FIG 51
M.P.R.R. BRIDGE TESTS
BR. NO. 131 19'-0 R.C. SLAB SPAN
BALLASTED FLOOR
BOTTOM REINFORCING BARS
MAXIMUM STRESSES
TOTAL IMPACTS
MIKADO TYPE 2-8-2 (NOS. 1264-1301)

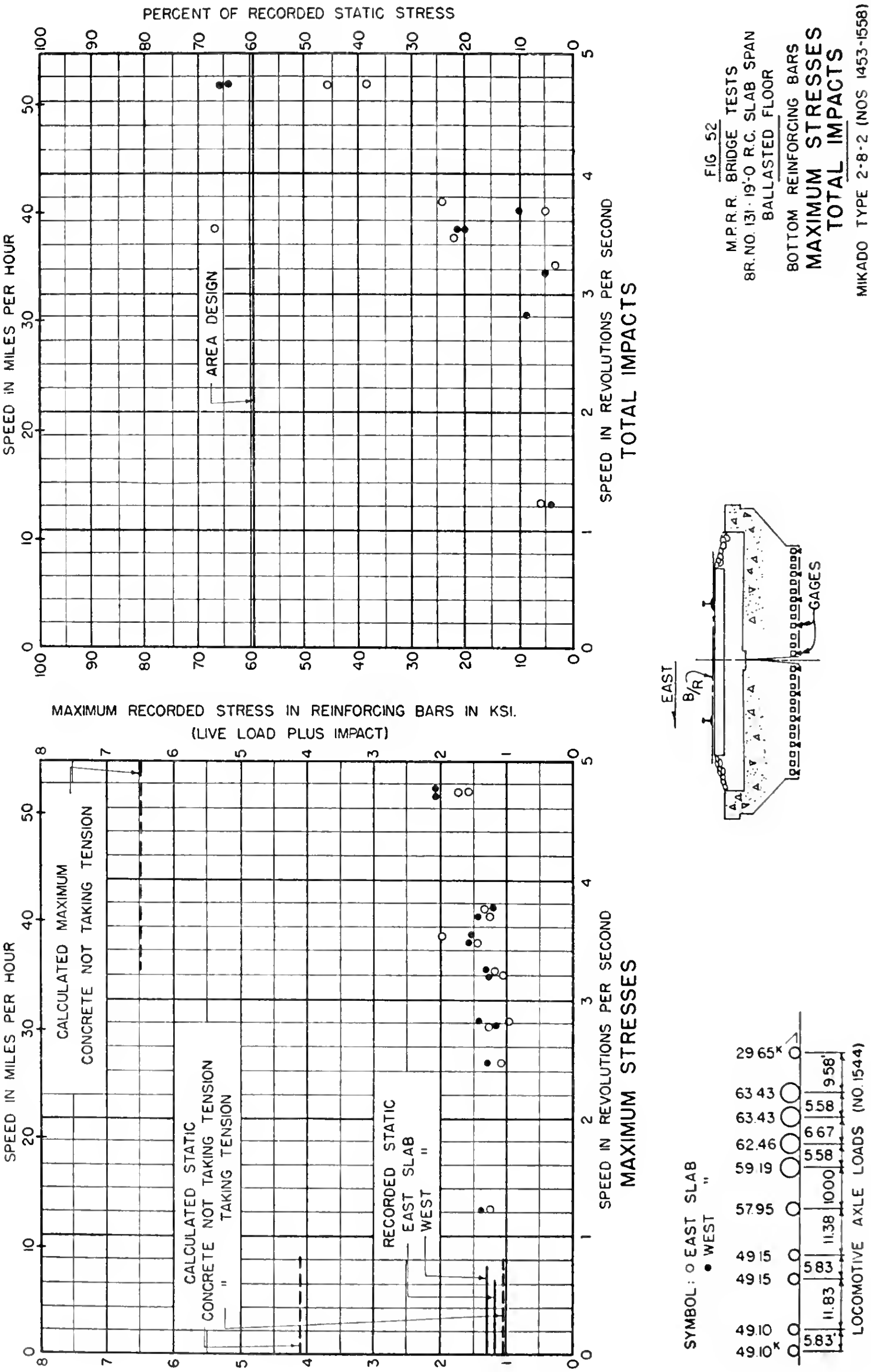


FIG. 52
M.P.R.R. BRIDGE TESTS
BR. NO. 131 · 19'-0 R.C. SLAB SPAN
BALLASTED FLOOR
BOTTOM REINFORCING BARS
MAXIMUM STRESSES
TOTAL IMPACTS
MIKADO TYPE 2-8-2 (NOS 1453-1558)

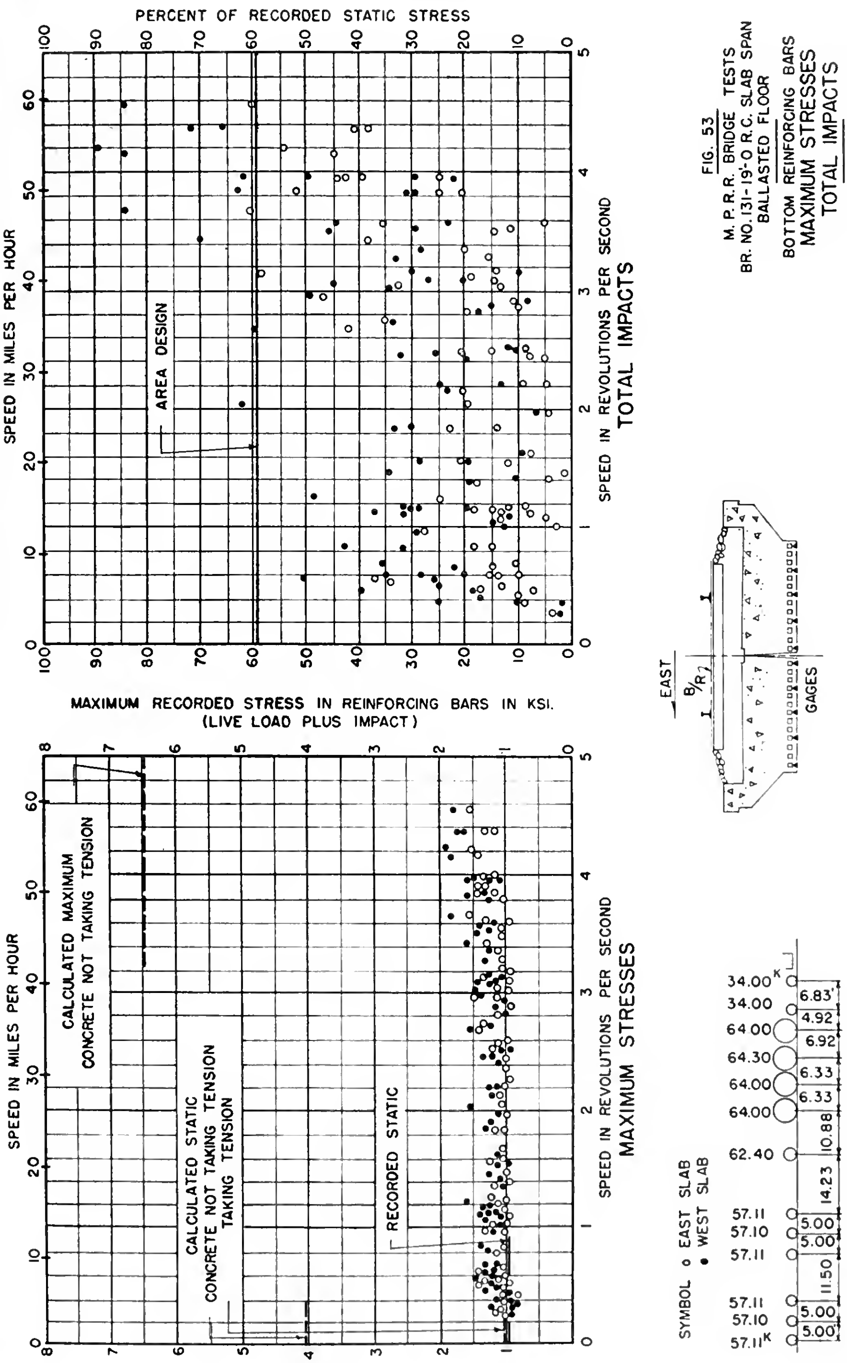


FIG. 53
M. P. R.R. BRIDGE TESTS
BR. NO. 131-19'-0 R.C. SLAB SPAN
BALLASTED FLOOR
BOTTOM REINFORCING BARS
MAXIMUM STRESSES
TOTAL IMPACTS
MOUNTAIN TYPE 4-8-2 (NO 5337)

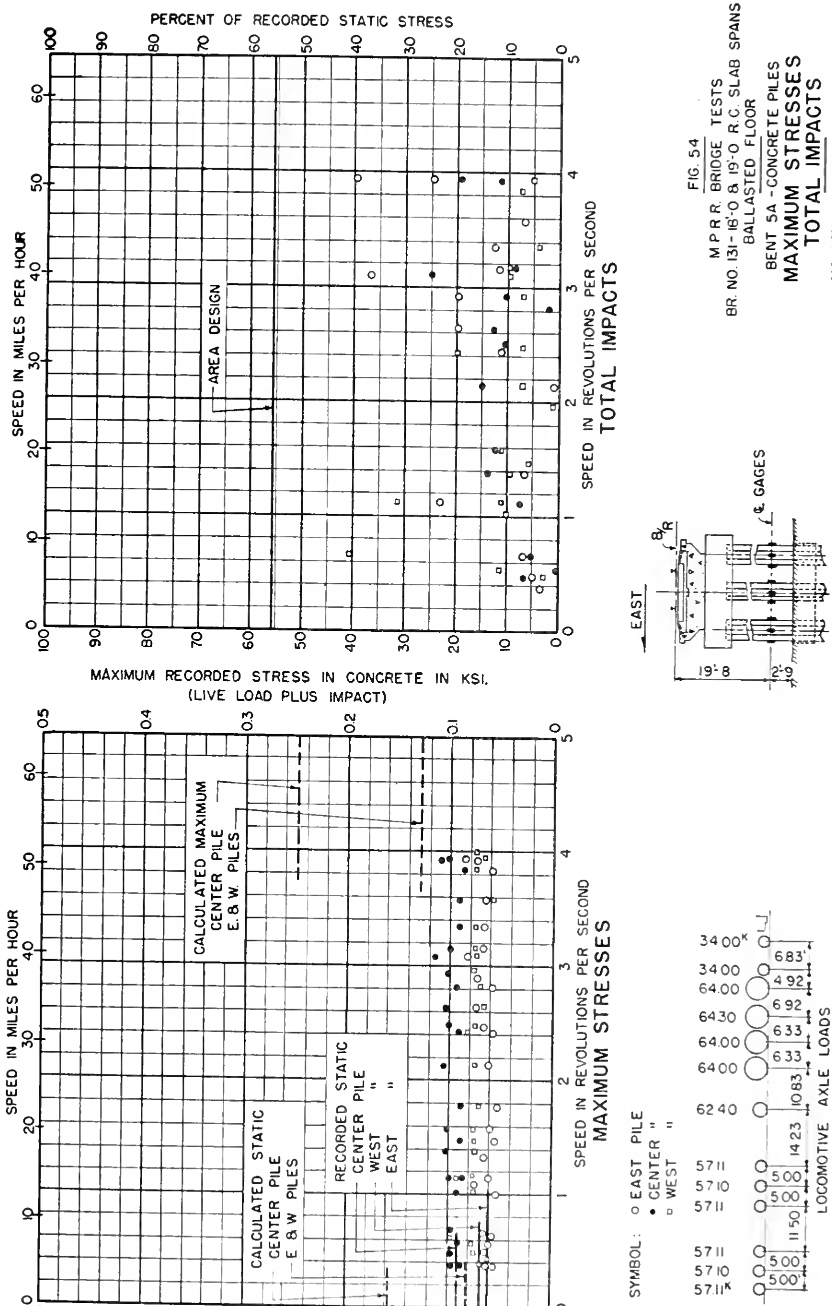


FIG. 54
M P R R. BRIDGE TESTS
BR. NO. 131 - 18'-0 & 19'-0 R.C. SLAB SPANS
BALLASTED FLOOR
BENT 5A - CONCRETE PILES
MAXIMUM STRESSES
TOTAL IMPACTS
MOUNTAIN TYPE 4-8-2 (NO. 5337)

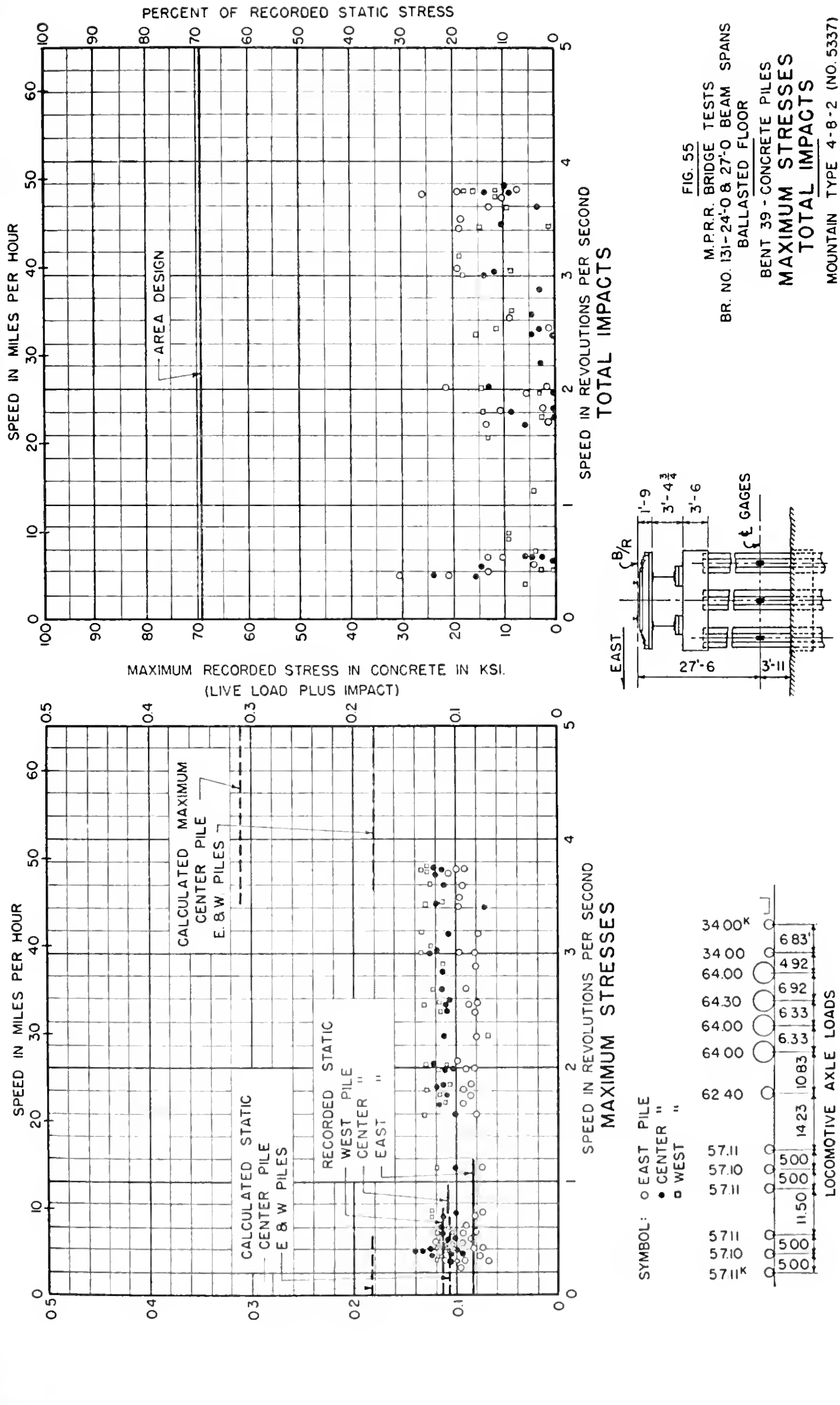


FIG. 55
M.P.R.R. BRIDGE TESTS
BR. NO. 131-24'-0 & 27'-0 BEAM SPANS
BALLASTED FLOOR
BENT 39 - CONCRETE PILES
MAXIMUM STRESSES
TOTAL IMPACTS
MOUNTAIN TYPE 4-8-2 (NO. 5337)

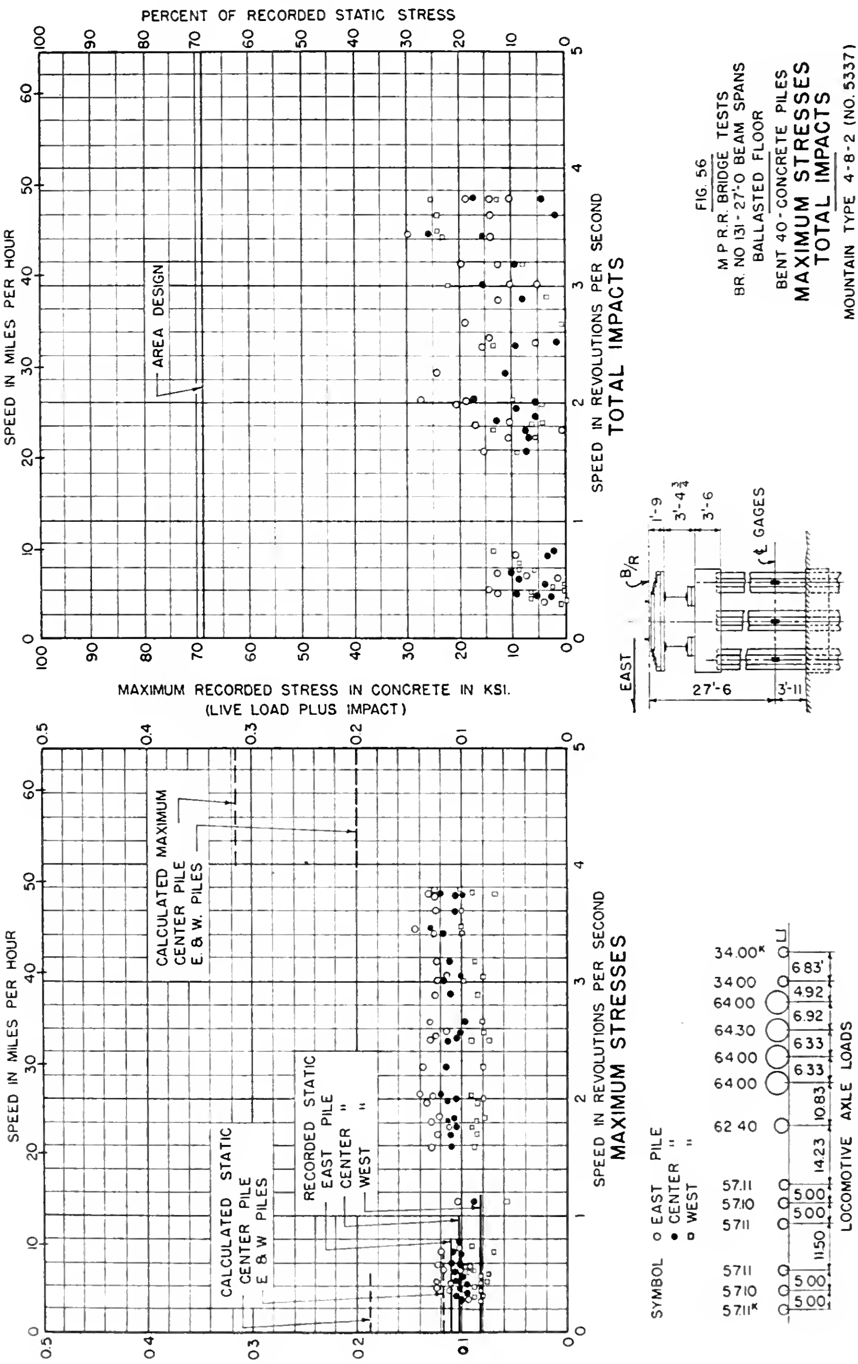


FIG. 56
M P R.R. BRIDGE TESTS
BR. NO 131 - 27'-0 BEAM SPANS
BALLASTED FLOOR
BENT 40 - CONCRETE PILES
MAXIMUM STRESSES
TOTAL IMPACTS
MOUNTAIN TYPE 4-8-2 (NO. 5337)

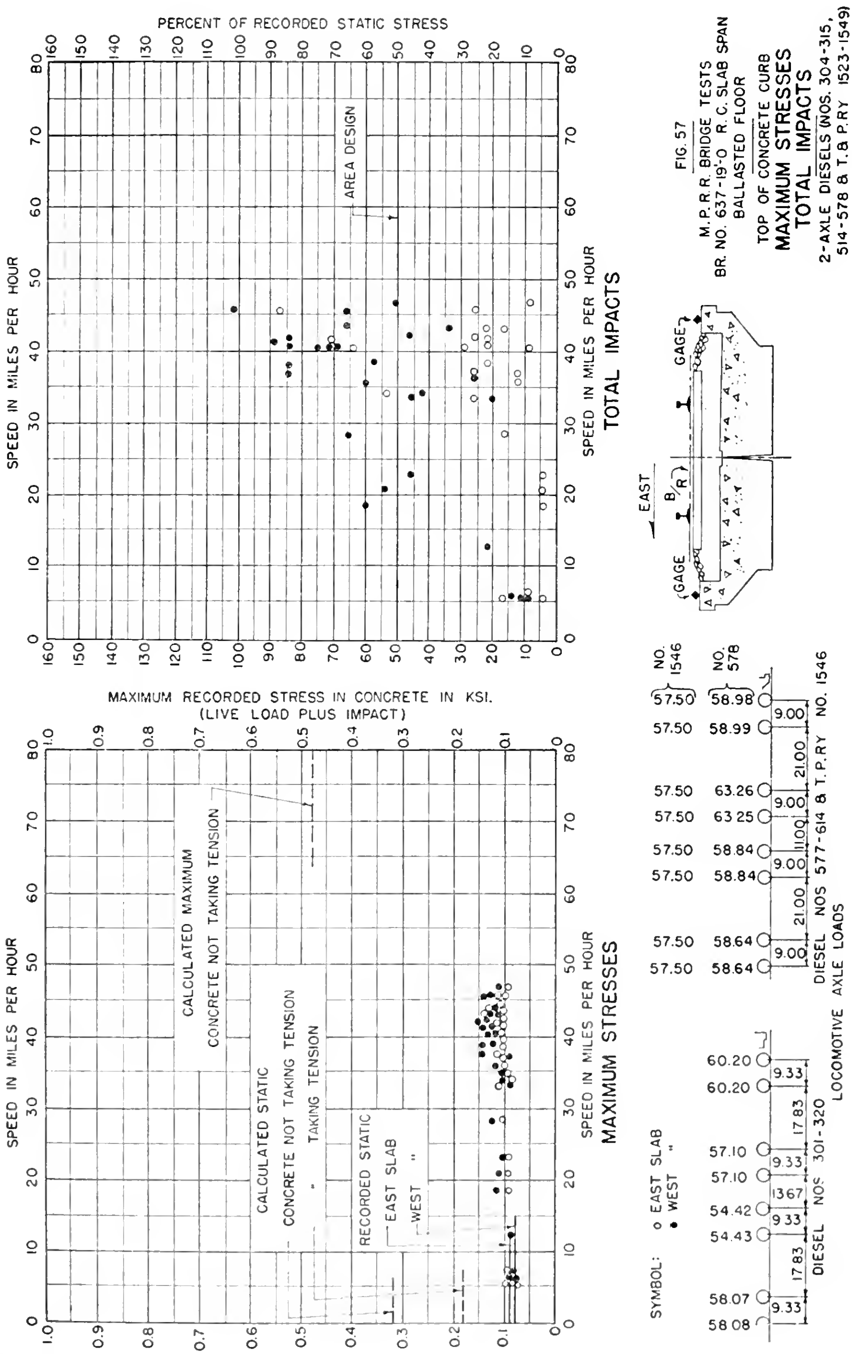


FIG. 57
M.P.R.R. BRIDGE TESTS
BR. NO. 637-19'-0 R.C. SLAB SPAN
BALLASTED FLOOR
TOP OF CONCRETE CURB
MAXIMUM STRESSES
TOTAL IMPACTS
2-AXLE DIESELS (NOS. 304-315, 514-578 & T.& P.RY 1523-1549)

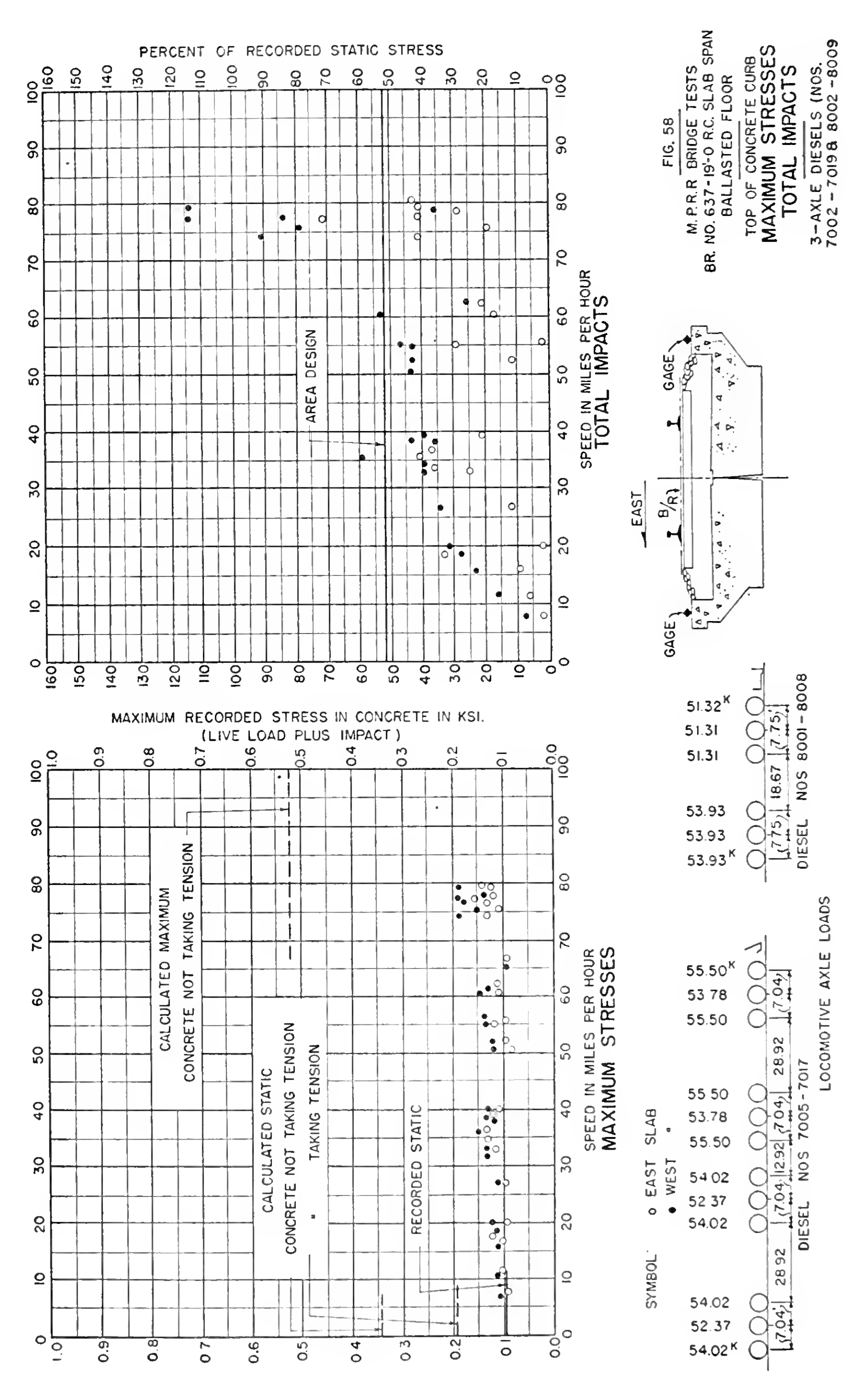


FIG. 58
M.P.R.R. BRIDGE TESTS
BR. NO. 637-19'-0 R.C. SLAB SPAN
BALLASTED FLOOR
TOP OF CONCRETE CURB
MAXIMUM STRESSES
TOTAL IMPACTS
3-AXLE DIESELS (NOS. 7002-7019 & 8002-8009

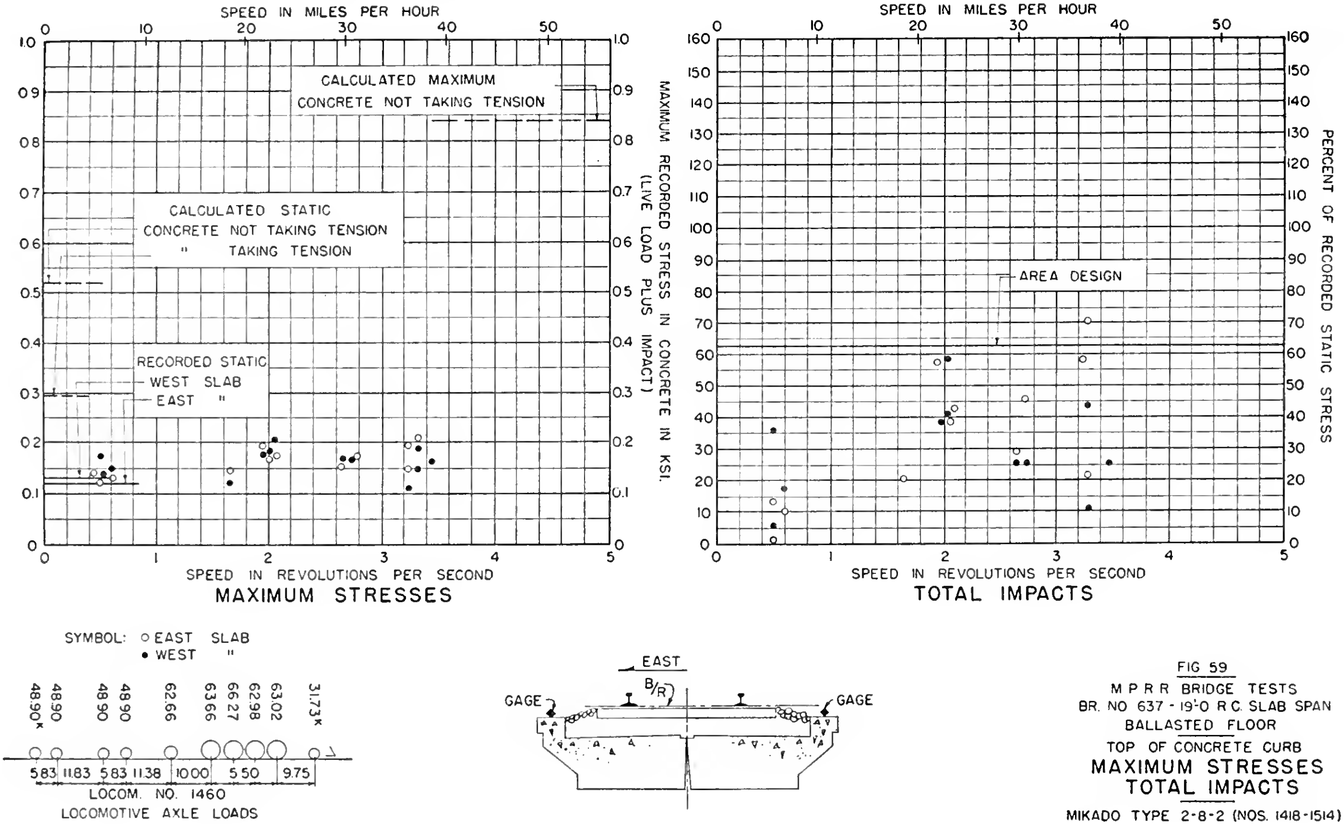


FIG 59
M P R R BRIDGE TESTS
BR. NO 637 - 19'-0 R.C. SLAB SPAN
BALLASTED FLOOR
TOP OF CONCRETE CURB
MAXIMUM STRESSES
TOTAL IMPACTS
MIKADO TYPE 2-8-2 (NOS. 1418-1514)

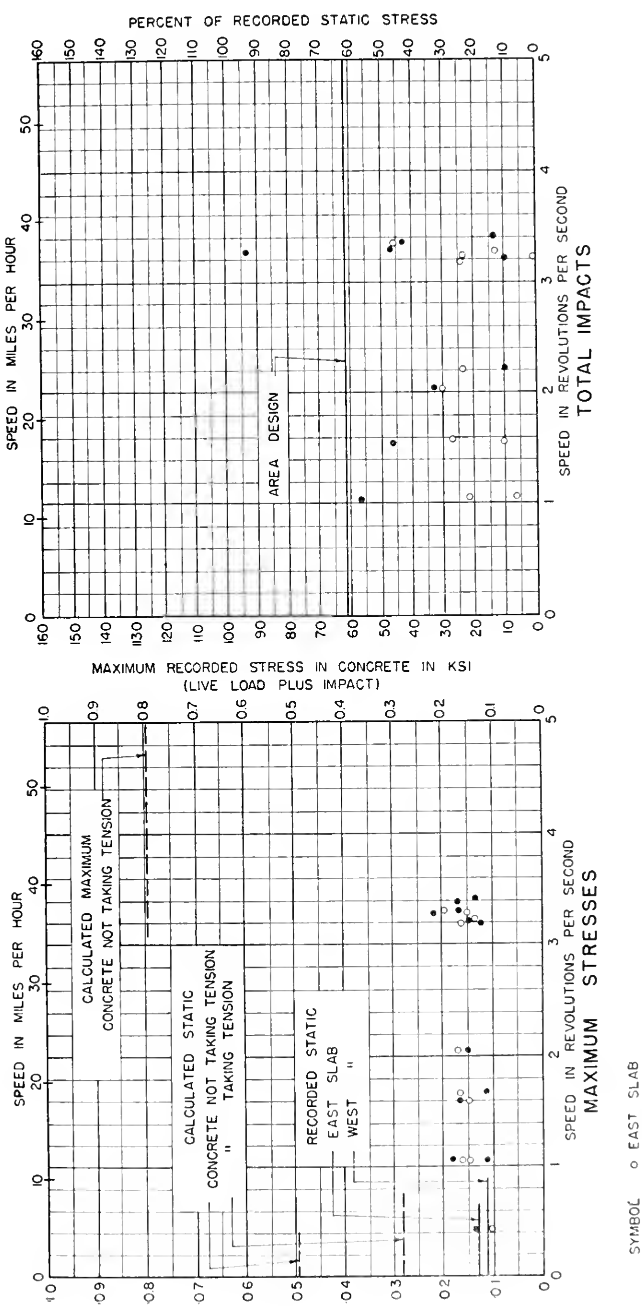


FIG 60
M.P.R.R. BRIDGE TESTS
BR NO 637 - 19'-0 R.C. SLAB SPAN
BALLASTED FLOOR
TOP OF CONCRETE CURB
MAXIMUM STRESSES
TOTAL IMPACTS
MIKADO TYPE 2-8-2 (NOS. 1537-1553)

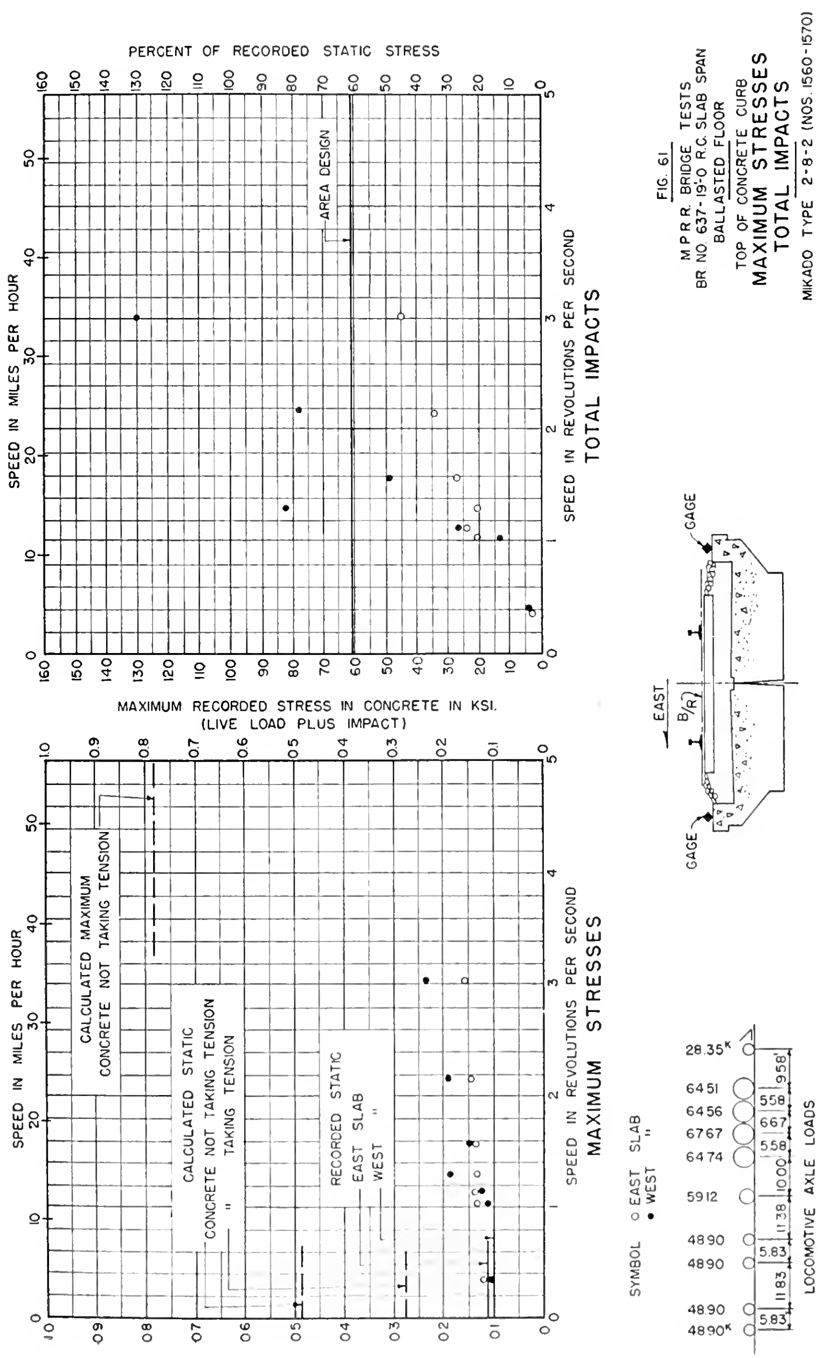


FIG. 61
M P R R. BRIDGE TESTS
BR. NO. 637-19'-0 R.C. SLAB SPAN
BALLASTED FLOOR
TOP OF CONCRETE CURB
MAXIMUM STRESSES
TOTAL IMPACTS
MIKADO TYPE 2-8-2 (NOS. 1560-1570)

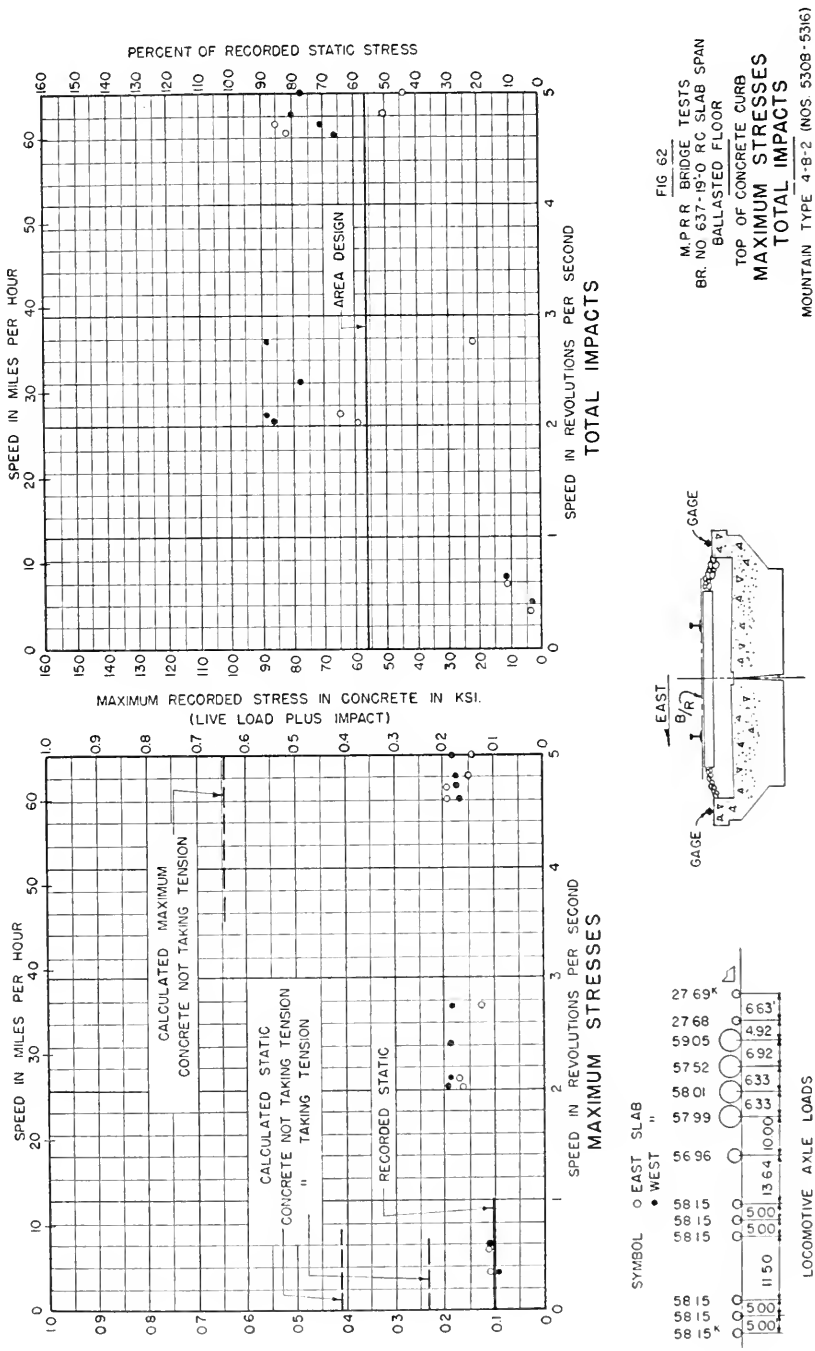


FIG 62
M.P.R.R. BRIDGE TESTS
BR. NO 637-19'-0 RC SLAB SPAN
BALLASTED FLOOR
TOP OF CONCRETE CURB
MAXIMUM STRESSES
TOTAL IMPACTS
MOUNTAIN TYPE 4-8-2 (NOS. 5308-5316)

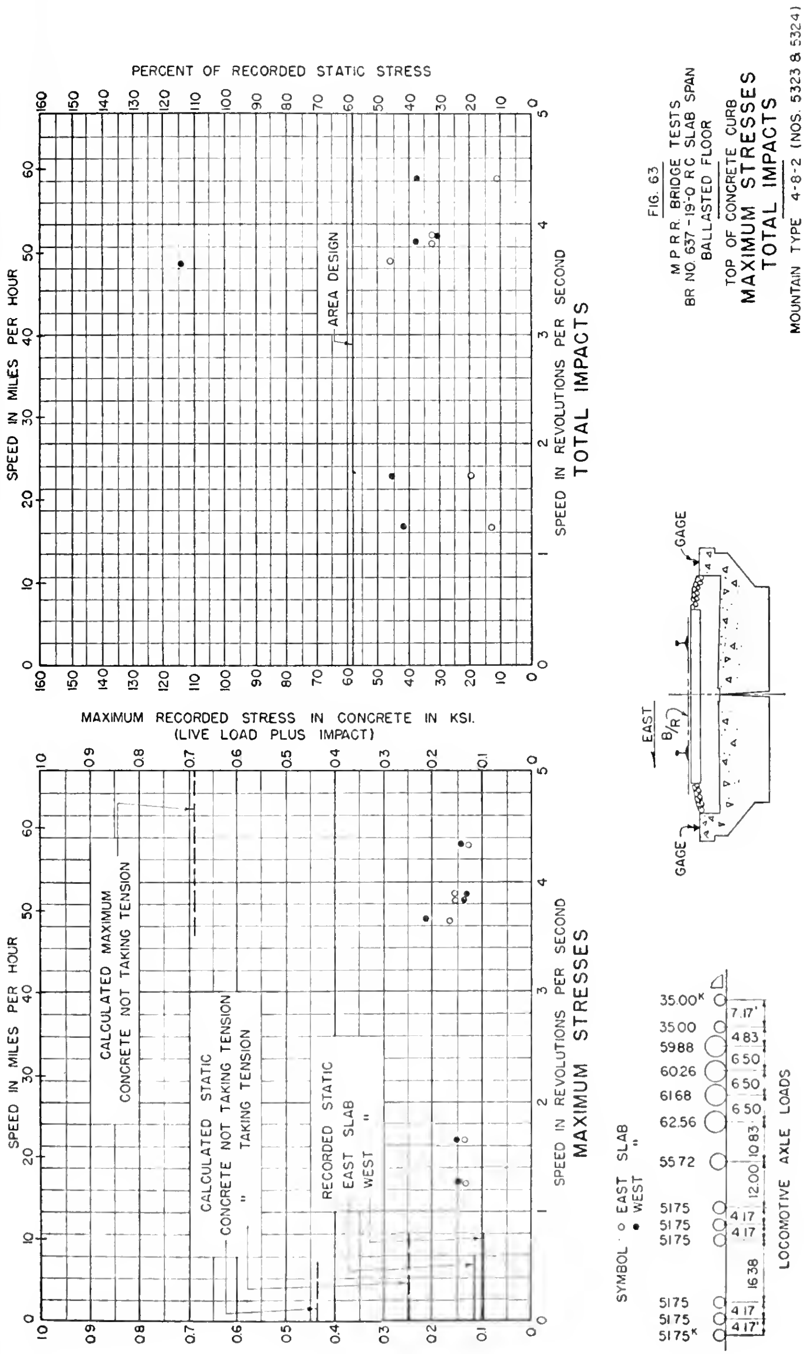


FIG. 63
M P R R. BRIDGE TESTS
BR NO. 637 - 19'-0 R C SLAB SPAN
BALLASTED FLOOR

TOP OF CONCRETE CURB
MAXIMUM STRESSES
TOTAL IMPACTS

MOUNTAIN TYPE 4-8-2 (NOS. 5323 & 5324)

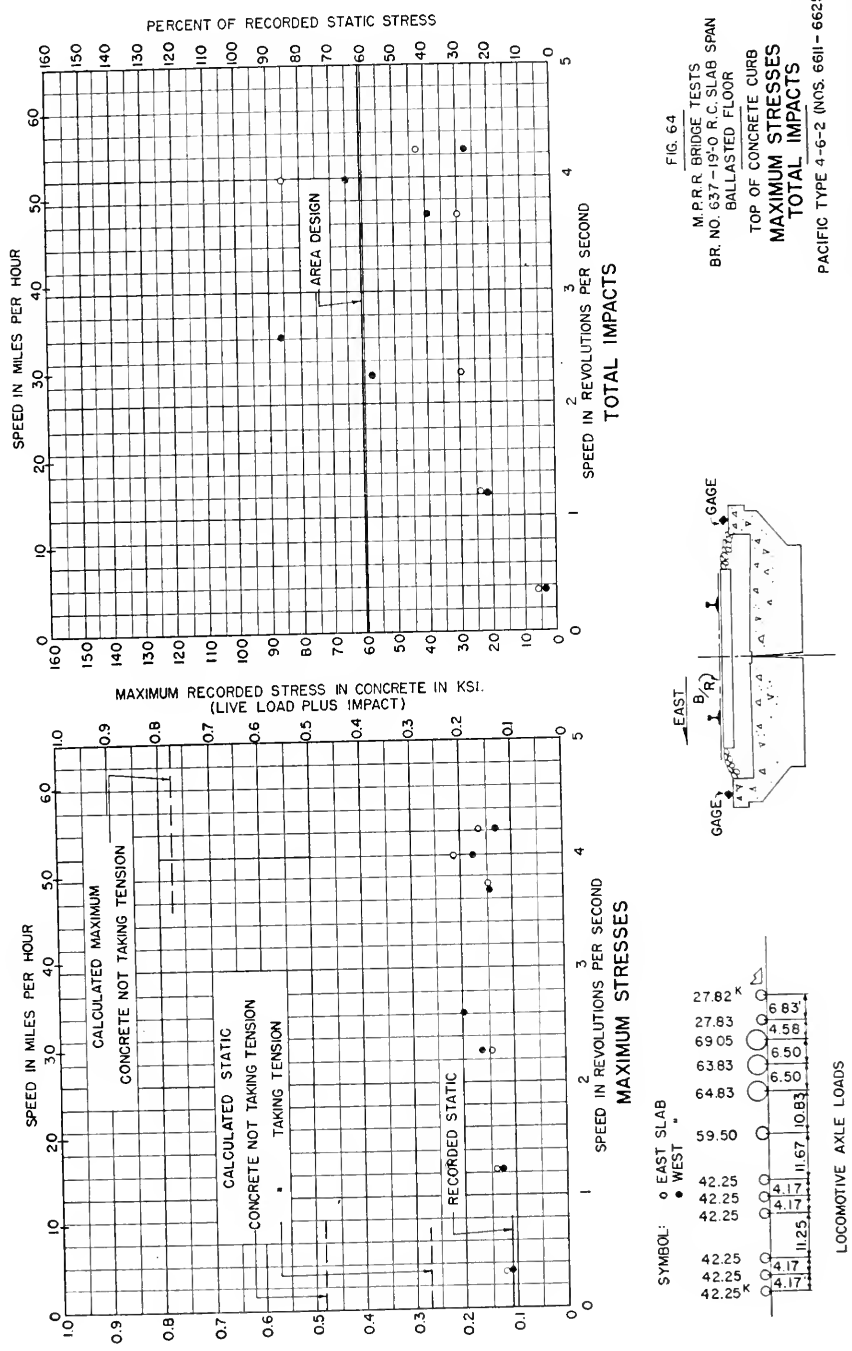


FIG. 64
M.P.R.R. BRIDGE TESTS
BR. NO. 637 – 19'-0 R.C. SLAB SPAN
BALLASTED FLOOR
TOP OF CONCRETE CURB
MAXIMUM STRESSES
TOTAL IMPACTS
PACIFIC TYPE 4-6-2 (NOS. 6611 – 6625)

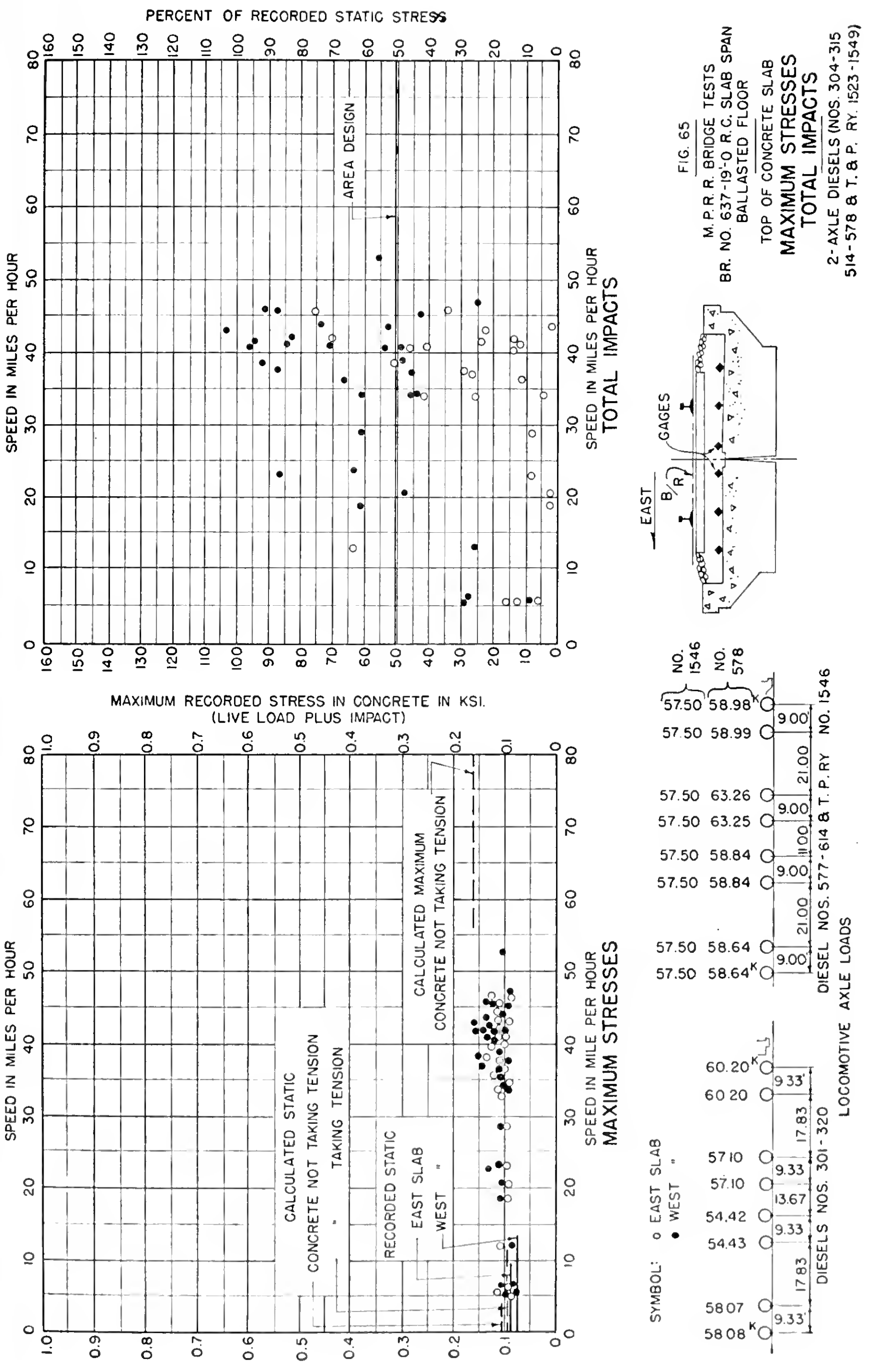


FIG. 65
M.P.R.R. BRIDGE TESTS
BR. NO. 637-19'-0 R.C. SLAB SPAN
BALLASTED FLOOR
TOP OF CONCRETE SLAB
MAXIMUM STRESSES
TOTAL IMPACTS
2-AXLE DIESELS (NOS. 304-315 514-578 & T. & P. RY. 1523-1549)

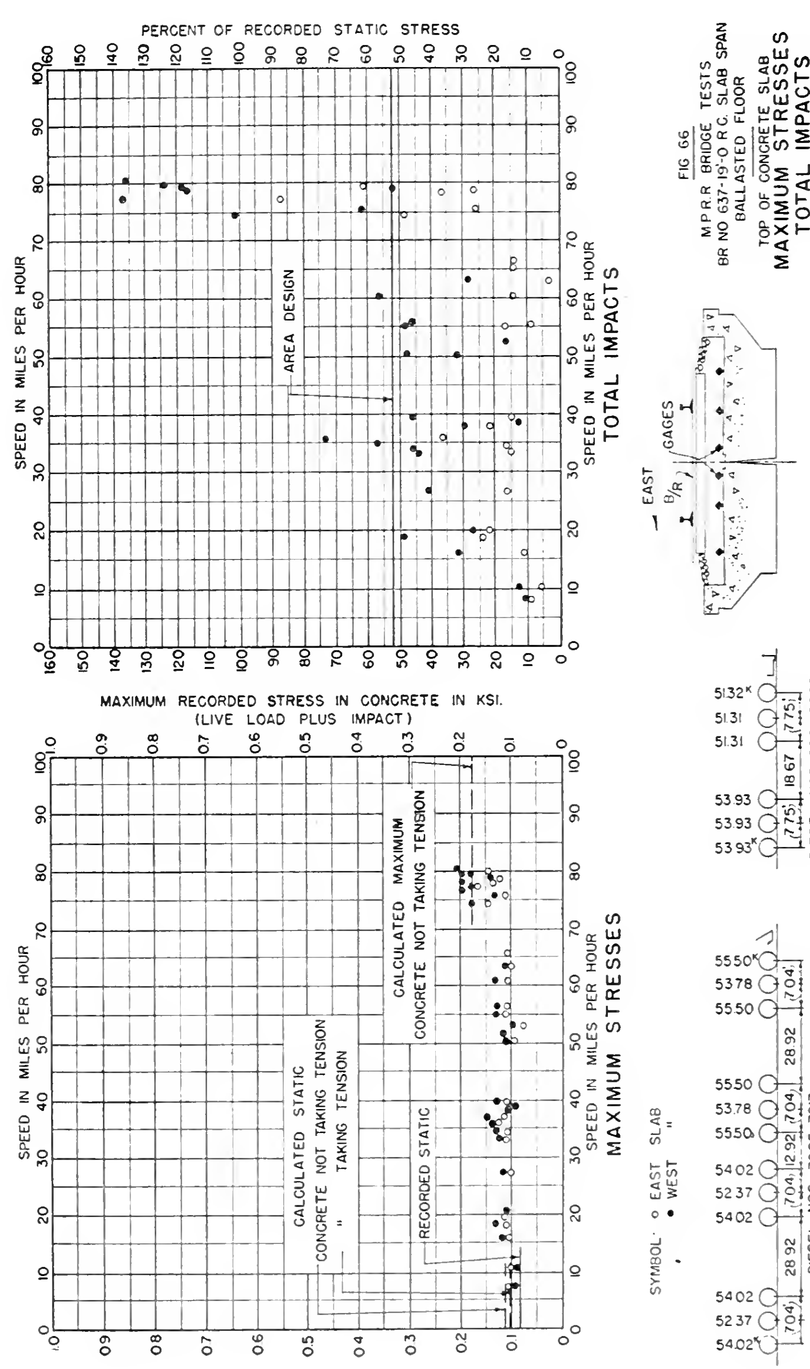


FIG 66
MPRR BRIDGE TESTS
BR NO 637-19'-0 R C SLAB SPAN
BALLASTED FLOOR
TOP OF CONCRETE SLAB
MAXIMUM STRESSES
TOTAL IMPACTS
3-AXLE DIESELS
(NOS. 7002-7019 & 8002-8009)

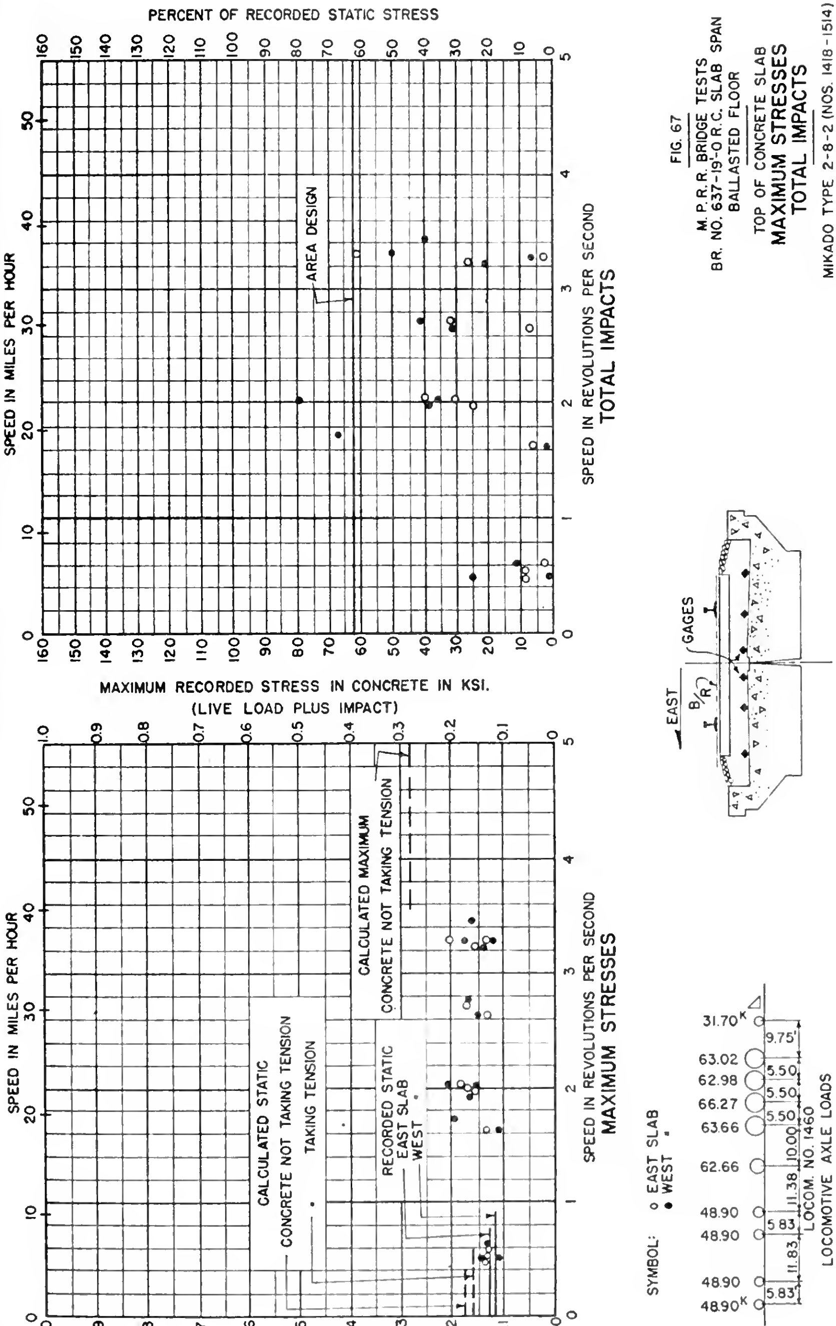
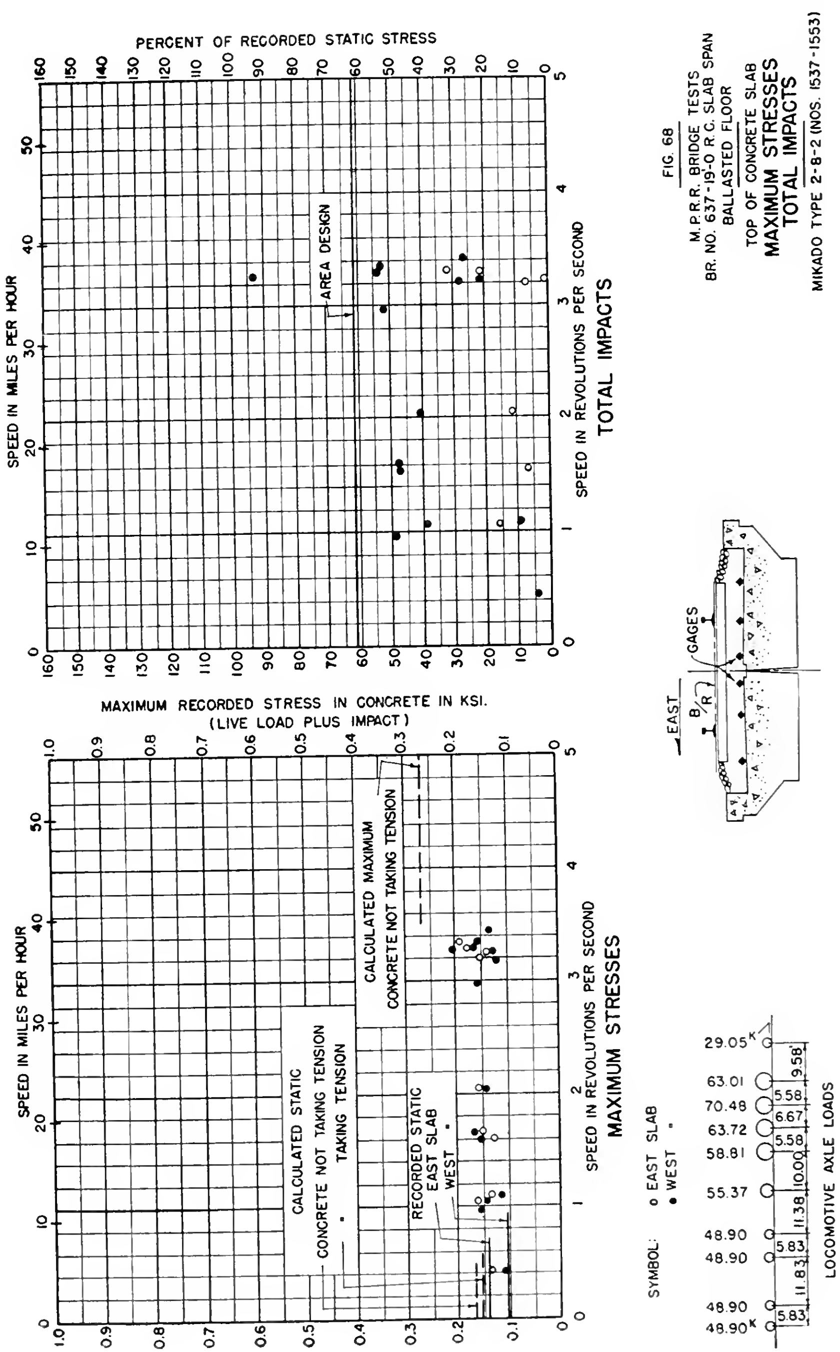


FIG. 67
M. P. R. R. BRIDGE TESTS
BR. NO. 637-19'-0 R.C. SLAB SPAN
BALLASTED FLOOR
TOP OF CONCRETE SLAB
MAXIMUM STRESSES
TOTAL IMPACTS
MIKADO TYPE 2-8-2 (NOS. 1418-1514)


PERCENT OF RECORDED STATIC STRESS
SPEED IN MILES PER HOUR
AREA DESIGN
SPEED IN REVOLUTIONS PER SECOND
TOTAL IMPACTS
MAXIMUM RECORDED STRESS IN CONCRETE IN KSI.
(LIVE LOAD PLUS IMPACT)
CALCULATED MAXIMUM
CONCRETE NOT TAKING TENSION
CALCULATED STATIC
CONCRETE NOT TAKING TENSION
TAKING TENSION
RECORDED STATIC
EAST SLAB
WEST
MAXIMUM STRESSES
SYMBOL: o EAST SLAB
• WEST
GAGES
EAST
B/R
29.05K
63.01
70.48
63.72
58.81
55.37
48.90
48.90
48.90
48.90K
9.58
5.58
6.67
5.58
10.00
11.38
5.83
11.83
5.83
LOCOMOTIVE AXLE LOADS
FIG. 68
M.P.R.R. BRIDGE TESTS
BR. NO. 637-19-0 R.C. SLAB SPAN
BALLASTED FLOOR
TOP OF CONCRETE SLAB
MAXIMUM STRESSES
TOTAL IMPACTS
MIKADO TYPE 2-8-2 (NOS. 1537-1553)

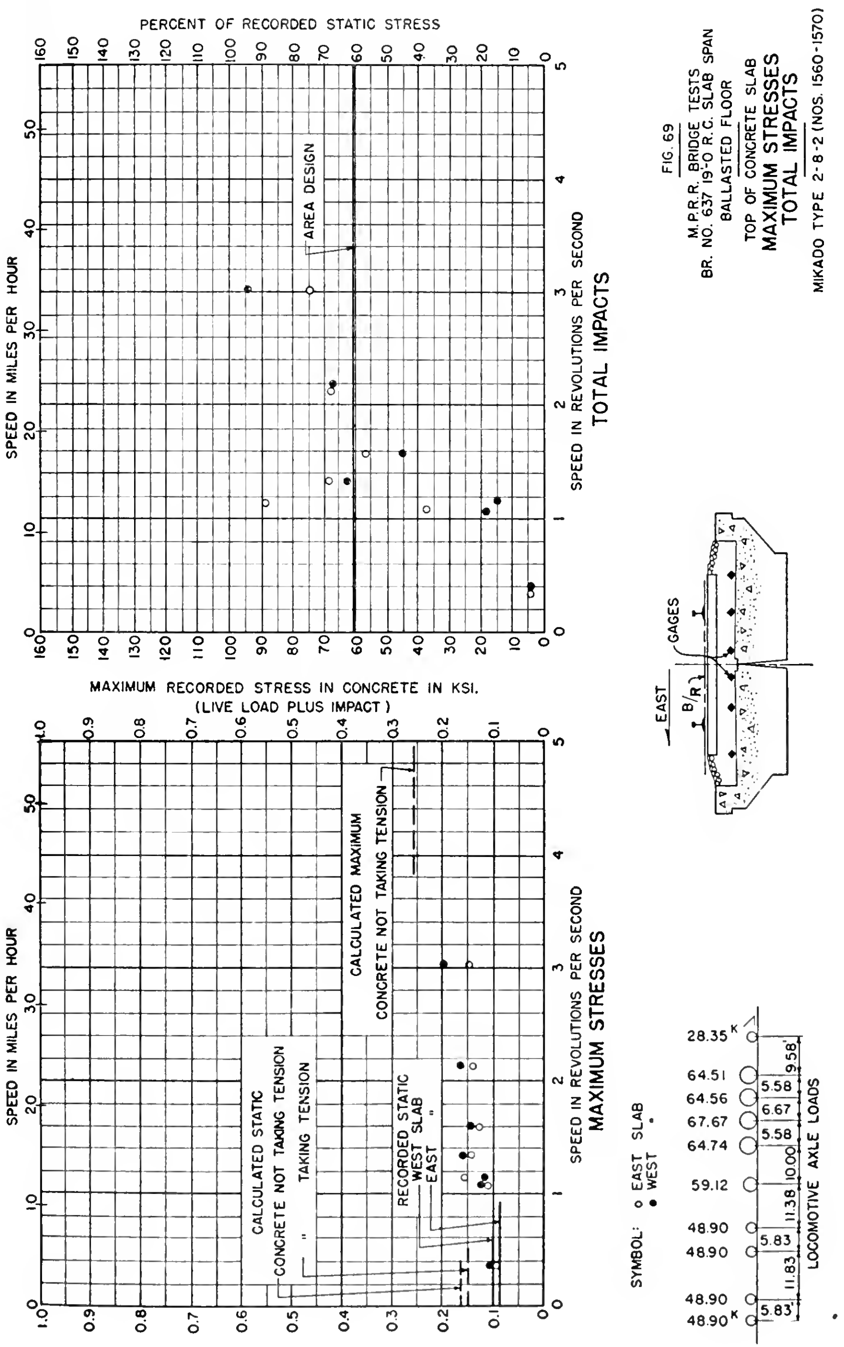


FIG. 69
M.P.R.R. BRIDGE TESTS
BR. NO. 637 19'-0 R.C. SLAB SPAN
BALLASTED FLOOR
TOP OF CONCRETE SLAB
MAXIMUM STRESSES
TOTAL IMPACTS
MIKADO TYPE 2-8-2 (NOS. 1560-1570)

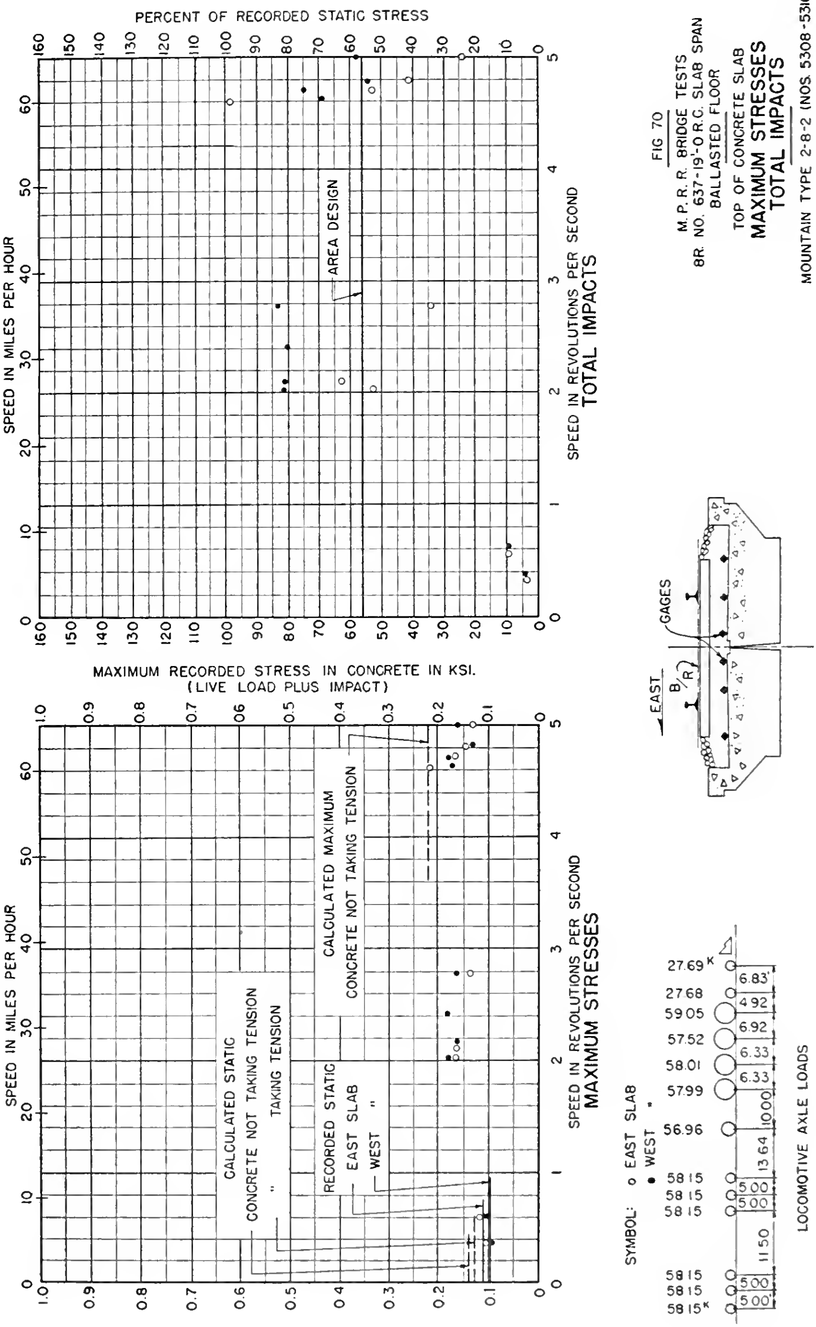


FIG 70
M. P. R. R. BRIDGE TESTS
BR. NO. 637-19'-0 R.C. SLAB SPAN
BALLASTED FLOOR
TOP OF CONCRETE SLAB
MAXIMUM STRESSES
TOTAL IMPACTS
MOUNTAIN TYPE 2-8-2 (NOS. 5308-5316)

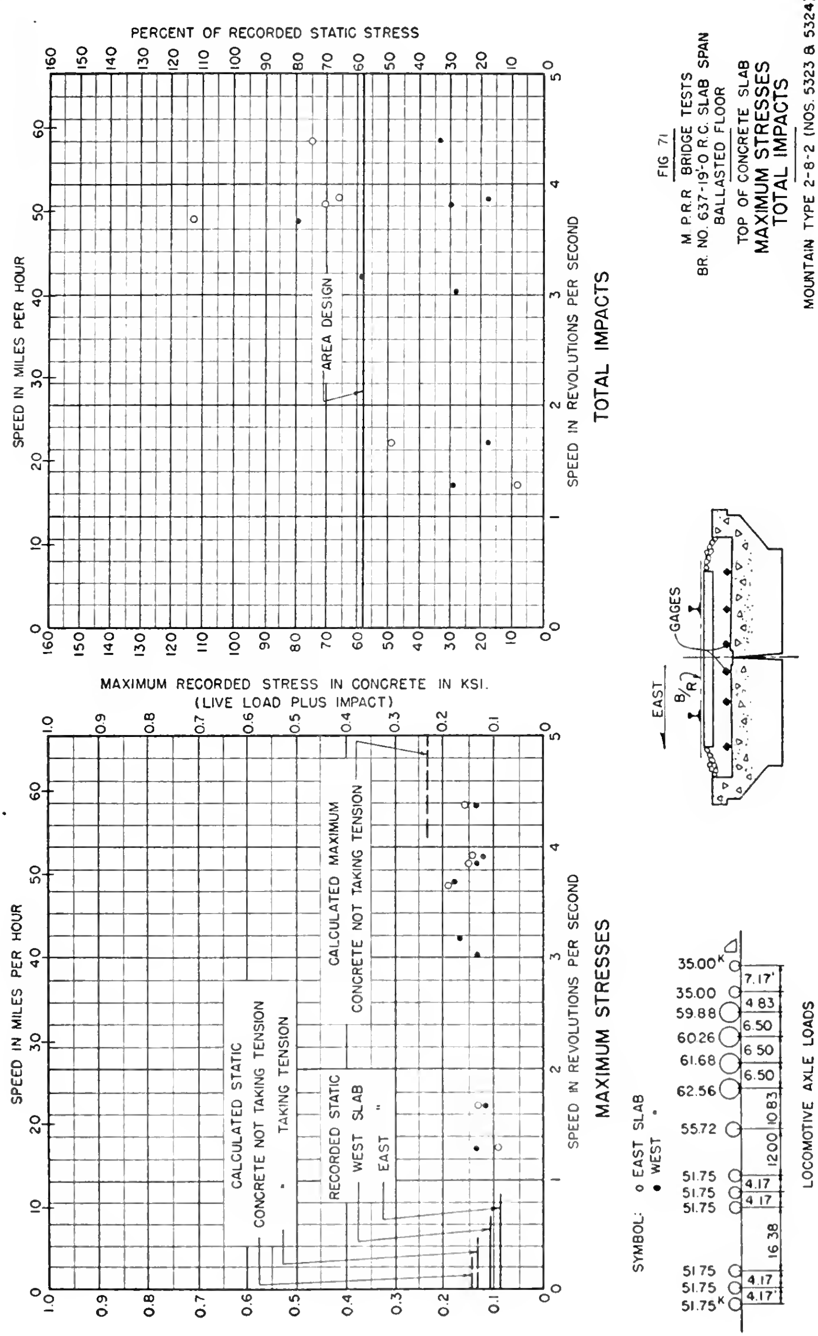


FIG 71
M. P. R. R. BRIDGE TESTS
BR. NO. 637-19'-0 R. C. SLAB SPAN
BALLASTED FLOOR
TOP OF CONCRETE SLAB
MAXIMUM STRESSES
TOTAL IMPACTS
MOUNTAIN TYPE 2-8-2 (NOS. 5323 & 5324)

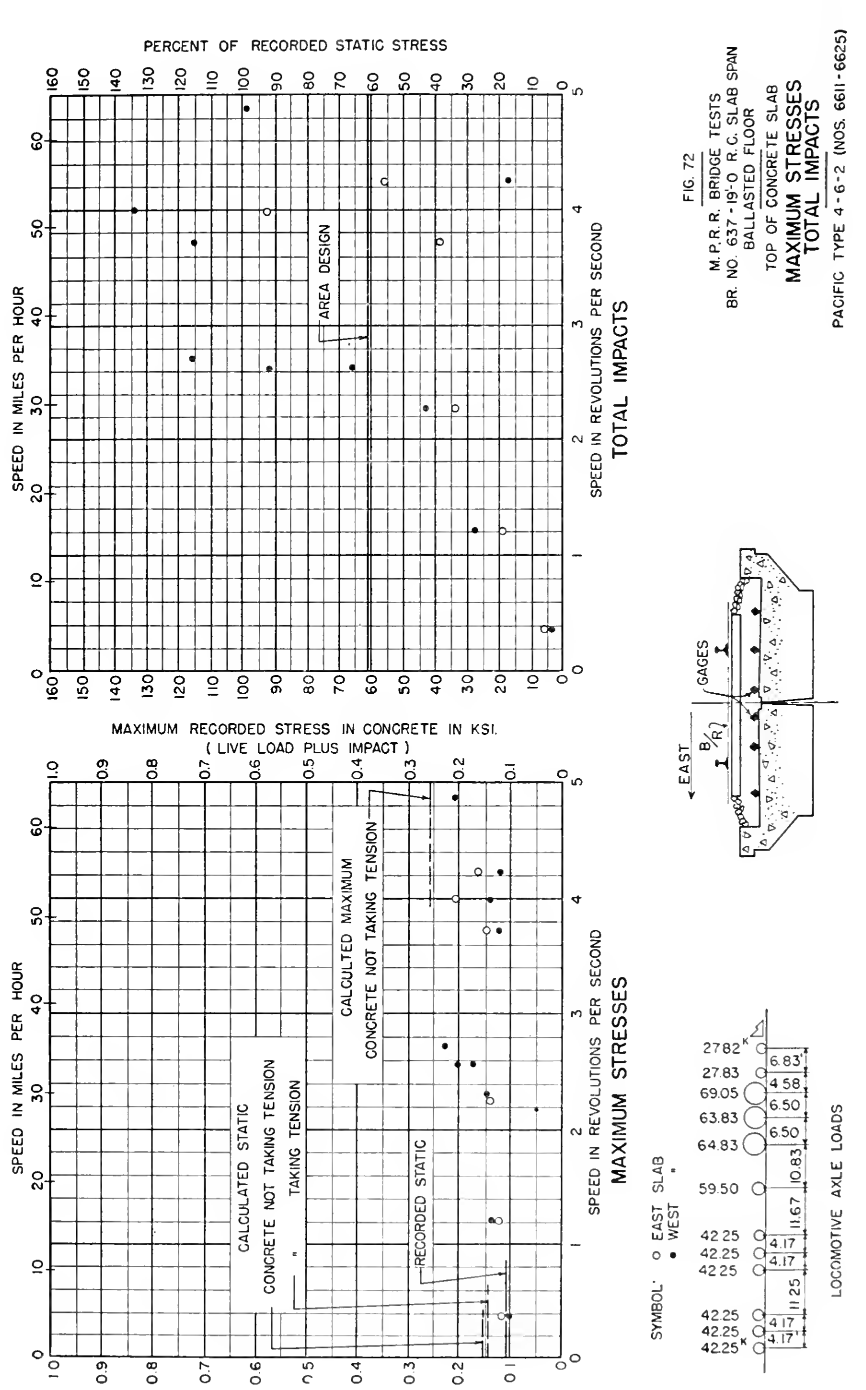


FIG. 72
M.P.R.R. BRIDGE TESTS
BR. NO. 637 - 19'-0 R.C. SLAB SPAN
BALLASTED FLOOR
TOP OF CONCRETE SLAB
MAXIMUM STRESSES
TOTAL IMPACTS
PACIFIC TYPE 4-6-2 (NOS. 6611-6625)

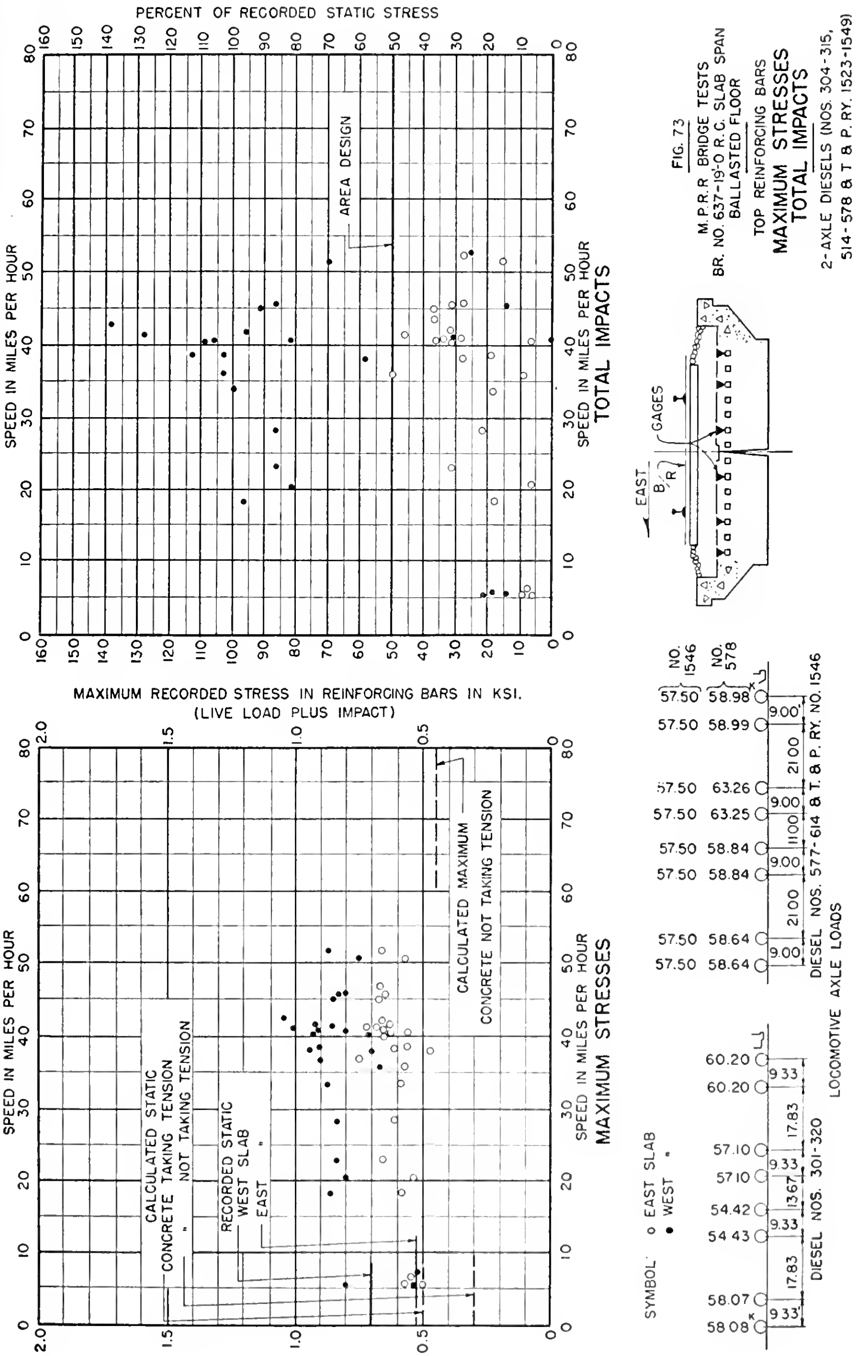


FIG. 73
M.P.R.R. BRIDGE TESTS
BR. NO. 637-19'-0 R.C. SLAB SPAN
BALLASTED FLOOR
TOP REINFORCING BARS
MAXIMUM STRESSES
TOTAL IMPACTS
2-AXLE DIESELS (NOS. 304-315, 514-578 & T & P. RY. 1523-1549)

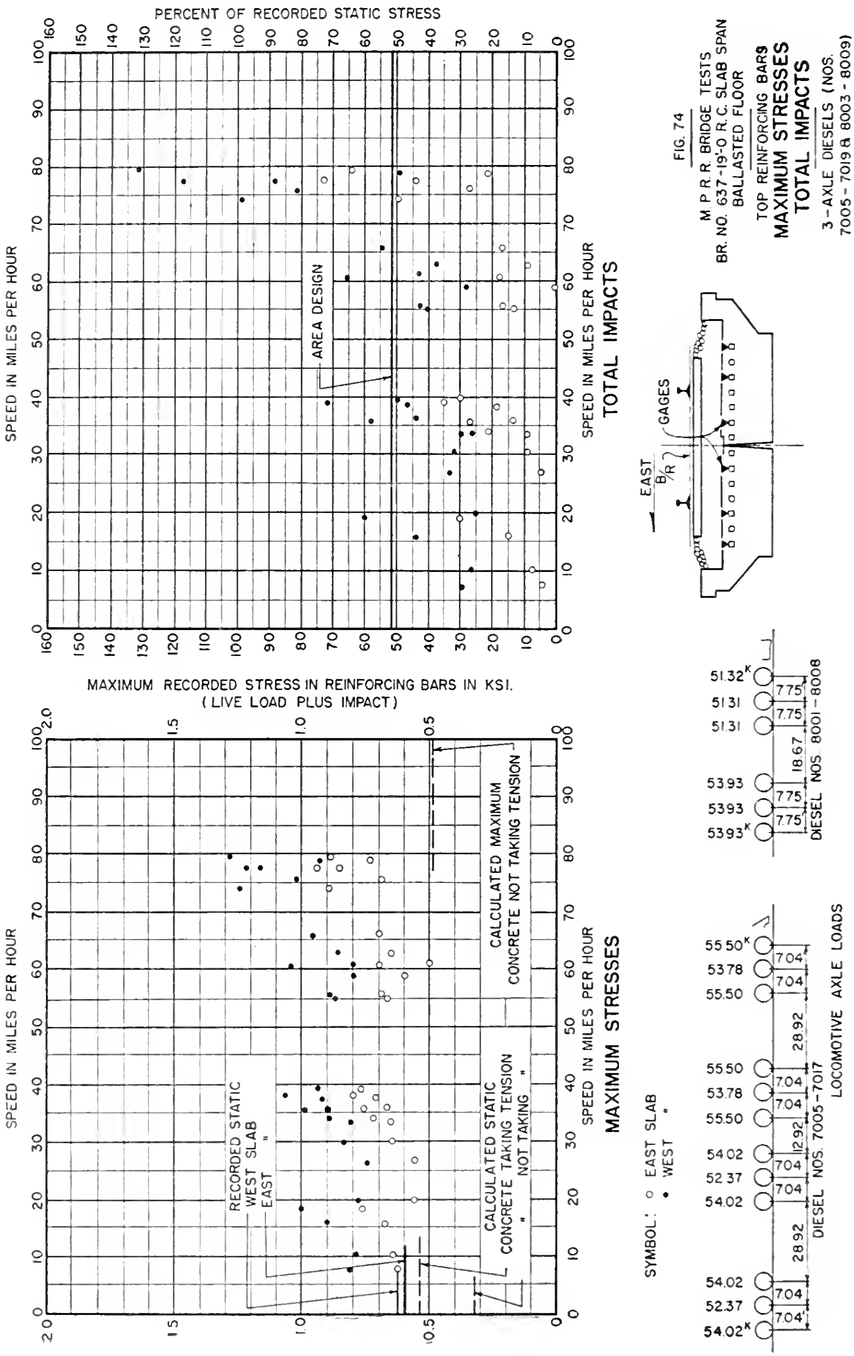


FIG. 74

M. P. R. R. BRIDGE TESTS
BR. NO. 637-19'-0 R.C. SLAB SPAN
BALLASTED FLOOR

TOP REINFORCING BARS
MAXIMUM STRESSES
TOTAL IMPACTS
3-AXLE DIESELS (NOS. 7005-7019 & 8003-8009)

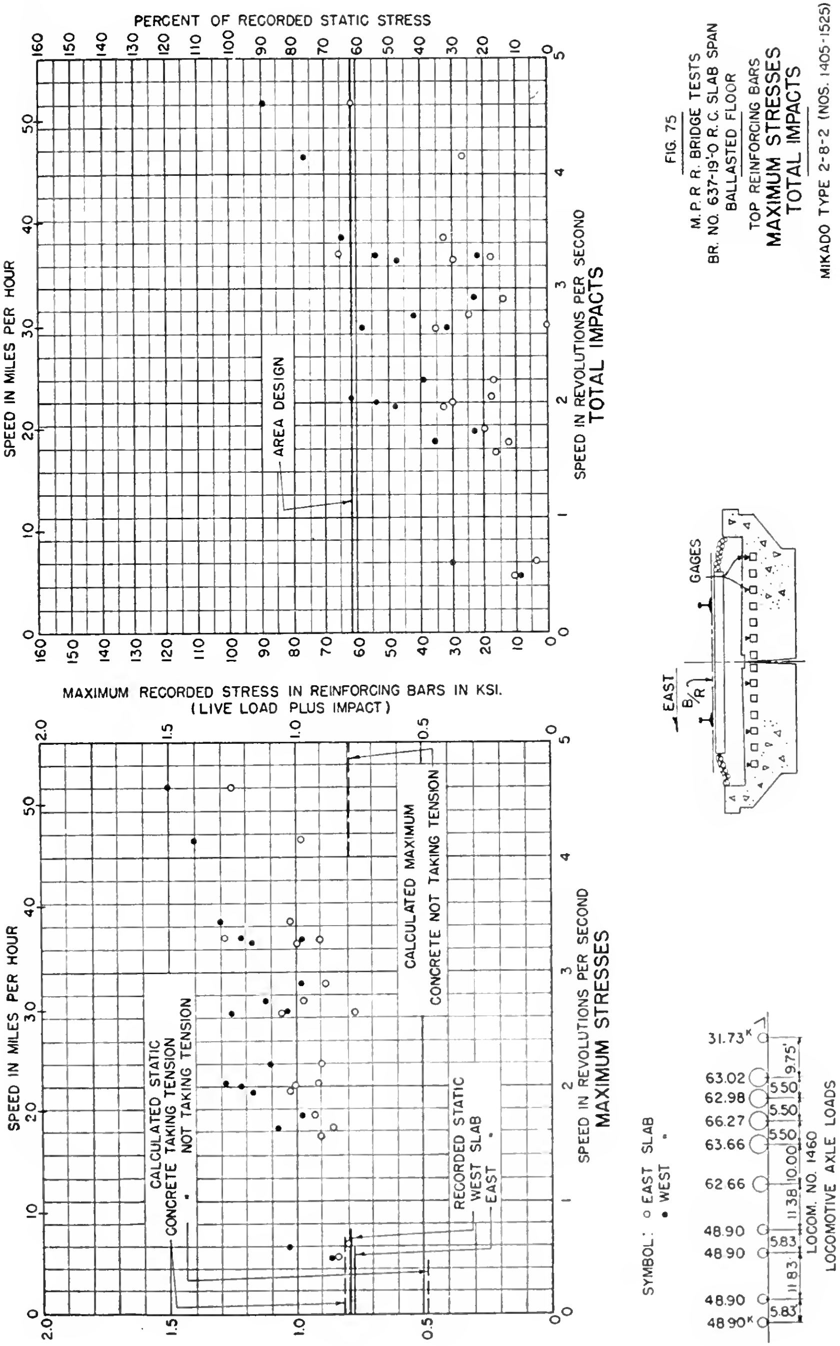


FIG. 75
M. P. R. R. BRIDGE TESTS
BR. NO. 637-19'-0 R. C. SLAB SPAN
BALLASTED FLOOR
TOP REINFORCING BARS
MAXIMUM STRESSES
TOTAL IMPACTS
MIKADO TYPE 2-8-2 (NOS. 1405-1525)

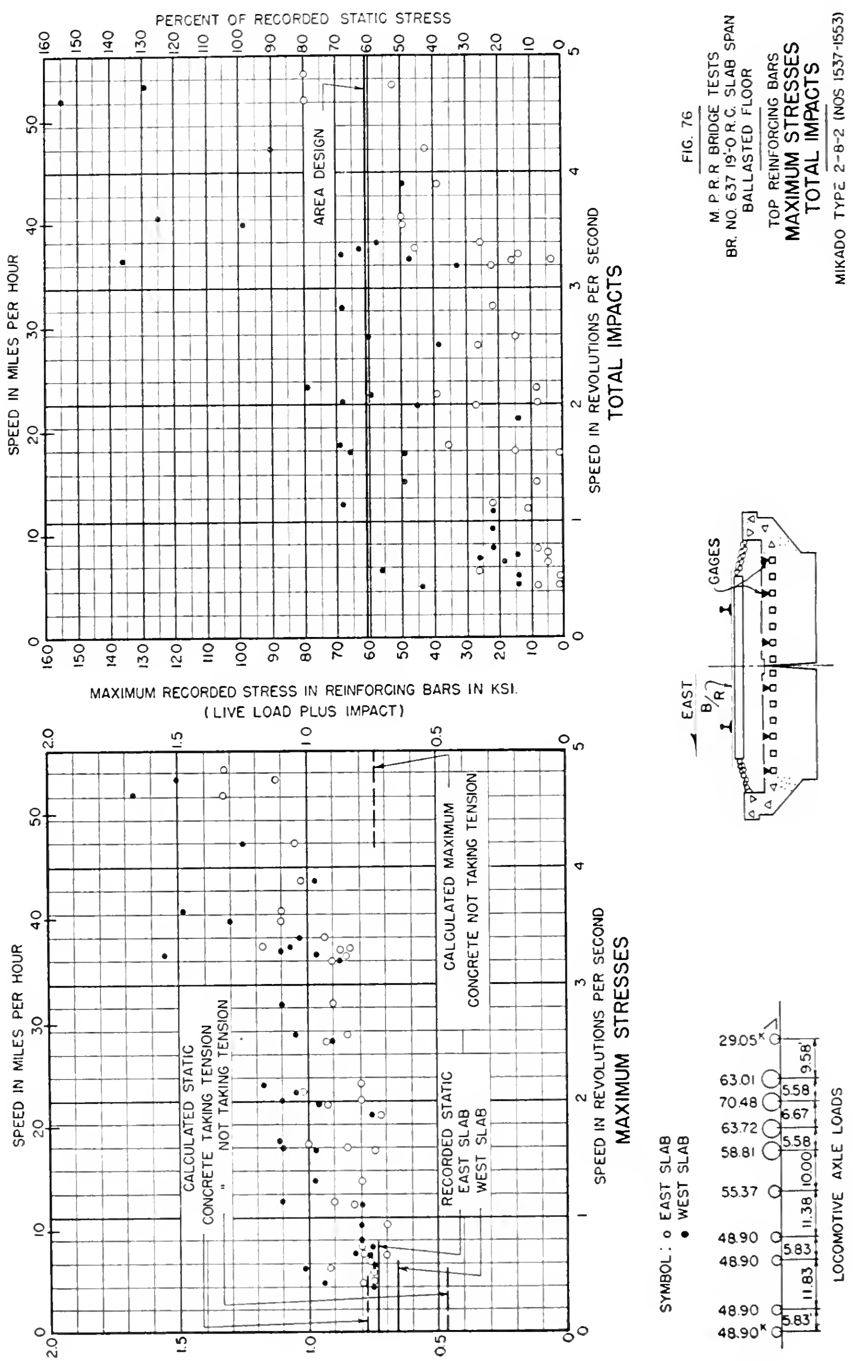


FIG. 76
M. P. R. R. BRIDGE TESTS
BR. NO. 637 19'-0 R. C. SLAB SPAN
BALLASTED FLOOR
TOP REINFORCING BARS
MAXIMUM STRESSES
TOTAL IMPACTS
MIKADO TYPE 2-8-2 (NOS 1537-1553)

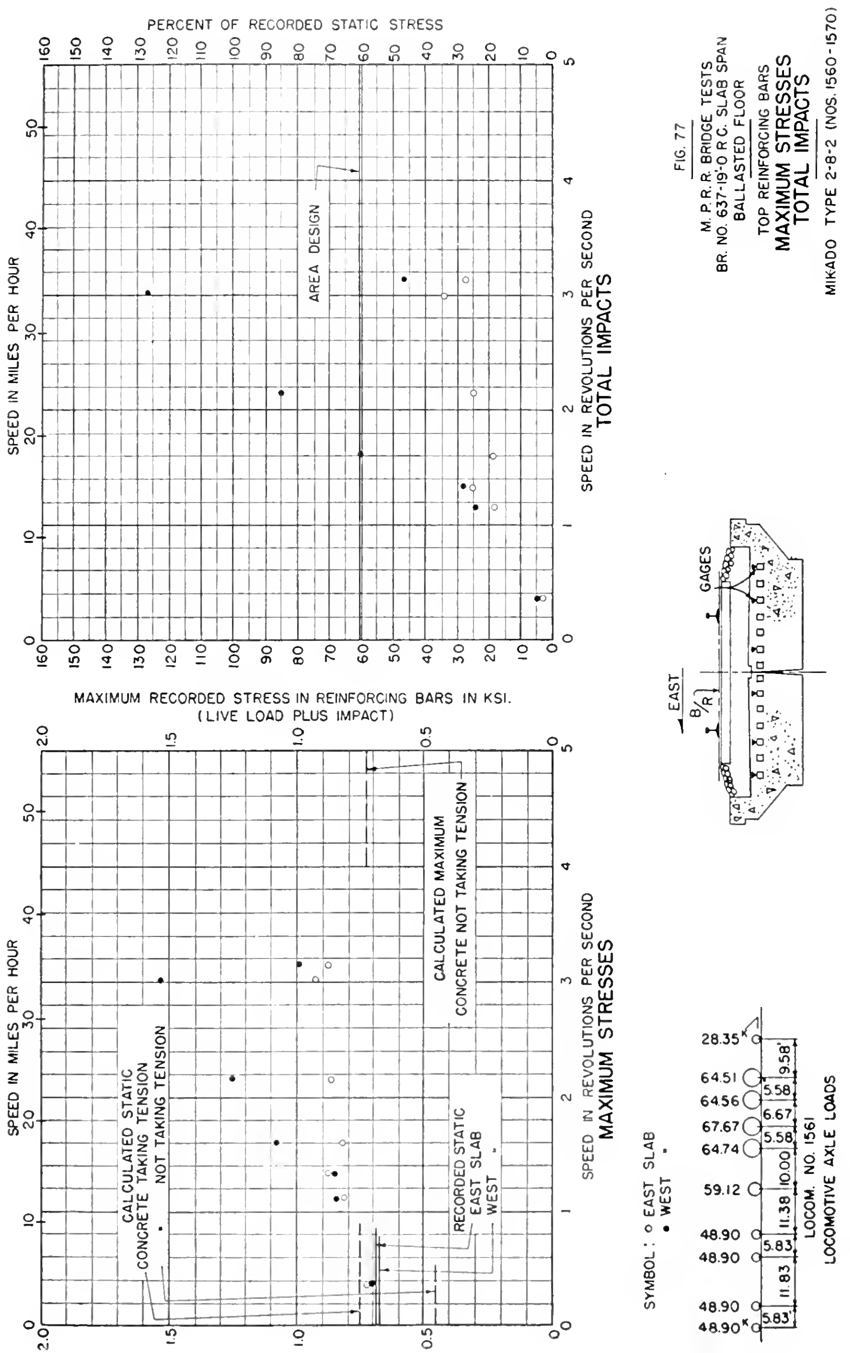


FIG. 77
M. P. R. R. BRIDGE TESTS
BR. NO. 637-19'-0 R.C. SLAB SPAN
BALLASTED FLOOR
TOP REINFORCING BARS
MAXIMUM STRESSES
TOTAL IMPACTS
MIKADO TYPE 2-8-2 (NOS. 1560-1570)

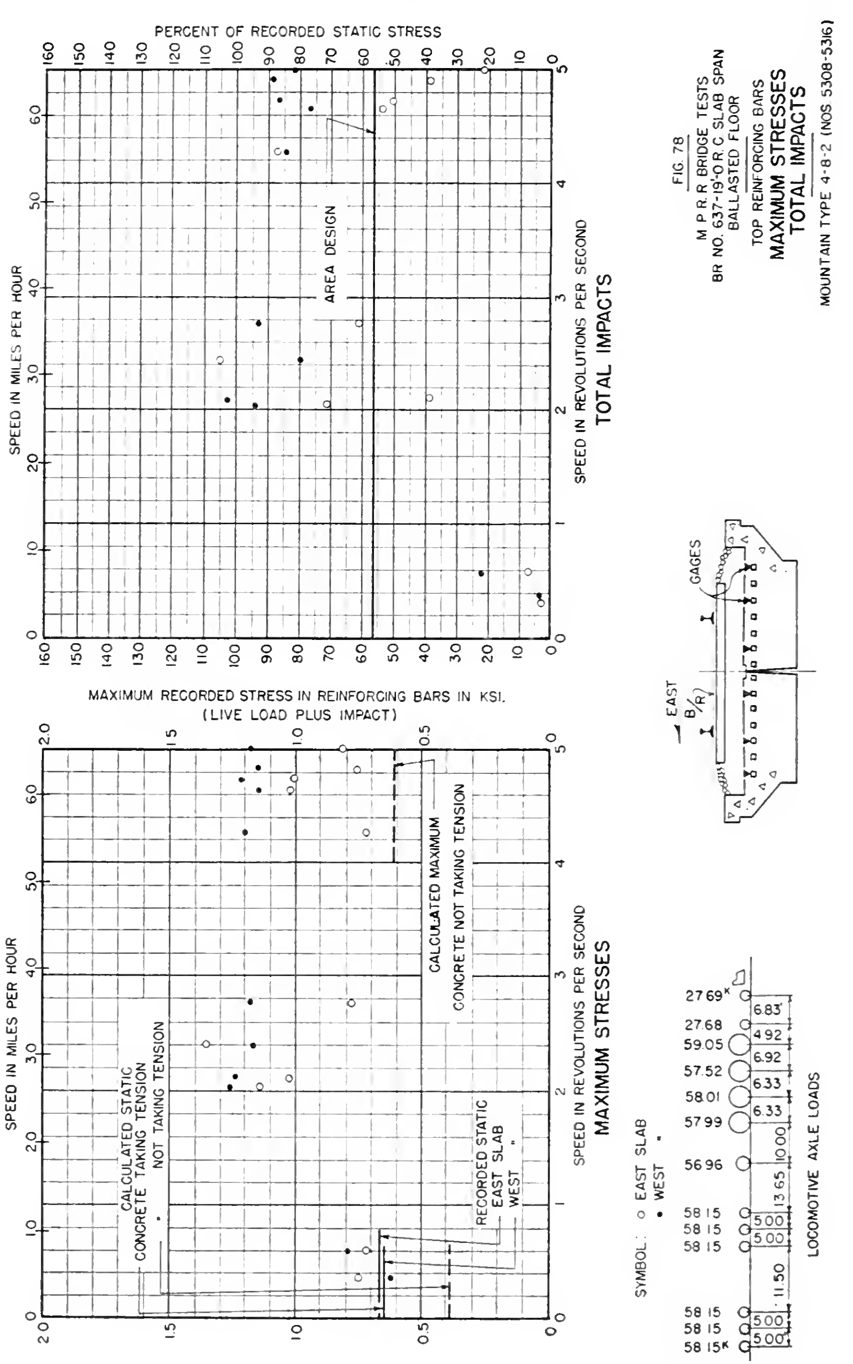
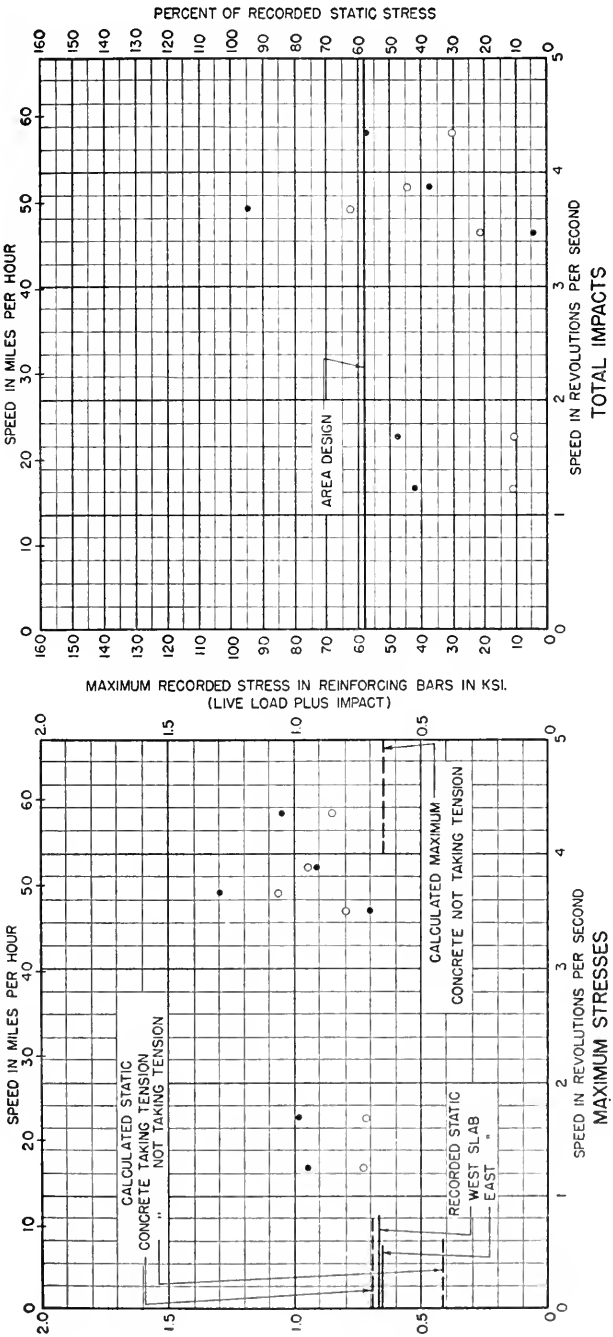


FIG. 78
M P R R BRIDGE TESTS
BR NO. 637-19'-0 R C SLAB SPAN
BALLASTED FLOOR
TOP REINFORCING BARS
MAXIMUM STRESSES
TOTAL IMPACTS
MOUNTAIN TYPE 4-8-2 (NOS 5308-5316)



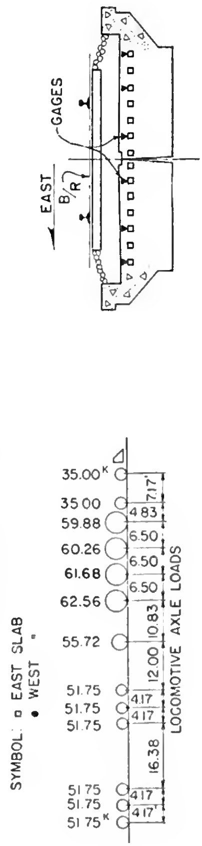


FIG. 79
M.P.R.R. BRIDGE TESTS
BR. NO. 637-19'-0 R.C. SLAB SPAN
BALLASTED FLOOR
TOP REINFORCING BARS
MAXIMUM STRESSES
TOTAL IMPACTS
MOUNTAIN TYPE 4-8-2 (NOS. 5323 & 5324)

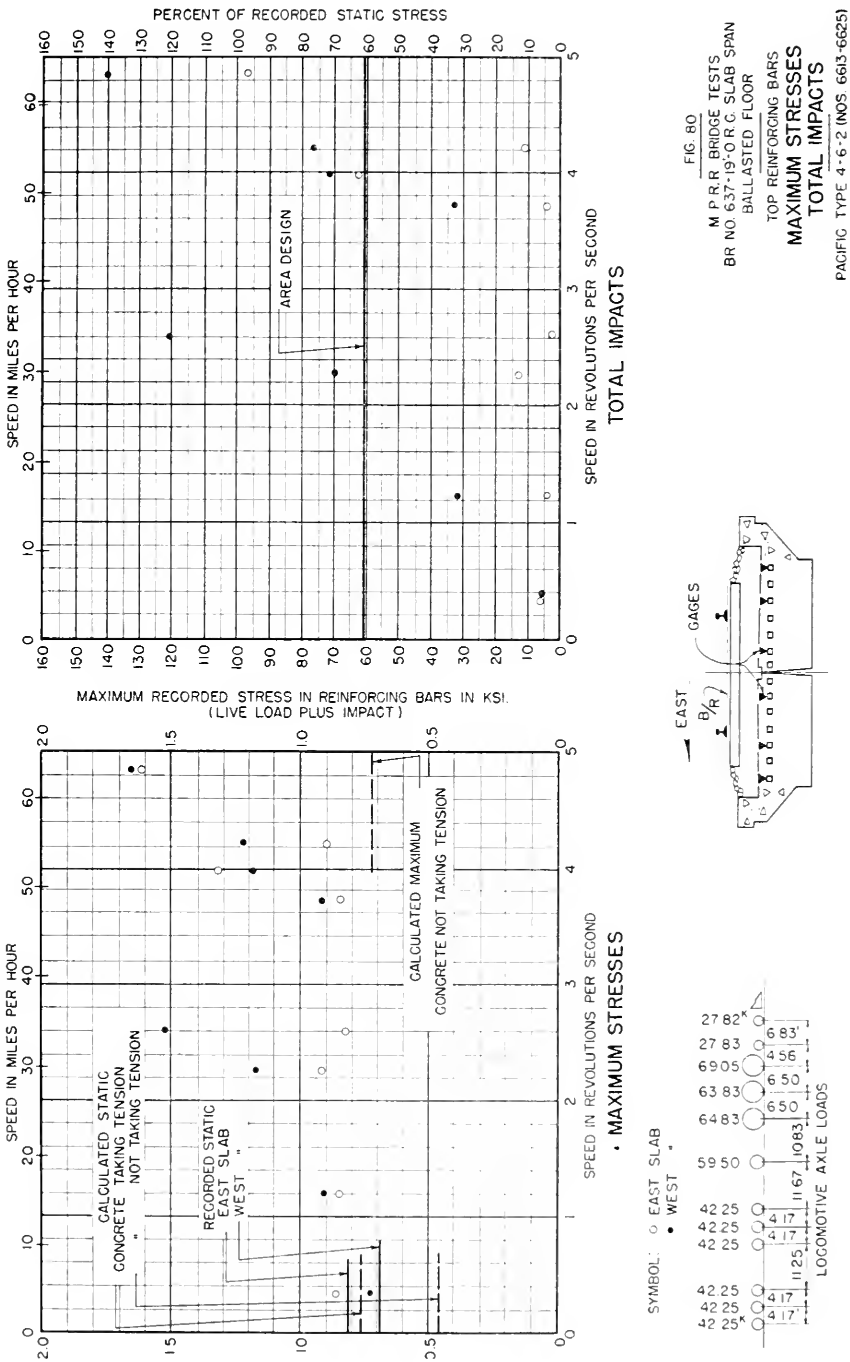


FIG. 80
M. P. R. R. BRIDGE TESTS
BR. NO. 637-19'-0 R. C. SLAB SPAN
BALLASTED FLOOR
TOP REINFORCING BARS
MAXIMUM STRESSES
TOTAL IMPACTS
PACIFIC TYPE 4-6-2 (NOS. 6613-6625)

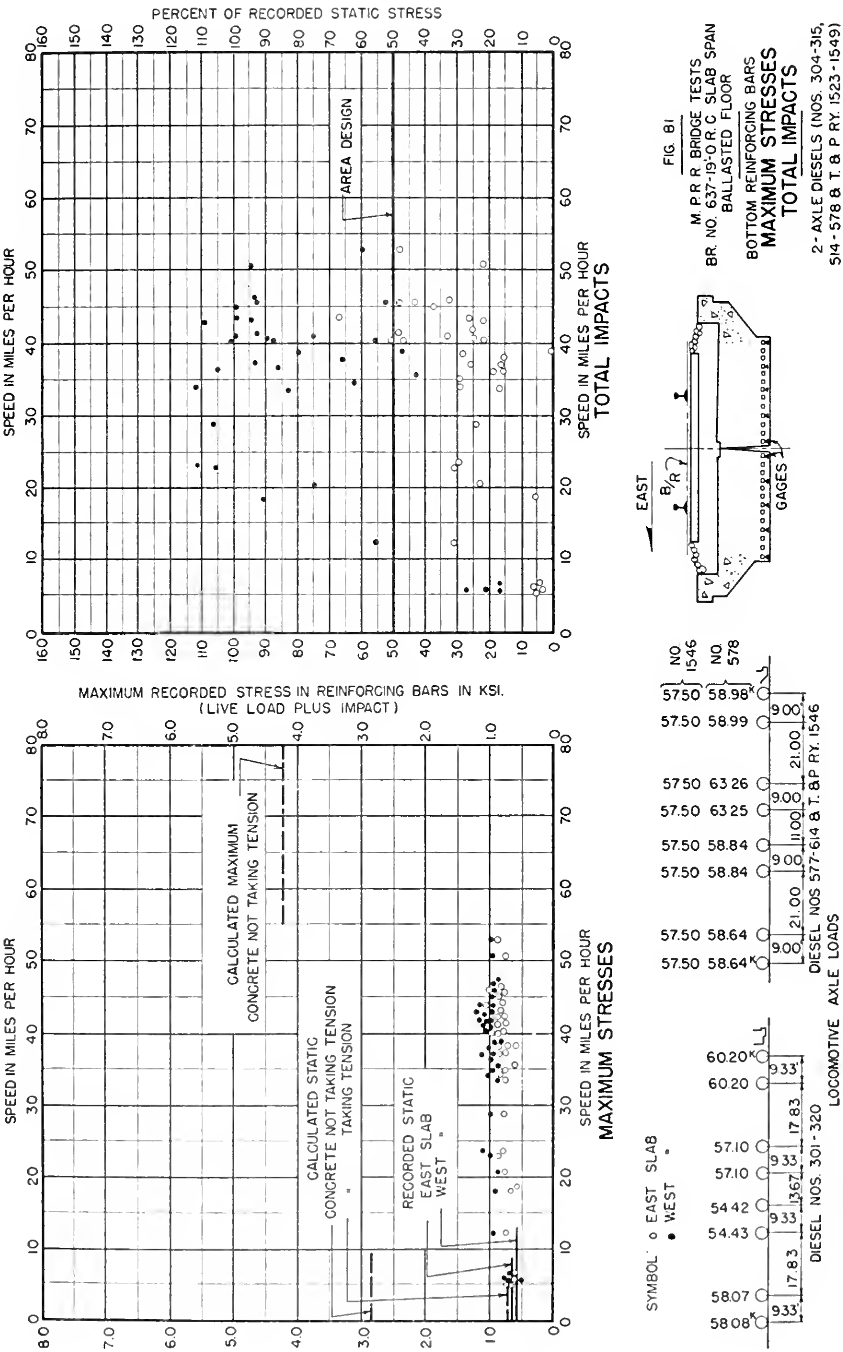


FIG. 81
M. P. R. R. BRIDGE TESTS
BR. NO. 637-19'-0 R. C. SLAB SPAN
BALLASTED FLOOR
BOTTOM REINFORCING BARS
MAXIMUM STRESSES
TOTAL IMPACTS
2-AXLE DIESELS (NOS. 304-315, 514-578 & T. & P RY. 1523-1549)

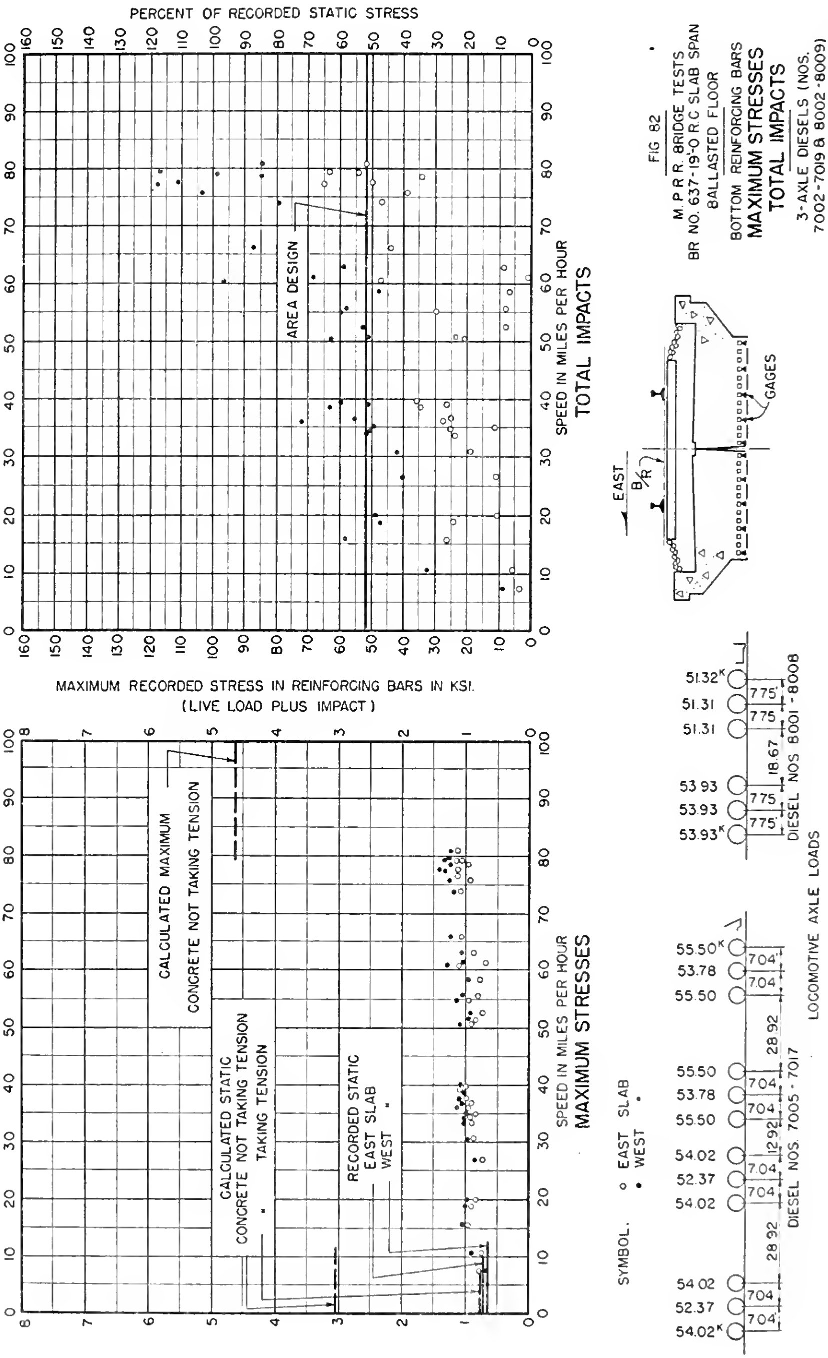


FIG 82
M.P.R.R. BRIDGE TESTS
BR NO. 637 - 19'-0 R.C SLAB SPAN
BALLASTED FLOOR
BOTTOM REINFORCING BARS
MAXIMUM STRESSES
TOTAL IMPACTS
3-AXLE DIESELS (NOS. 7002-7019 & 8002-8009)

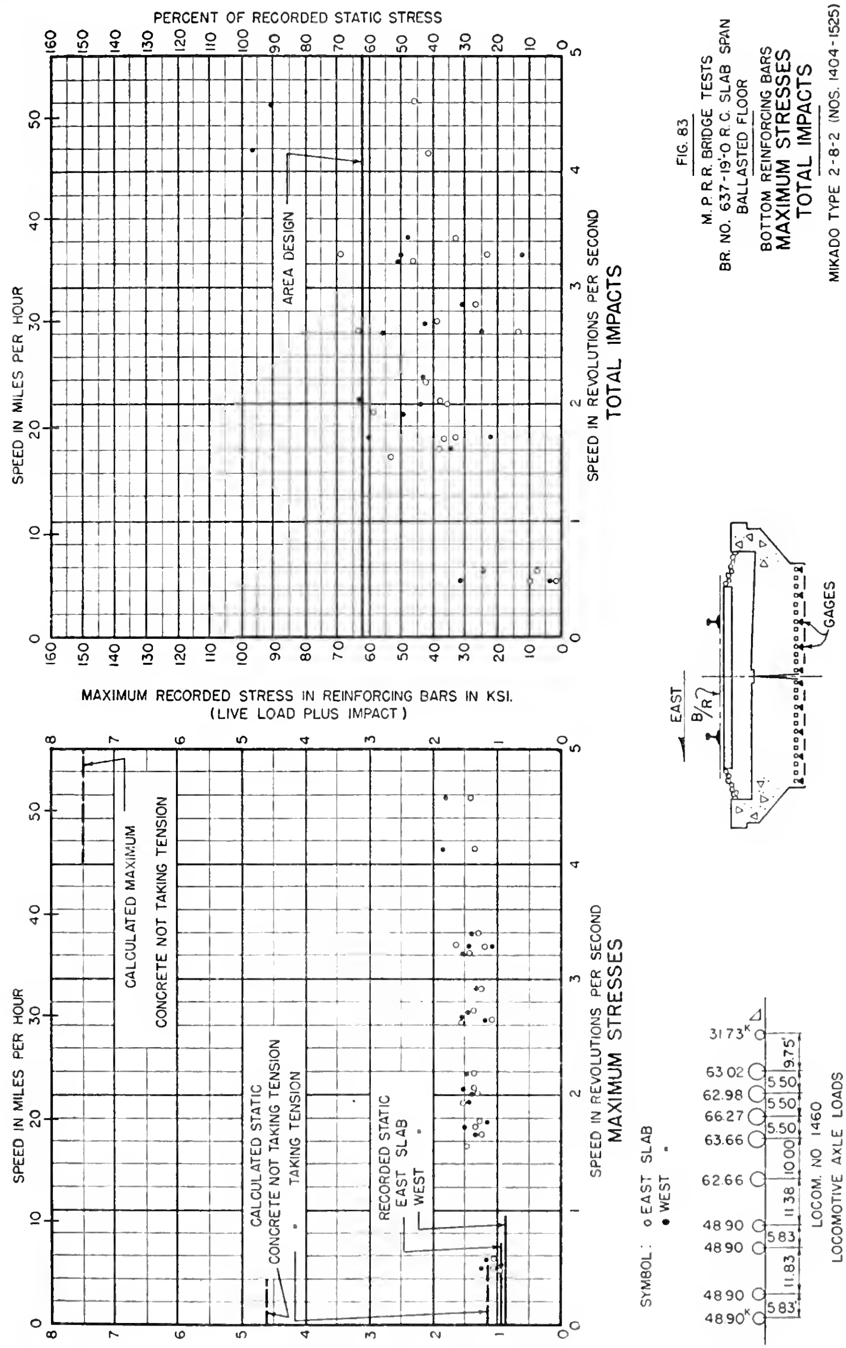


FIG. 83
M. P. R. R. BRIDGE TESTS
BR. NO. 637-19'-0 R. C. SLAB SPAN
BALLASTED FLOOR
BOTTOM REINFORCING BARS
MAXIMUM STRESSES
TOTAL IMPACTS
MIKADO TYPE 2-8-2 (NOS. 1404-1525)

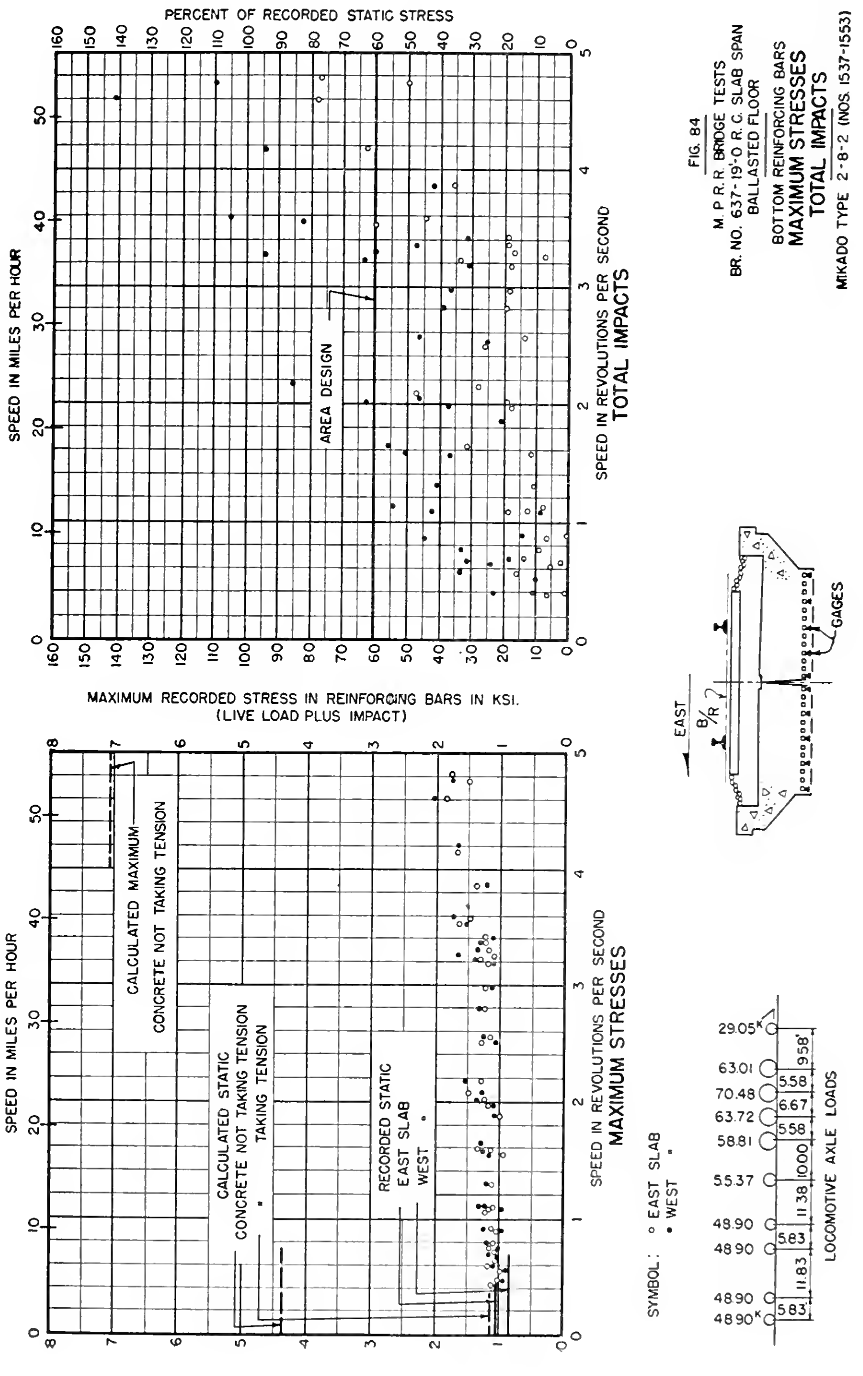


FIG. 84

M. P. R. R. BRIDGE TESTS
BR. NO. 637-19'-0 R. C. SLAB SPAN
BALLASTED FLOOR

BOTTOM REINFORCING BARS
MAXIMUM STRESSES
TOTAL IMPACTS
MIKADO TYPE 2-8-2 (NOS. 1537-1553)

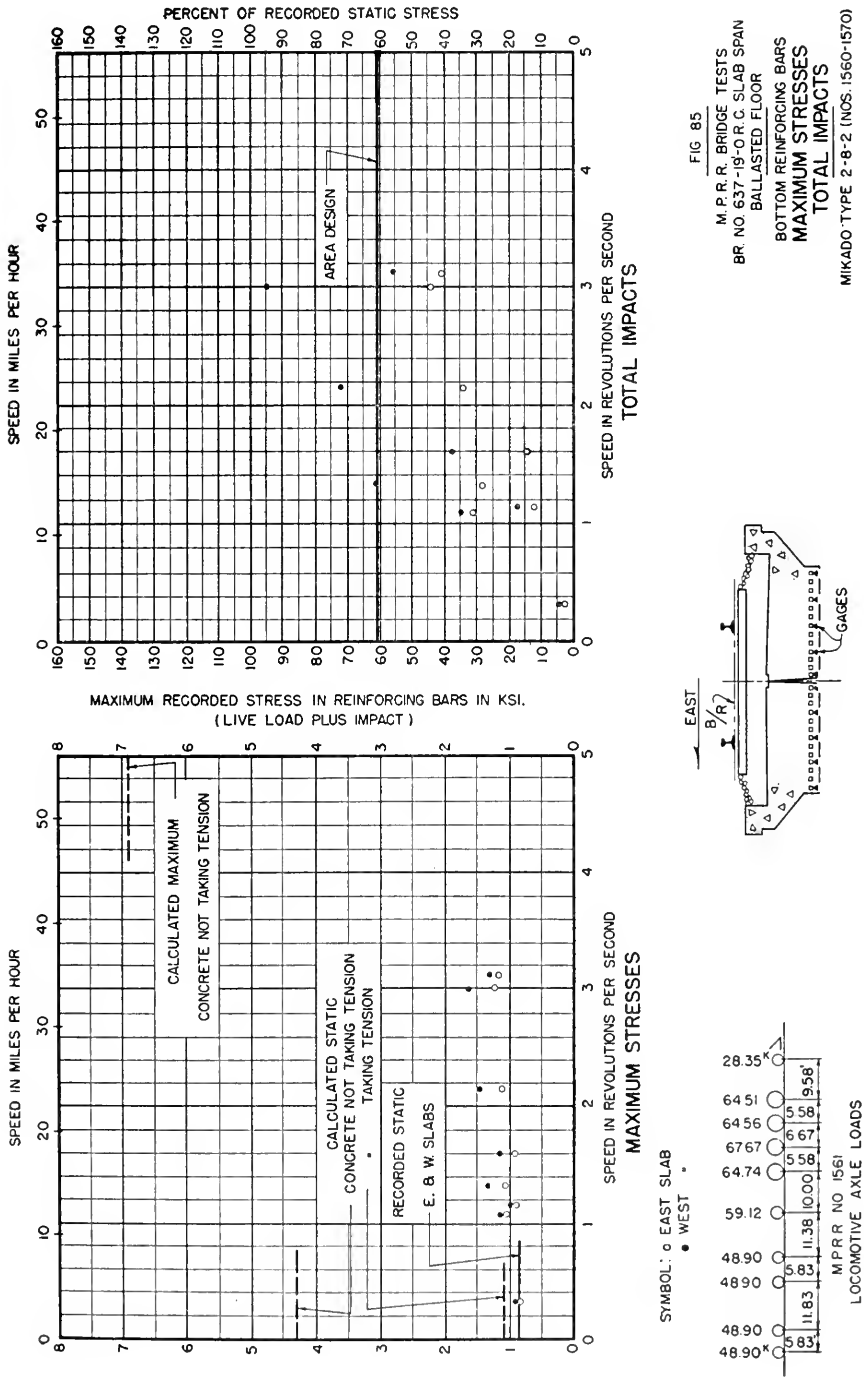


FIG 85
M. P. R. R. BRIDGE TESTS
BR. NO. 637 - 19'-0 R. C. SLAB SPAN
BALLASTED FLOOR
BOTTOM REINFORCING BARS
MAXIMUM STRESSES
TOTAL IMPACTS
MIKADO TYPE 2-8-2 (NOS. 1560-1570)

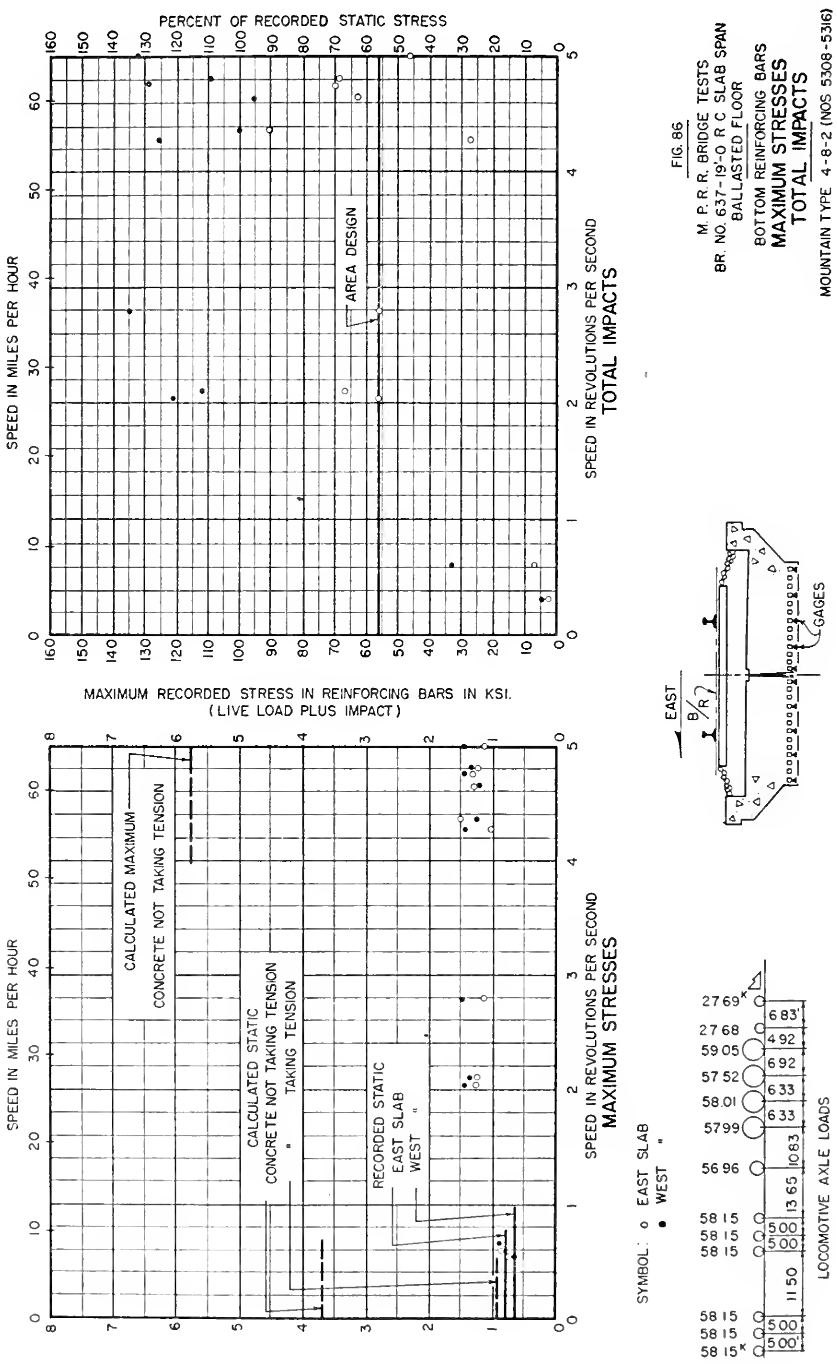


FIG. 86
M. P. R. R. BRIDGE TESTS
BR. NO. 637-19'-0 R C SLAB SPAN
BALLASTED FLOOR
BOTTOM REINFORCING BARS
MAXIMUM STRESSES
TOTAL IMPACTS
MOUNTAIN TYPE 4-8-2 (NOS 5308-5316)

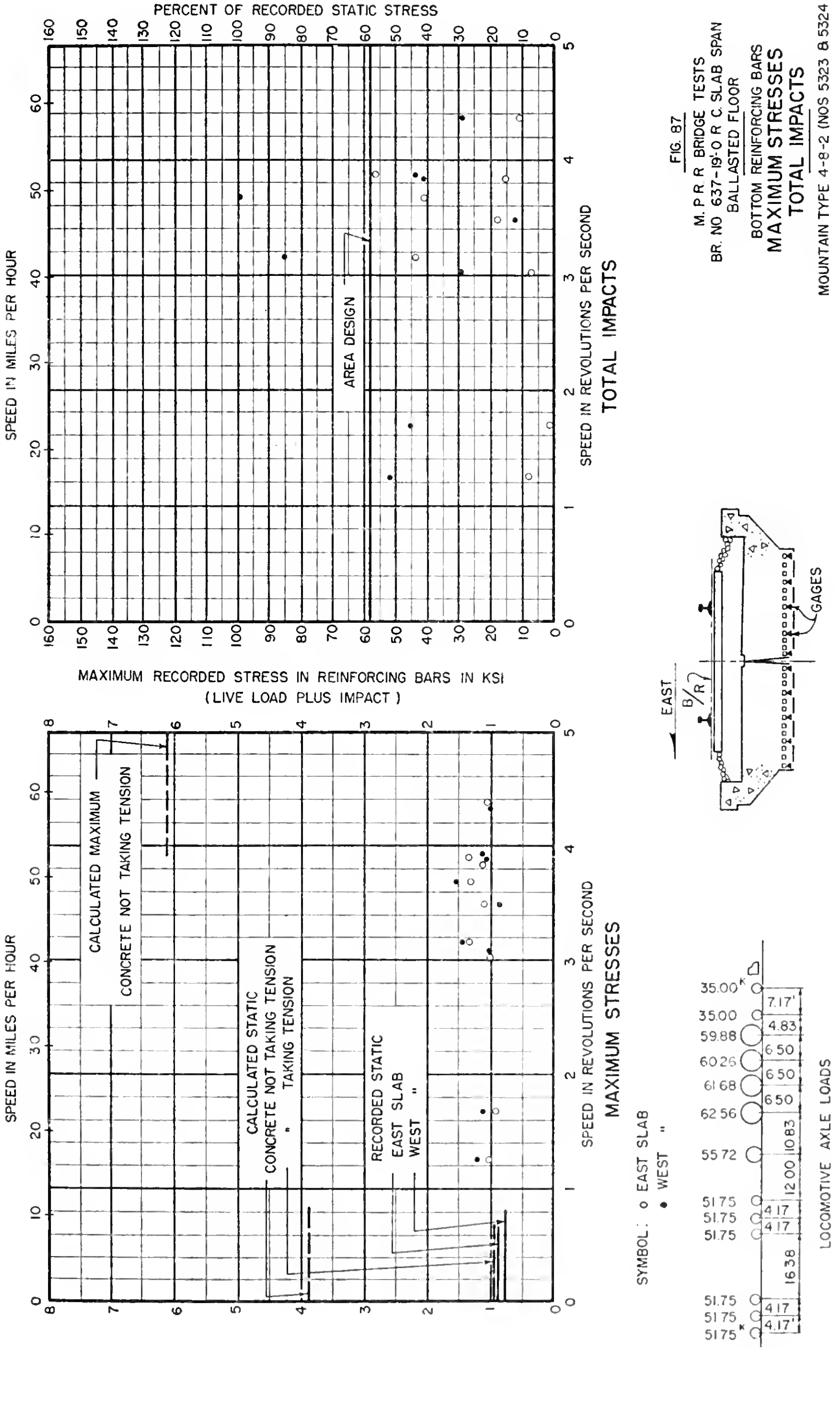


FIG. 87
M. P. R. R. BRIDGE TESTS
BR. NO 637-19'-0 R. C. SLAB SPAN
BALLASTED FLOOR
BOTTOM REINFORCING BARS
MAXIMUM STRESSES
TOTAL IMPACTS
MOUNTAIN TYPE 4-8-2 (NOS 5323 & 5324

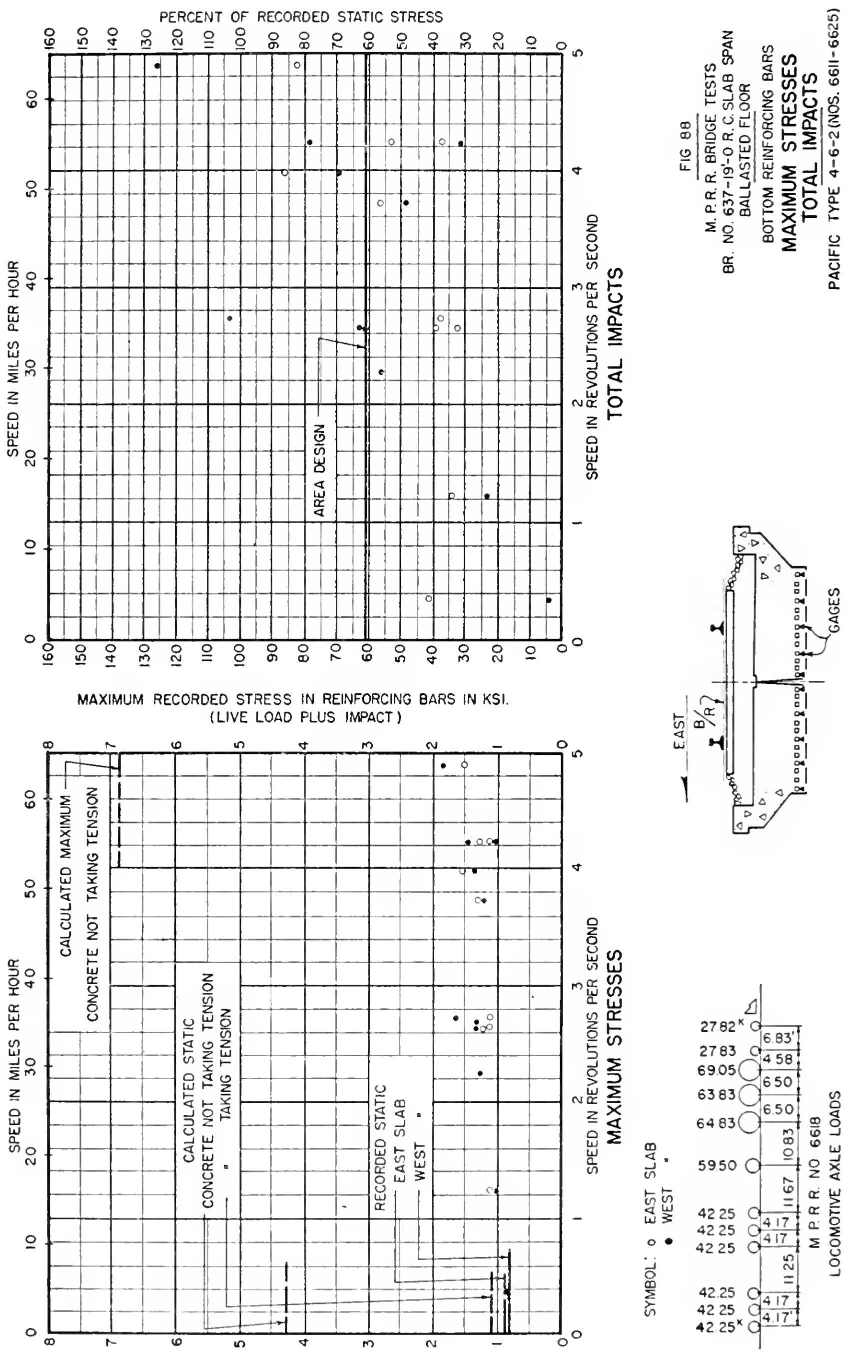


FIG. 88
M. P. R. R. BRIDGE TESTS
BR. NO. 637-19'-0 R. C. SLAB SPAN
BALLASTED FLOOR
BOTTOM REINFORCING BARS
MAXIMUM STRESSES
TOTAL IMPACTS
PACIFIC TYPE 4-6-2 (NOS. 6611-6625)

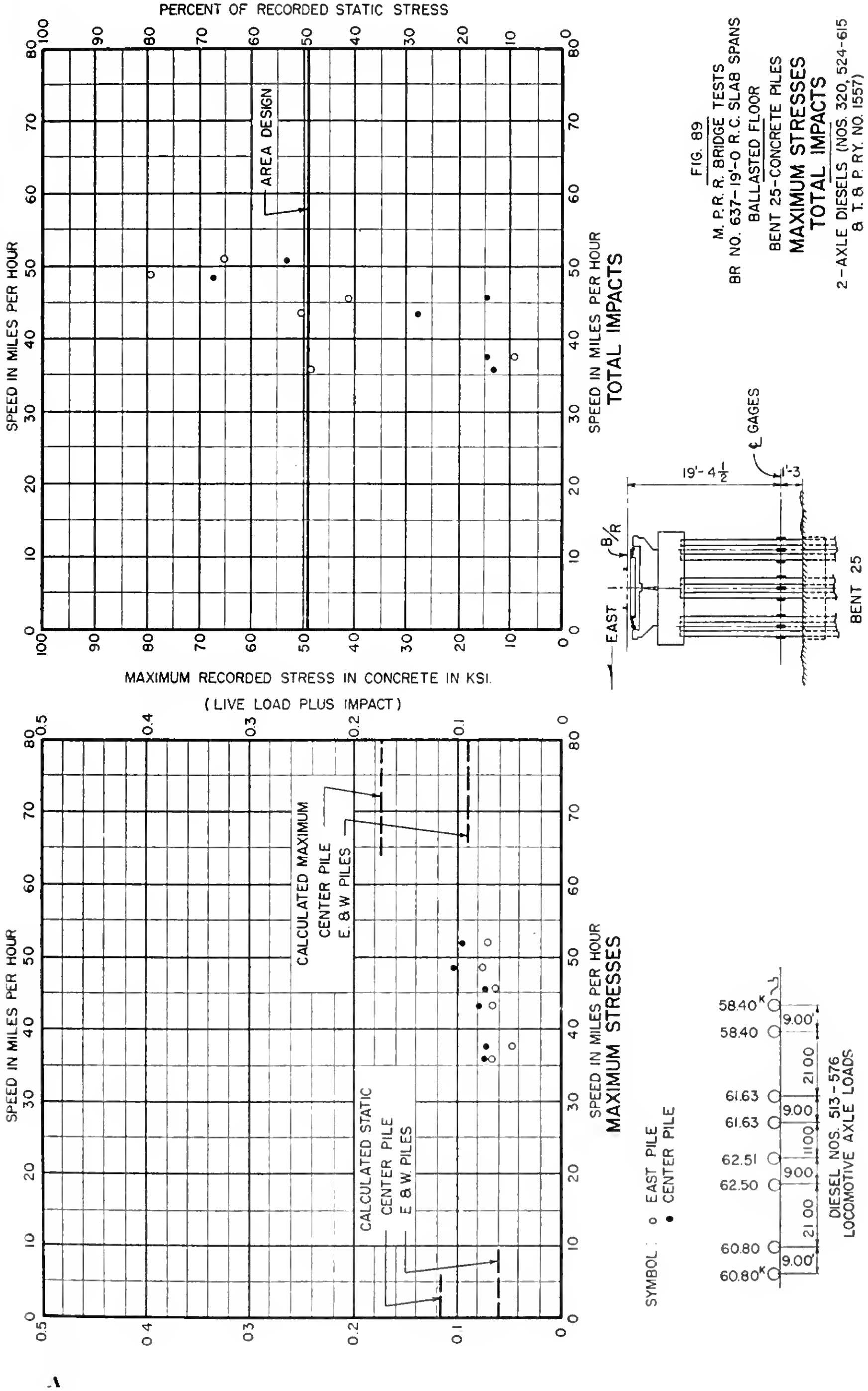


FIG. 89
M. P. R. R. BRIDGE TESTS
BR NO. 637–19'-0 R.C. SLAB SPANS
BALLASTED FLOOR
BENT 25–CONCRETE PILES
MAXIMUM STRESSES
TOTAL IMPACTS
2-AXLE DIESELS (NOS. 320, 524-615 & T. & P. RY. NO. 1557)

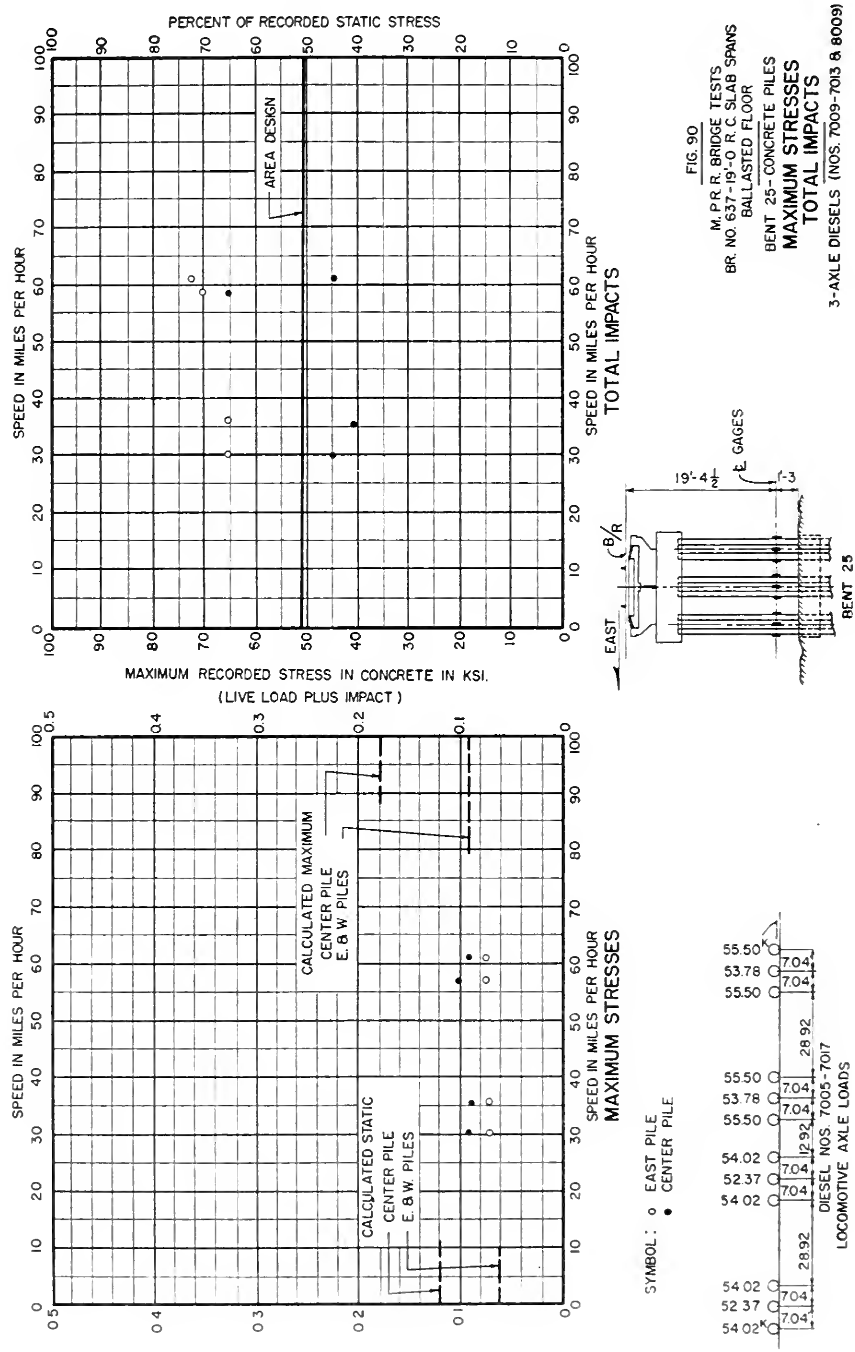


FIG. 90
M. P. R. R. BRIDGE TESTS
BR. NO. 637-19'-0 R. C. SLAB SPANS
BALLASTED FLOOR
BENT 25—CONCRETE PILES
MAXIMUM STRESSES
TOTAL IMPACTS
3-AXLE DIESELS (NOS. 7009-7013 & 8009)

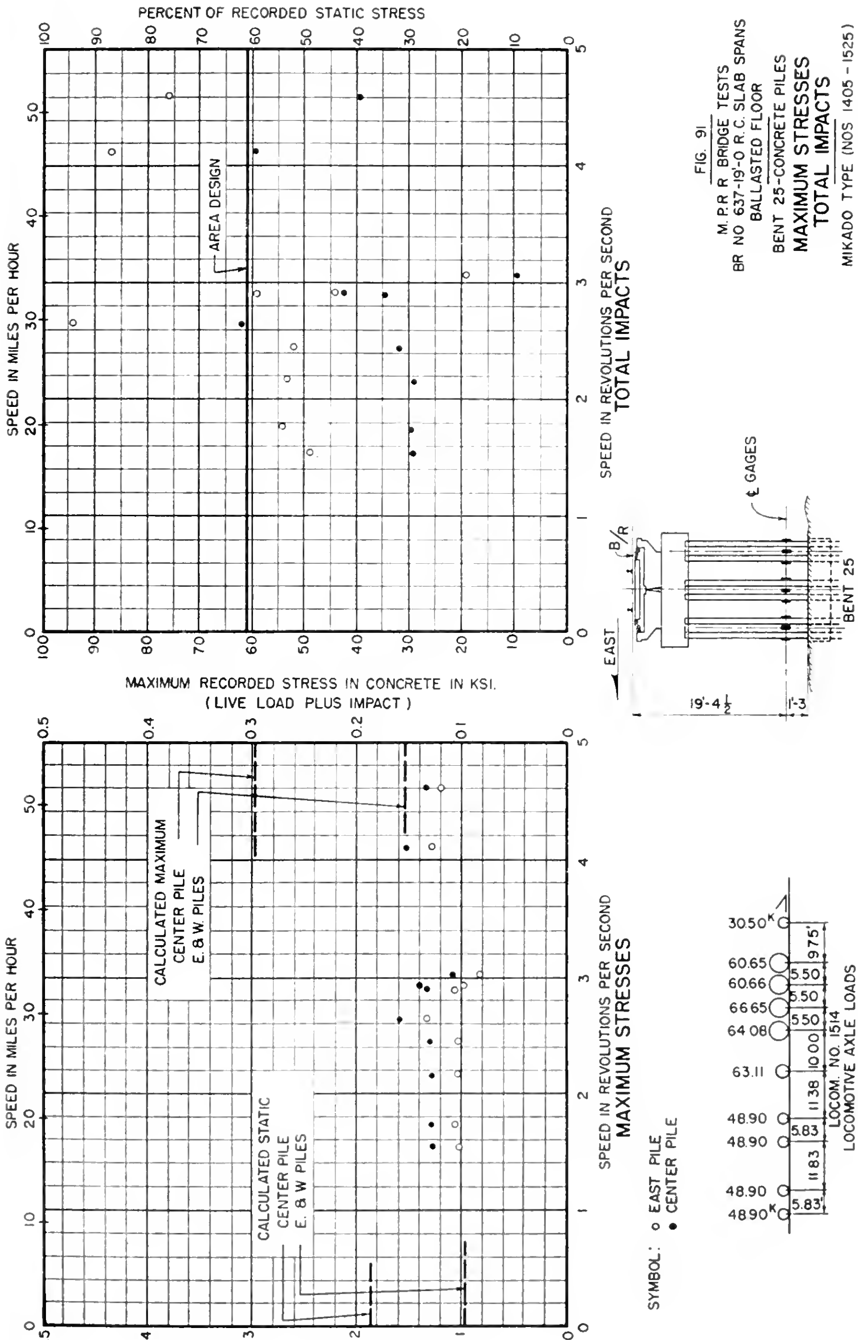


FIG. 91
M. P. R R BRIDGE TESTS
BR NO 637-19'-0 R.C. SLAB SPANS
BALLASTED FLOOR
BENT 25-CONCRETE PILES
MAXIMUM STRESSES
TOTAL IMPACTS
MIKADO TYPE (NOS 1405-1525)

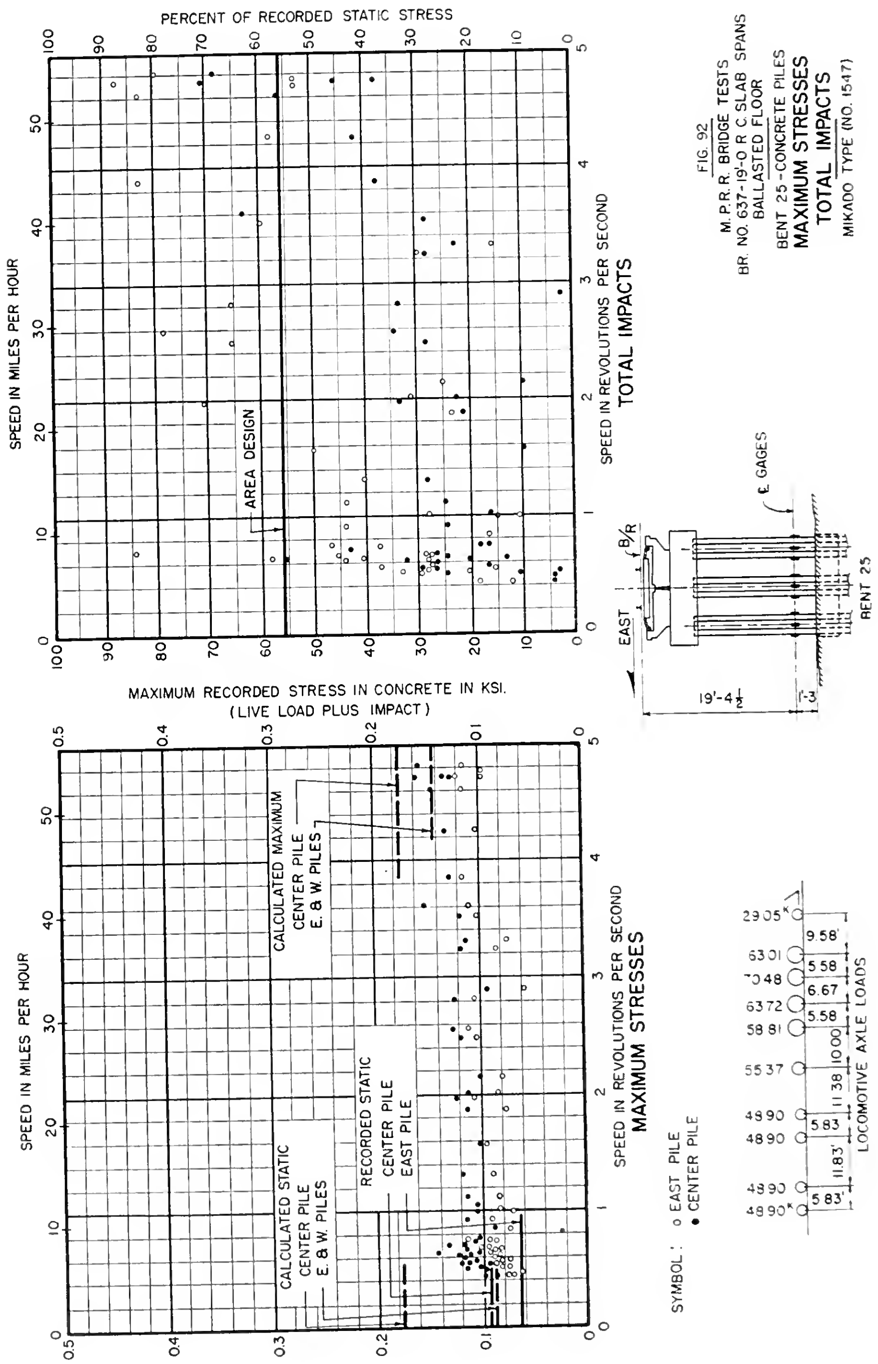


FIG. 92
M.P.R.R. BRIDGE TESTS
BR. NO. 637-19'-0 R.C. SLAB SPANS
BALLASTED FLOOR
BENT 25-CONCRETE PILES
MAXIMUM STRESSES
TOTAL IMPACTS
MIKADO TYPE (NO. 1547)

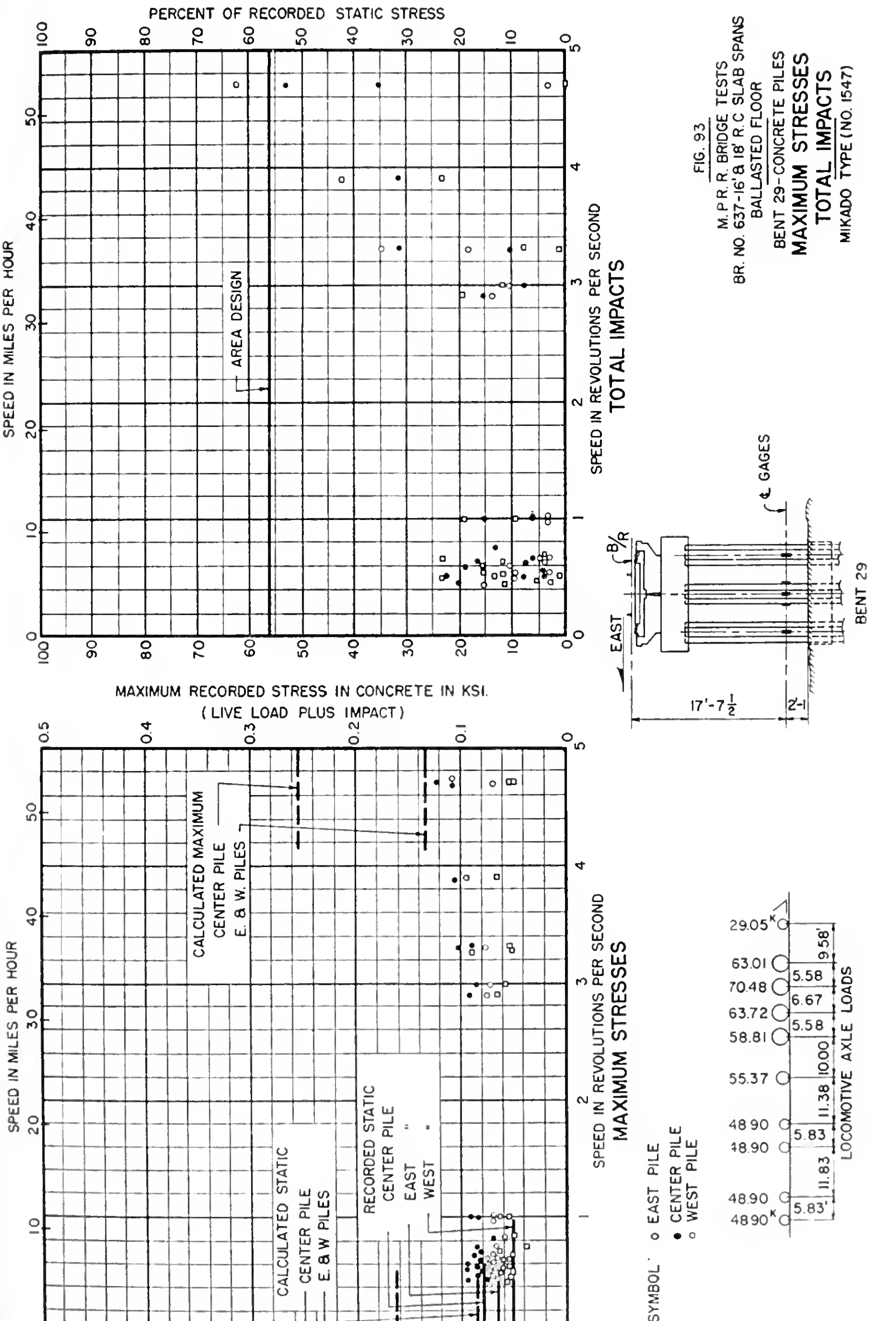


FIG. 93
M. P. R. R. BRIDGE TESTS
BR. NO. 637-16' & 18' R. C SLAB SPANS
BALLASTED FLOOR
BENT 29-CONCRETE PILES
MAXIMUM STRESSES
TOTAL IMPACTS
MIKADO TYPE (NO. 1547)

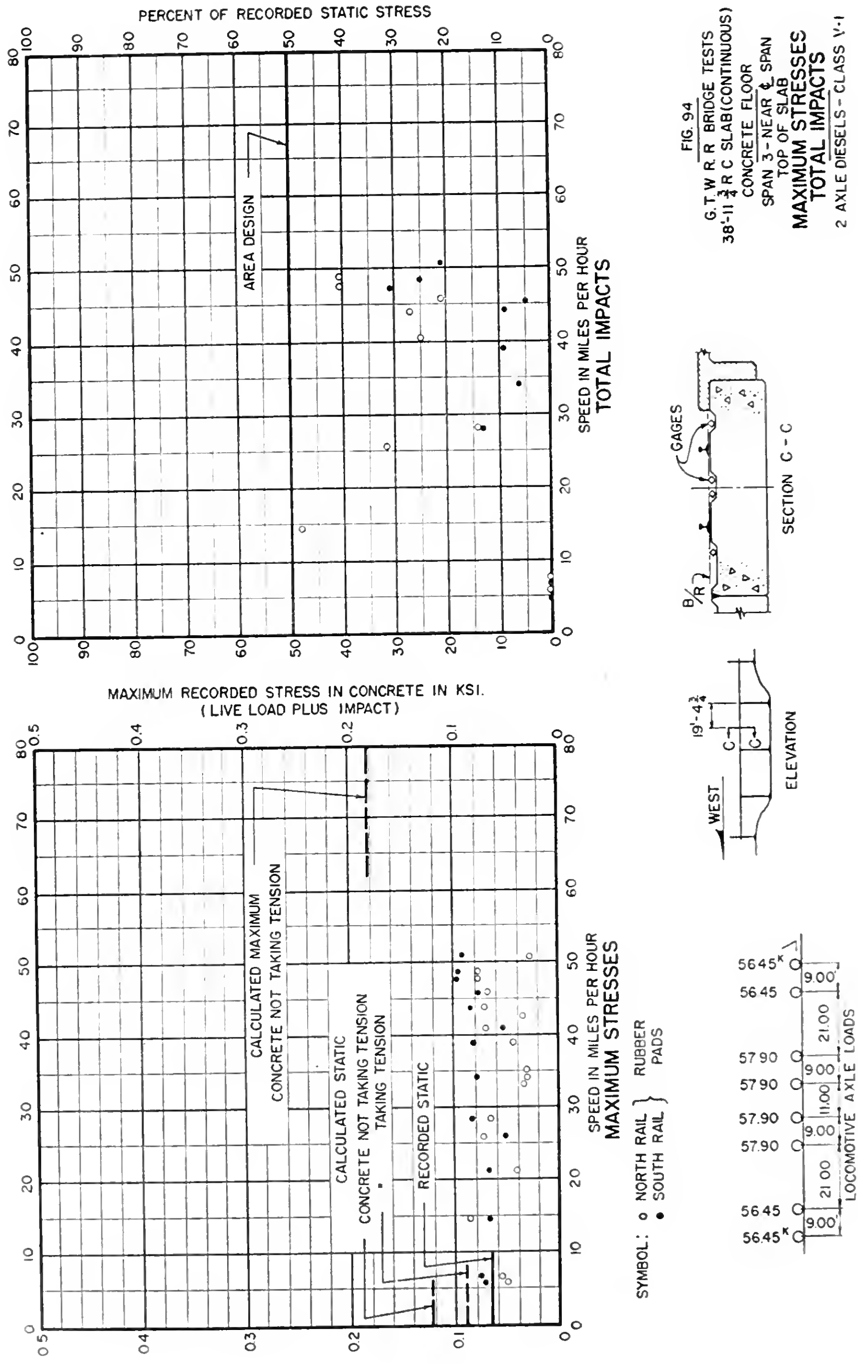


FIG. 94
G. T. W. R. R. BRIDGE TESTS
38'-11 3/4 R C SLAB (CONTINUOUS)
CONCRETE FLOOR
SPAN 3 - NEAR ℄ SPAN
TOP OF SLAB
MAXIMUM STRESSES
TOTAL IMPACTS
2 AXLE DIESELS - CLASS V-1

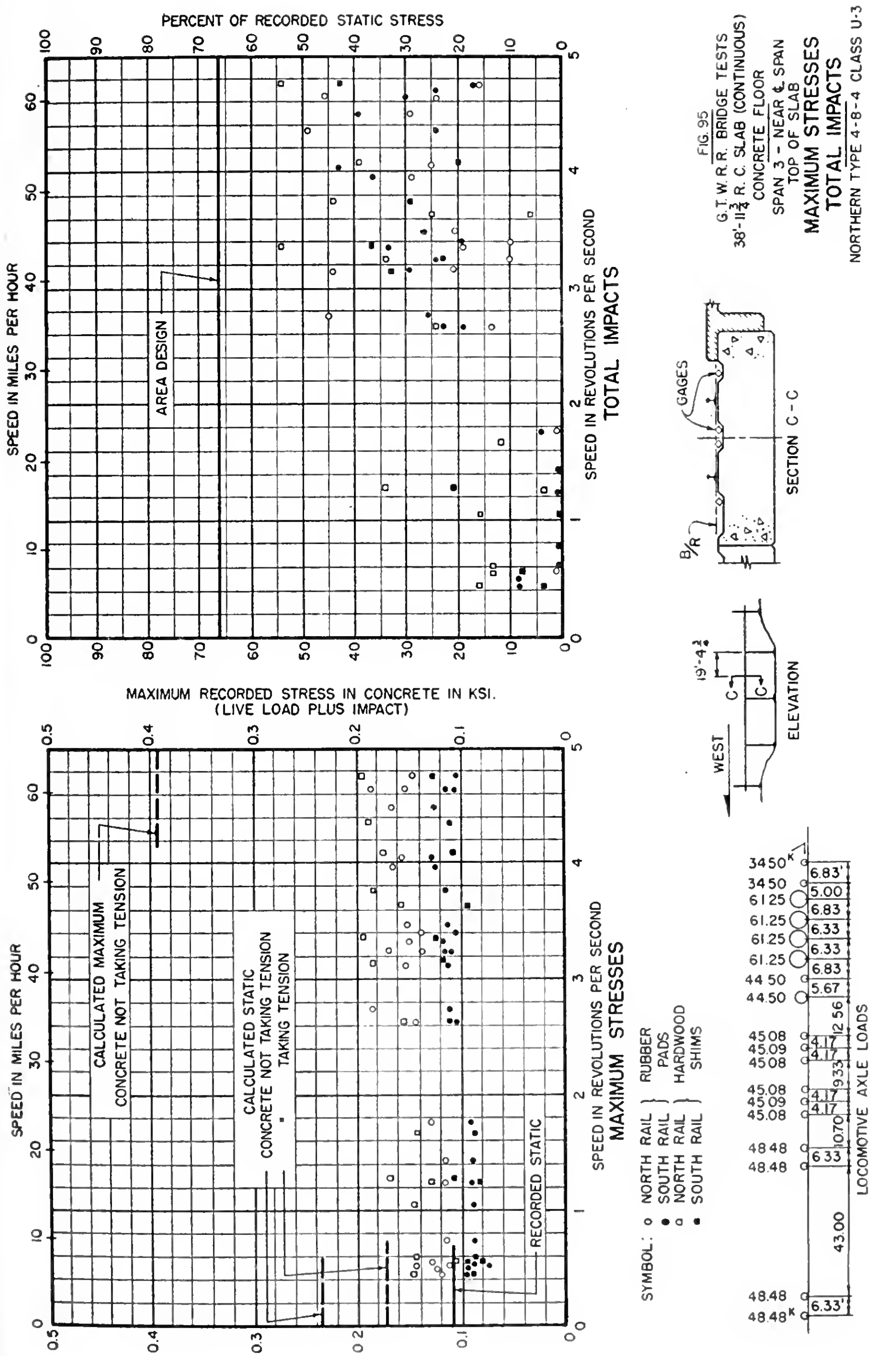


FIG. 95
G.T.W.R.R. BRIDGE TESTS
38'-11¾ R. C. SLAB (CONTINUOUS)
CONCRETE FLOOR
SPAN 3 - NEAR ℄ SPAN
TOP OF SLAB
MAXIMUM STRESSES
TOTAL IMPACTS
NORTHERN TYPE 4-8-4 CLASS U-3

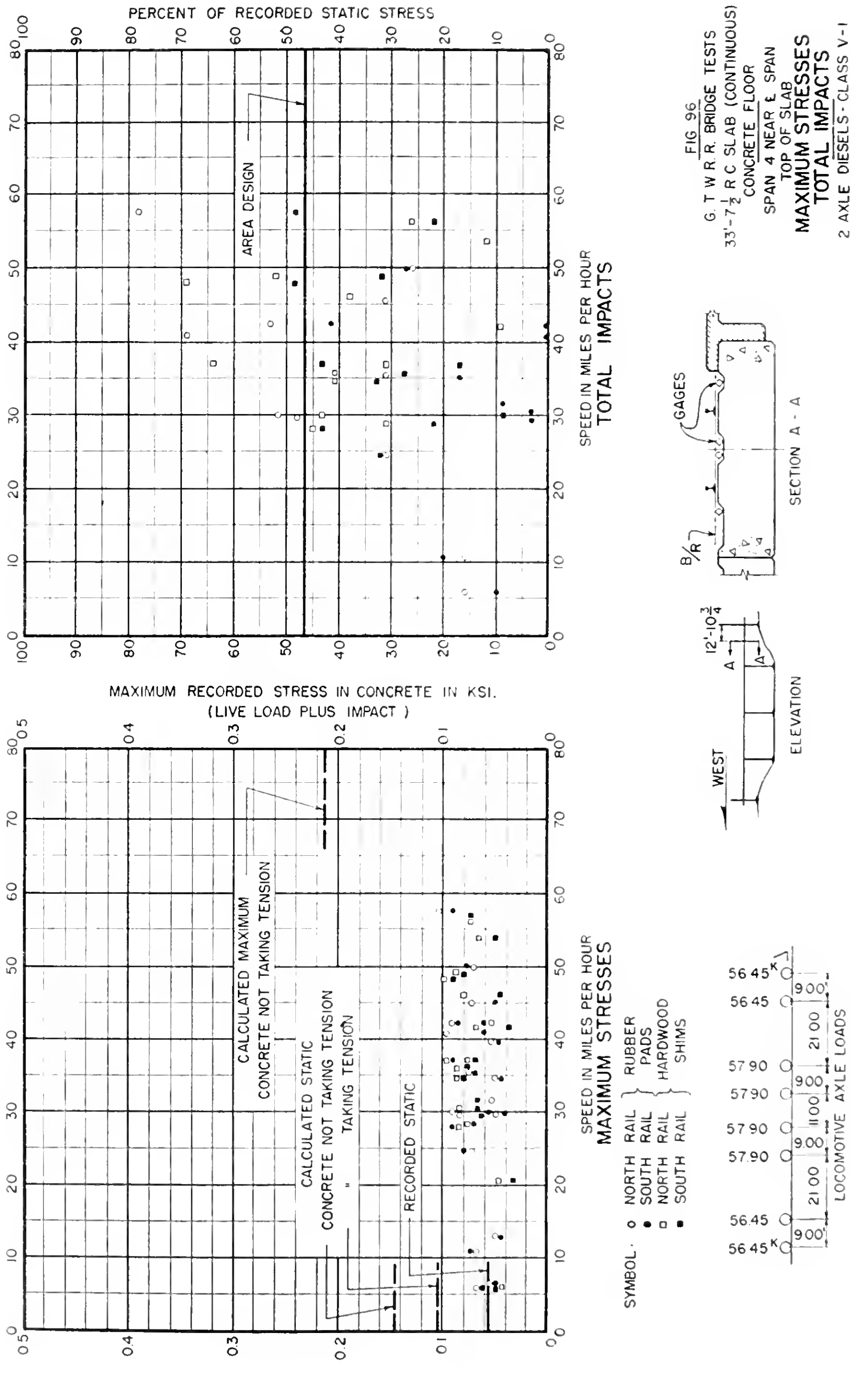


FIG 96
G.T.W.R.R. BRIDGE TESTS
33'-7½ R.C. SLAB (CONTINUOUS)
CONCRETE FLOOR
SPAN 4 NEAR ℄ SPAN
TOP OF SLAB
MAXIMUM STRESSES
TOTAL IMPACTS
2 AXLE DIESELS - CLASS V-1

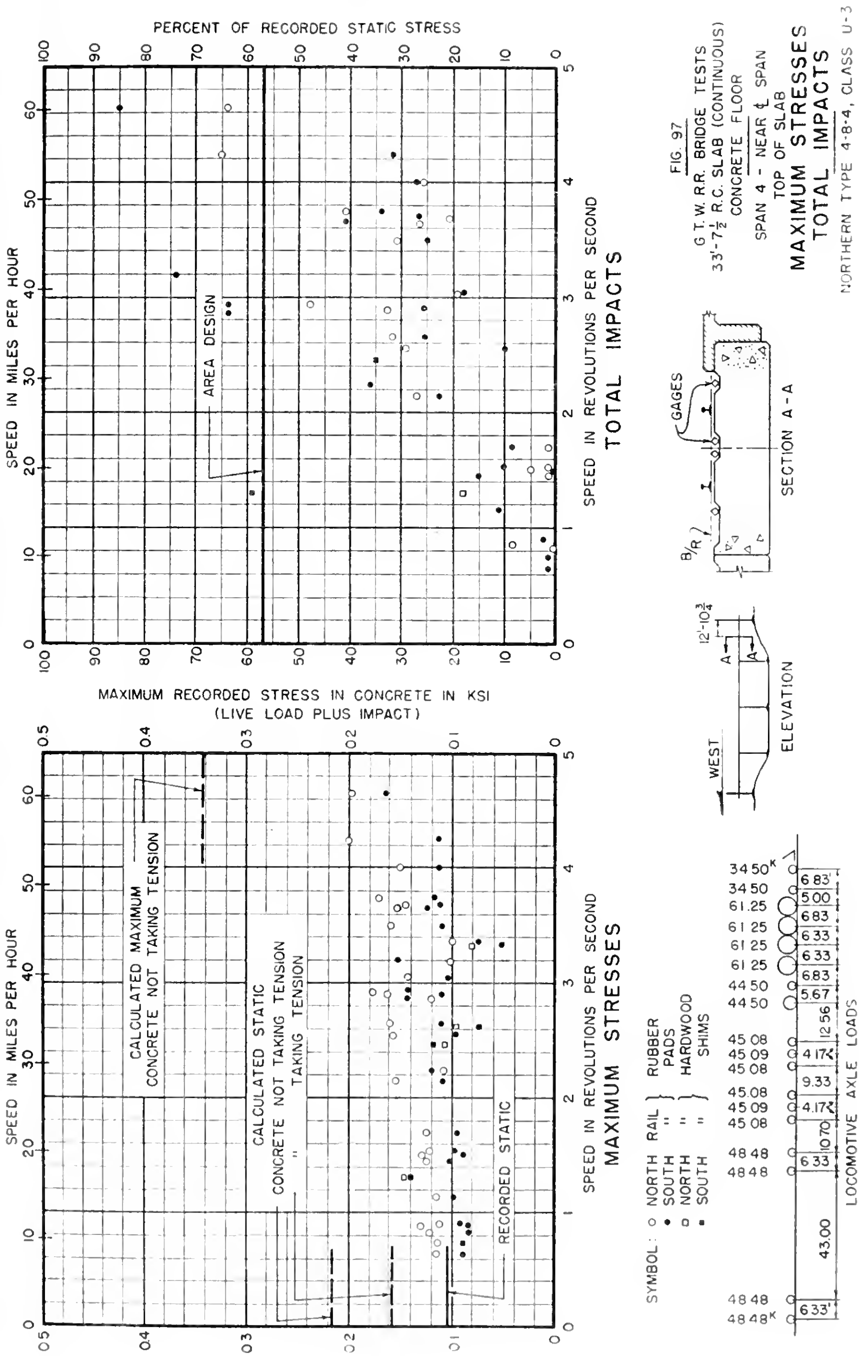


FIG. 97
G.T.W. R.R. BRIDGE TESTS
33'-7½ R.C. SLAB (CONTINUOUS)
CONCRETE FLOOR
SPAN 4 - NEAR ℄ SPAN
TOP OF SLAB
MAXIMUM STRESSES
TOTAL IMPACTS
NORTHERN TYPE 4-8-4, CLASS U-3

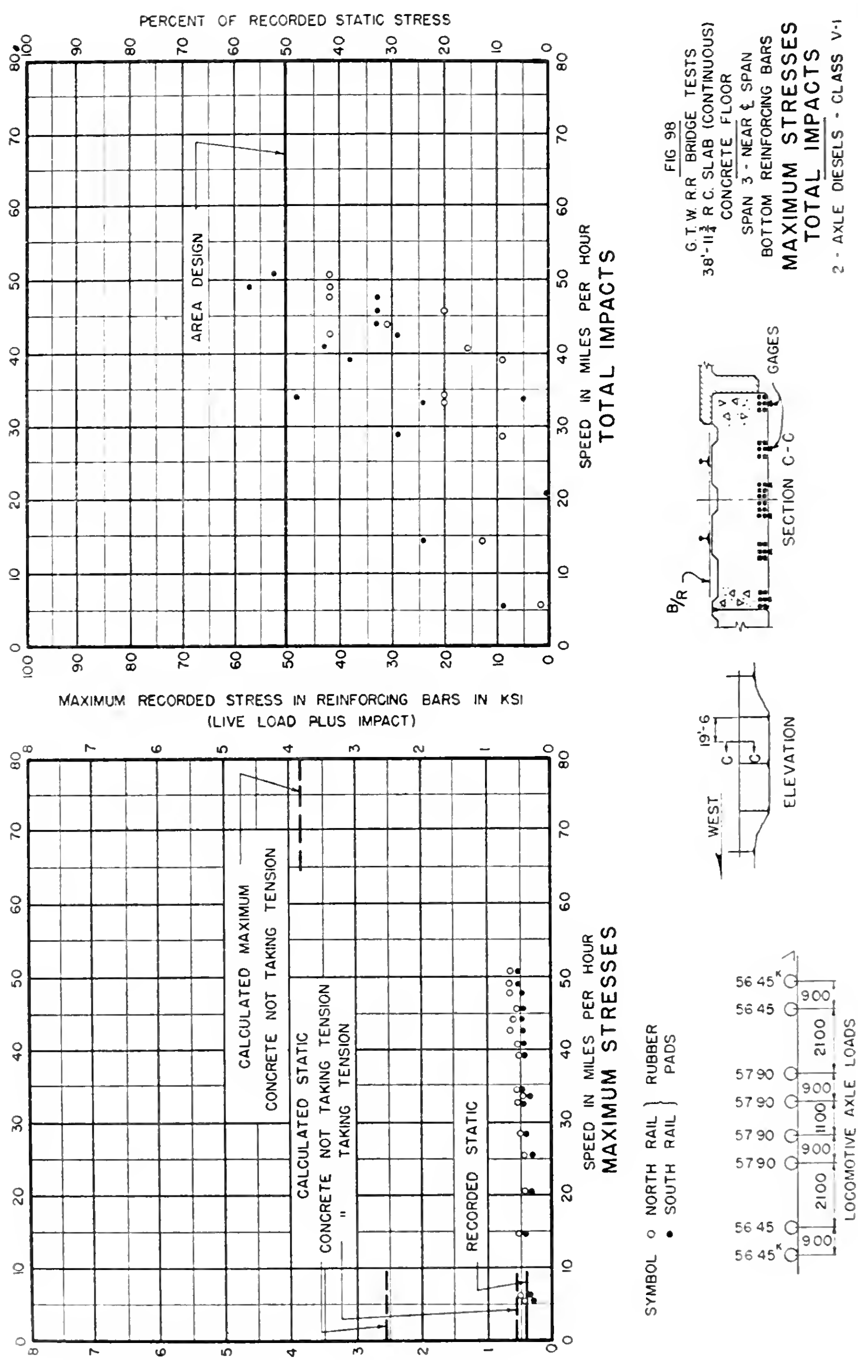


FIG 98
G.T.W. R.R. BRIDGE TESTS
38'-11¾ R.C. SLAB (CONTINUOUS)
CONCRETE FLOOR
SPAN 3 - NEAR ℄ SPAN
BOTTOM REINFORCING BARS
MAXIMUM STRESSES
TOTAL IMPACTS
2 - AXLE DIESELS - CLASS V-1

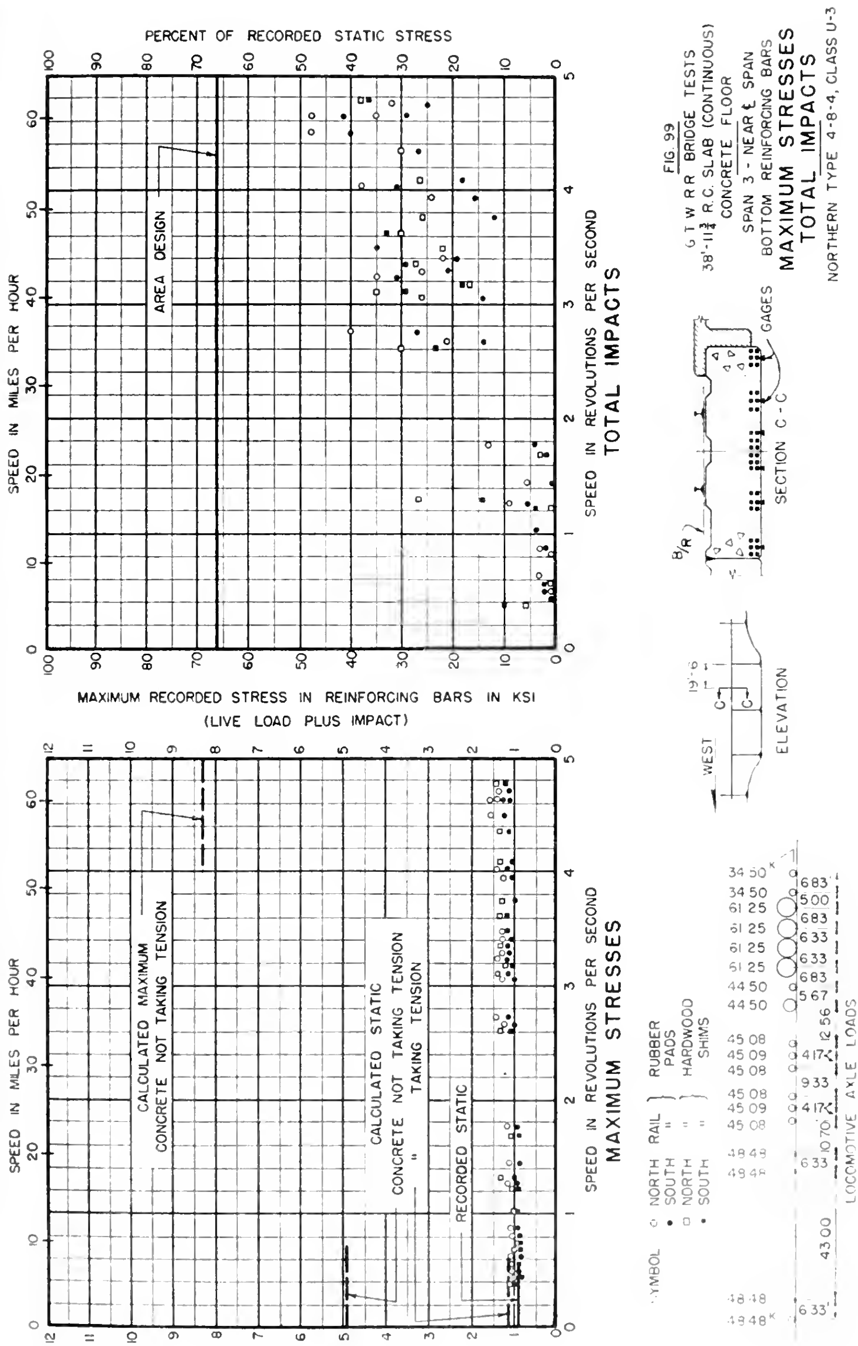


FIG. 99
G T W R R BRIDGE TESTS
38'-11¾ R.C. SLAB (CONTINUOUS)
CONCRETE FLOOR
SPAN 3 - NEAR ℄ SPAN
BOTTOM REINFORCING BARS
MAXIMUM STRESSES
TOTAL IMPACTS
NORTHERN TYPE 4-8-4, CLASS U-3

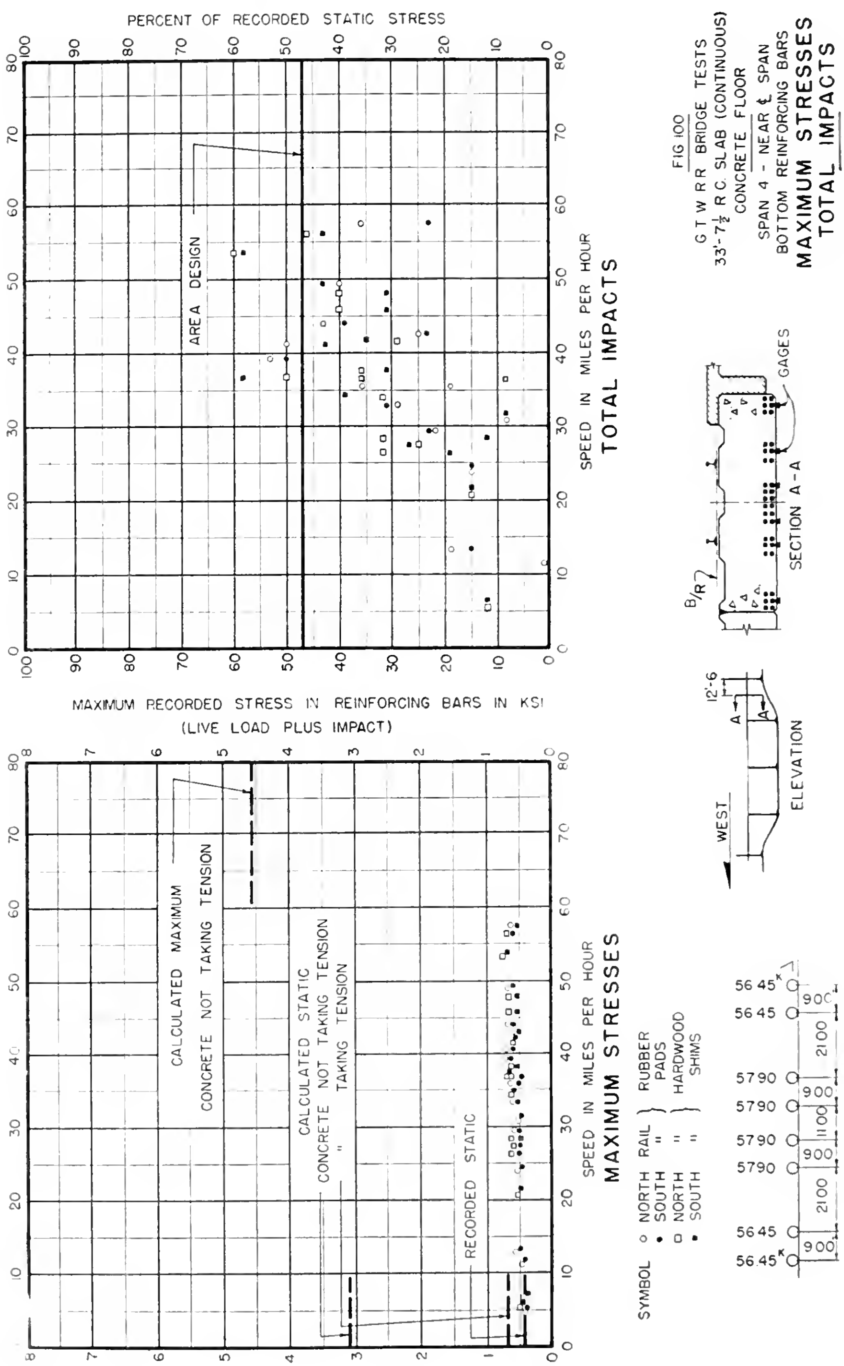


FIG 100
G T W R R BRIDGE TESTS
33'-7½ R.C. SLAB (CONTINUOUS)
CONCRETE FLOOR
SPAN 4 - NEAR ℄ SPAN
BOTTOM REINFORCING BARS
MAXIMUM STRESSES
TOTAL IMPACTS
2 - AXLE DIESELS - CLASS V-1

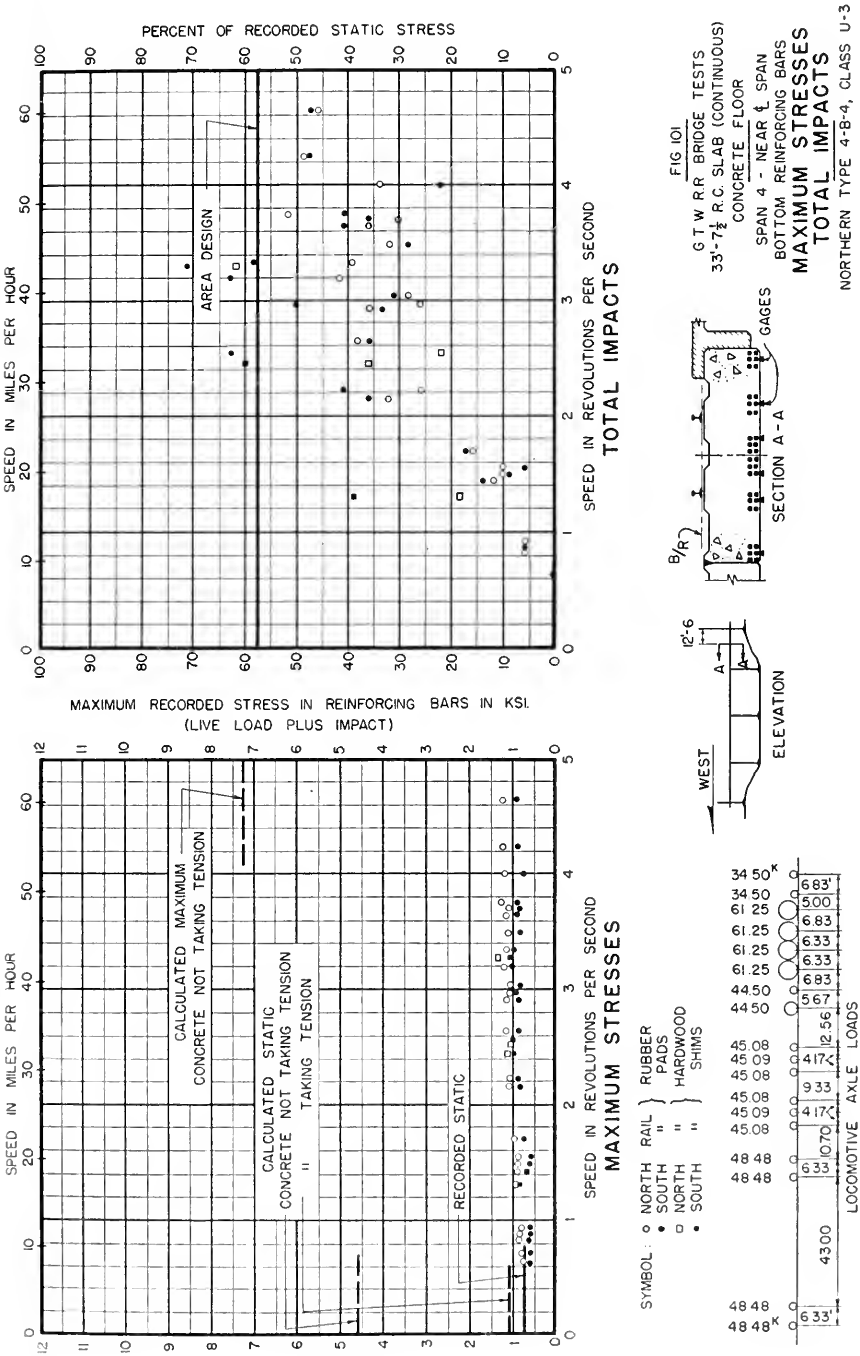


FIG 101
G T W R.R BRIDGE TESTS
33'-7½ R.C. SLAB (CONTINUOUS)
CONCRETE FLOOR
SPAN 4 - NEAR ℄ SPAN
BOTTOM REINFORCING BARS
MAXIMUM STRESSES
TOTAL IMPACTS
NORTHERN TYPE 4-B-4, CLASS U-3

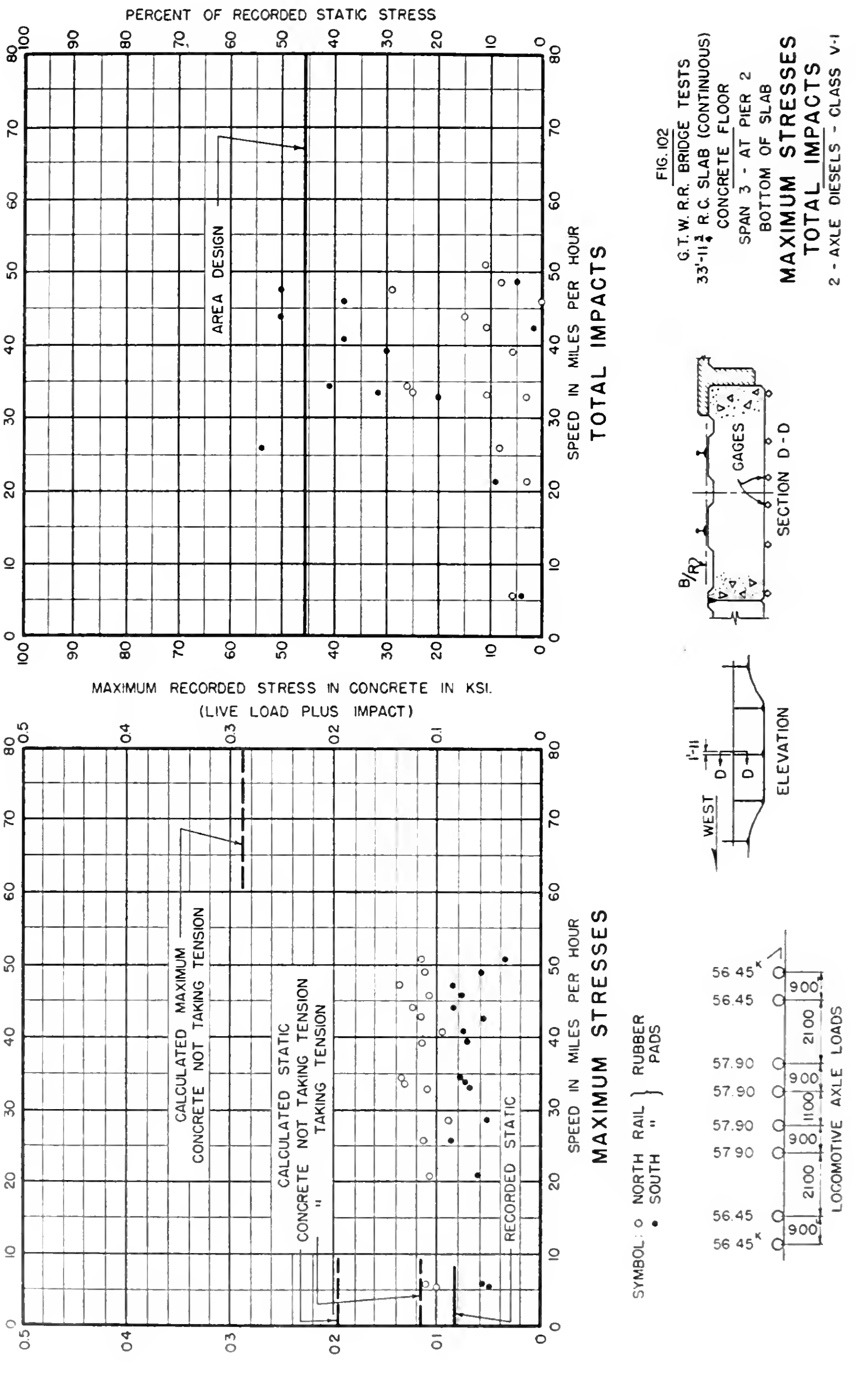


FIG. 102
G.T.W. R.R. BRIDGE TESTS
33'-11¼ R.C. SLAB (CONTINUOUS)
CONCRETE FLOOR
SPAN 3 - AT PIER 2
BOTTOM OF SLAB
MAXIMUM STRESSES
TOTAL IMPACTS
2 - AXLE DIESELS - CLASS V-1

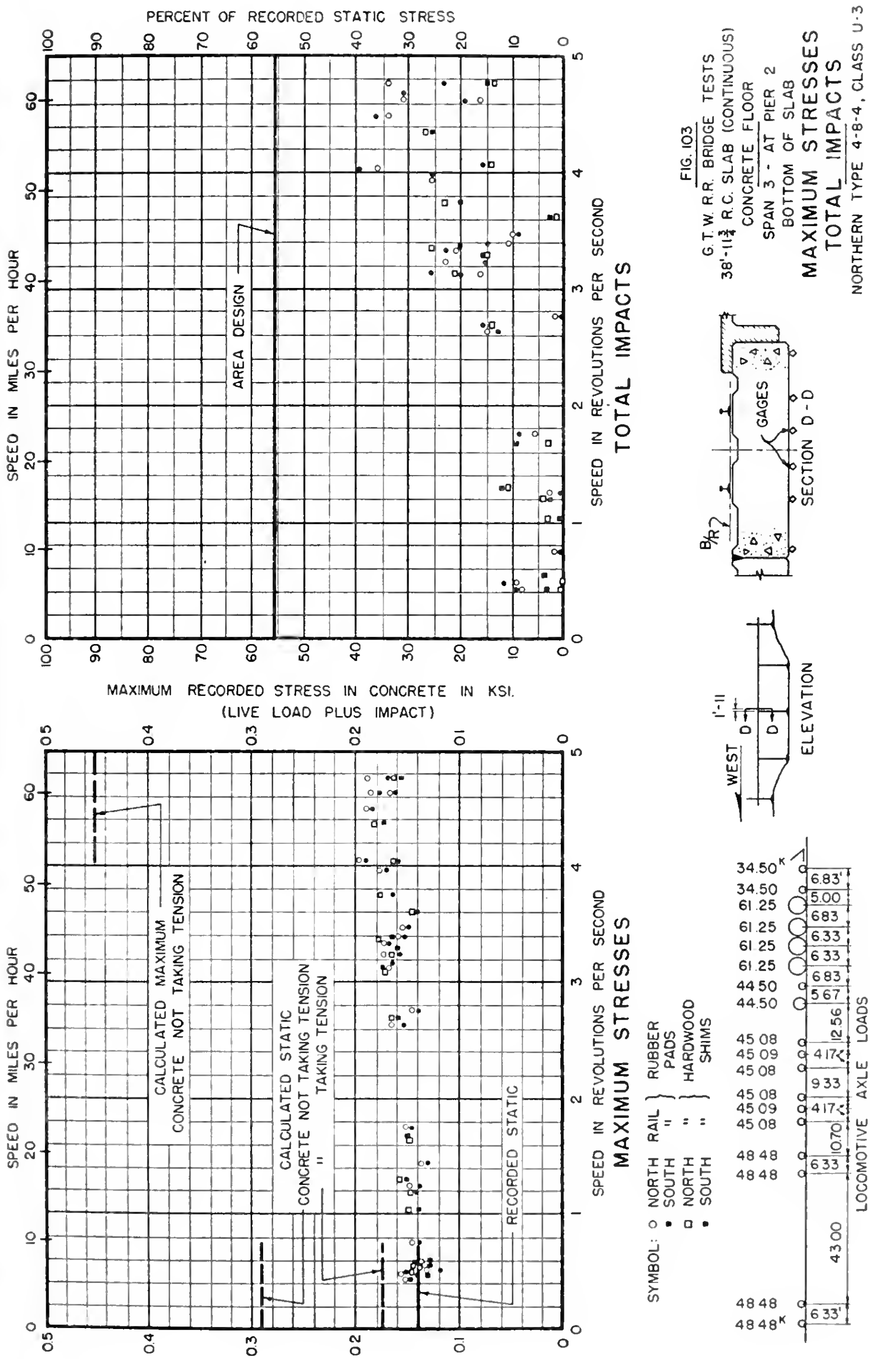


FIG. 103
G. T. W. R.R. BRIDGE TESTS
38'-11¾ R.C. SLAB (CONTINUOUS)
CONCRETE FLOOR
SPAN 3 - AT PIER 2
BOTTOM OF SLAB
MAXIMUM STRESSES
TOTAL IMPACTS
NORTHERN TYPE 4-8-4, CLASS U-3

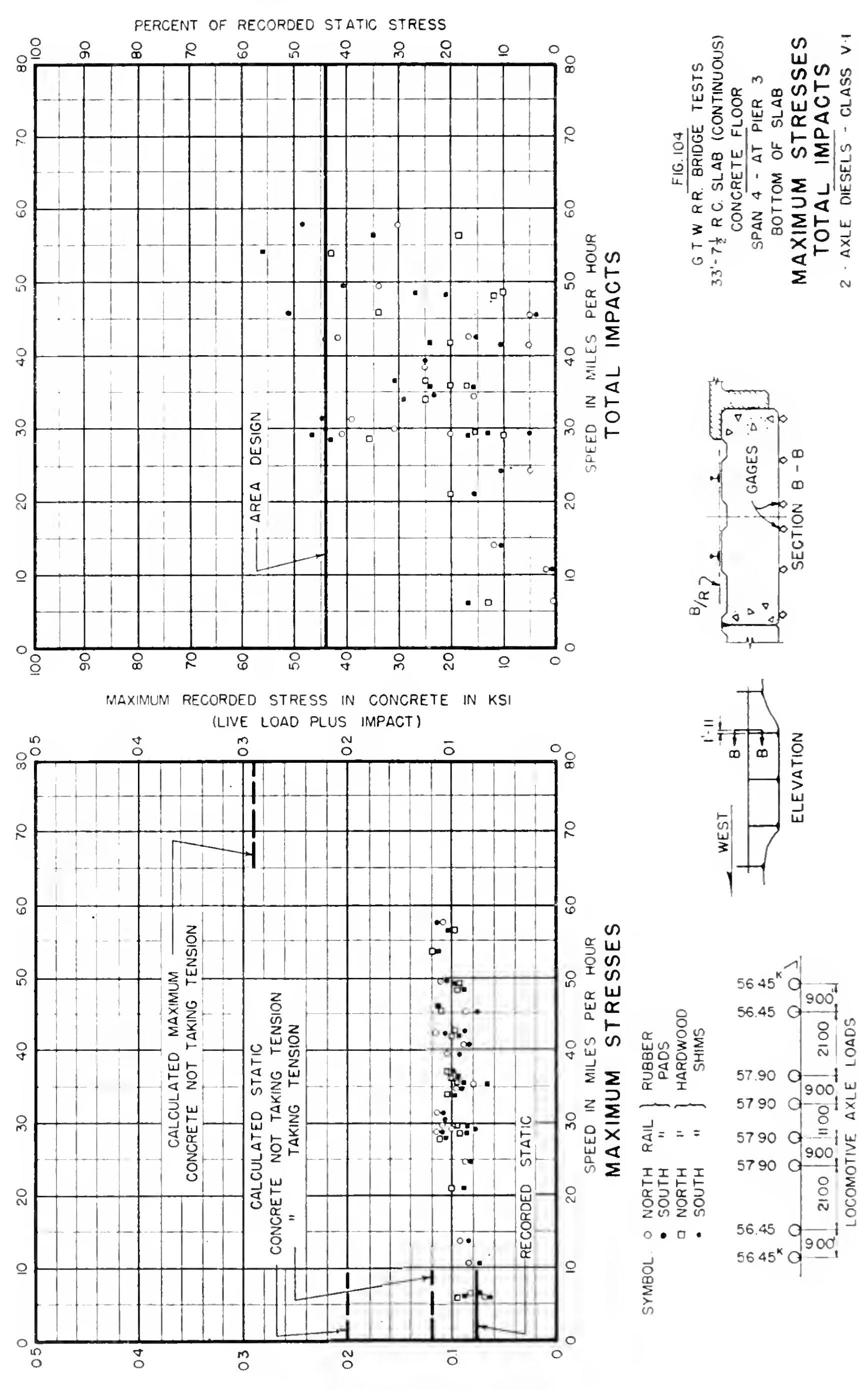


FIG. 104
G T W R R. BRIDGE TESTS
33'-7½ R C. SLAB (CONTINUOUS)
CONCRETE FLOOR
SPAN 4 - AT PIER 3
BOTTOM OF SLAB
MAXIMUM STRESSES
TOTAL IMPACTS
2 · AXLE DIESELS - CLASS V-1

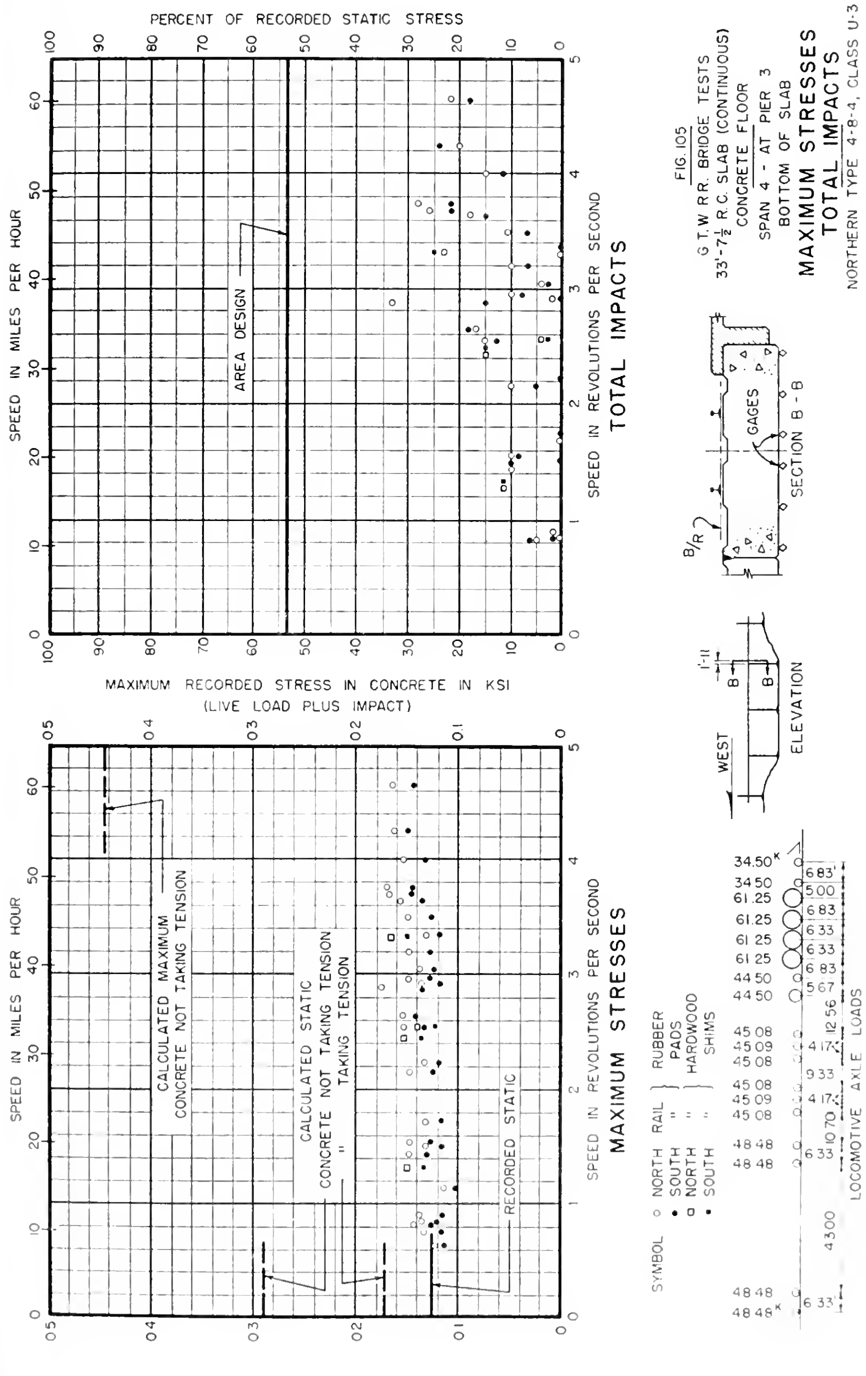


FIG. 105
G.T.W. R.R. BRIDGE TESTS
33'-7½ R.C. SLAB (CONTINUOUS)
CONCRETE FLOOR
SPAN 4 - AT PIER 3
BOTTOM OF SLAB
MAXIMUM STRESSES
TOTAL IMPACTS
NORTHERN TYPE 4-8-4, CLASS U-3

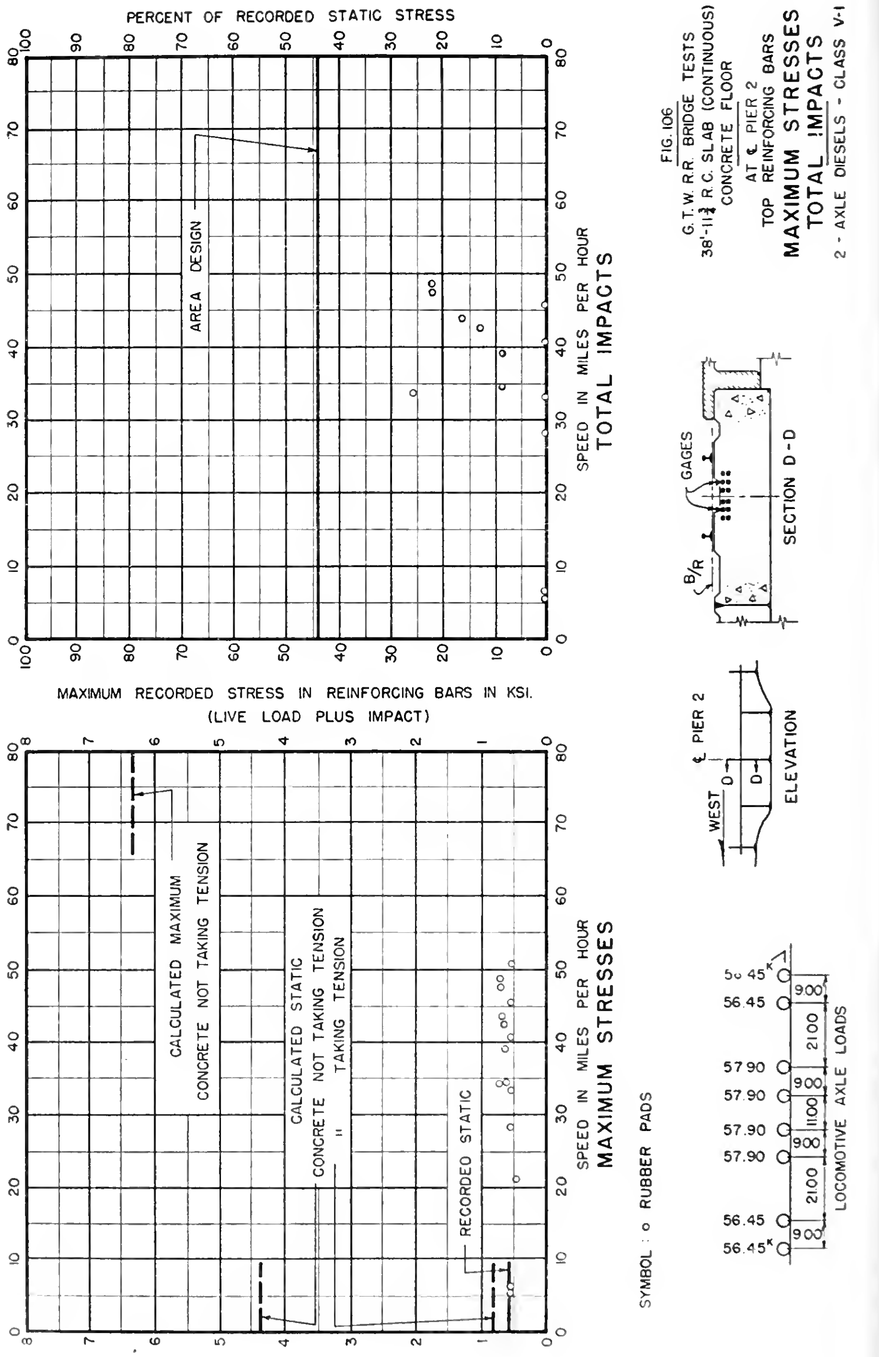


FIG. 106
G.T.W. R.R. BRIDGE TESTS
38'-11½ R.C. SLAB (CONTINUOUS)
CONCRETE FLOOR
AT ℄ PIER 2
TOP REINFORCING BARS
MAXIMUM STRESSES
TOTAL IMPACTS
2 - AXLE DIESELS - CLASS V-1

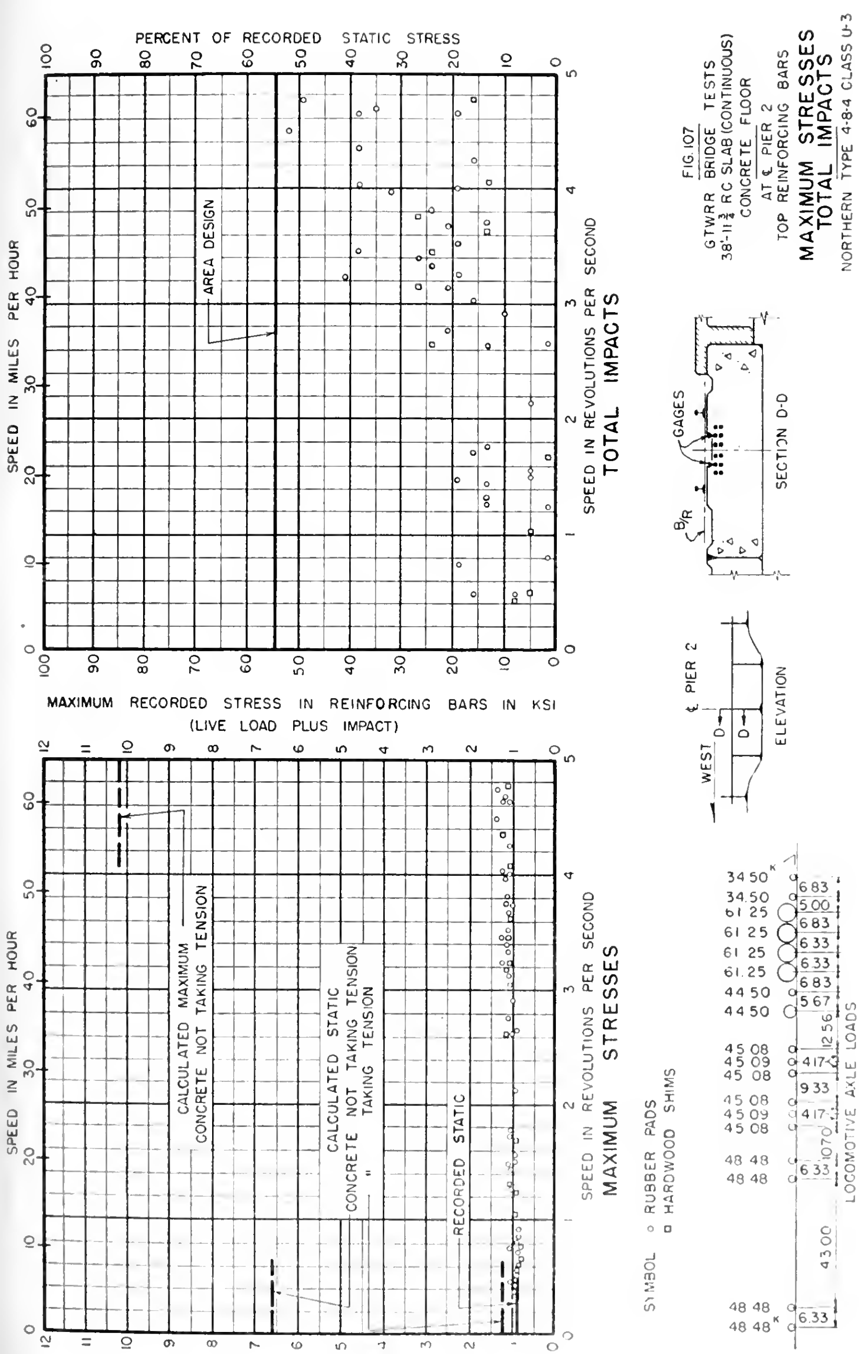


FIG. 107
GTWRR BRIDGE TESTS
38'-11¾ RC SLAB (CONTINUOUS)
CONCRETE FLOOR
AT ℄ PIER 2
TOP REINFORCING BARS
MAXIMUM STRESSES
TOTAL IMPACTS
NORTHERN TYPE 4-8-4 CLASS U-3

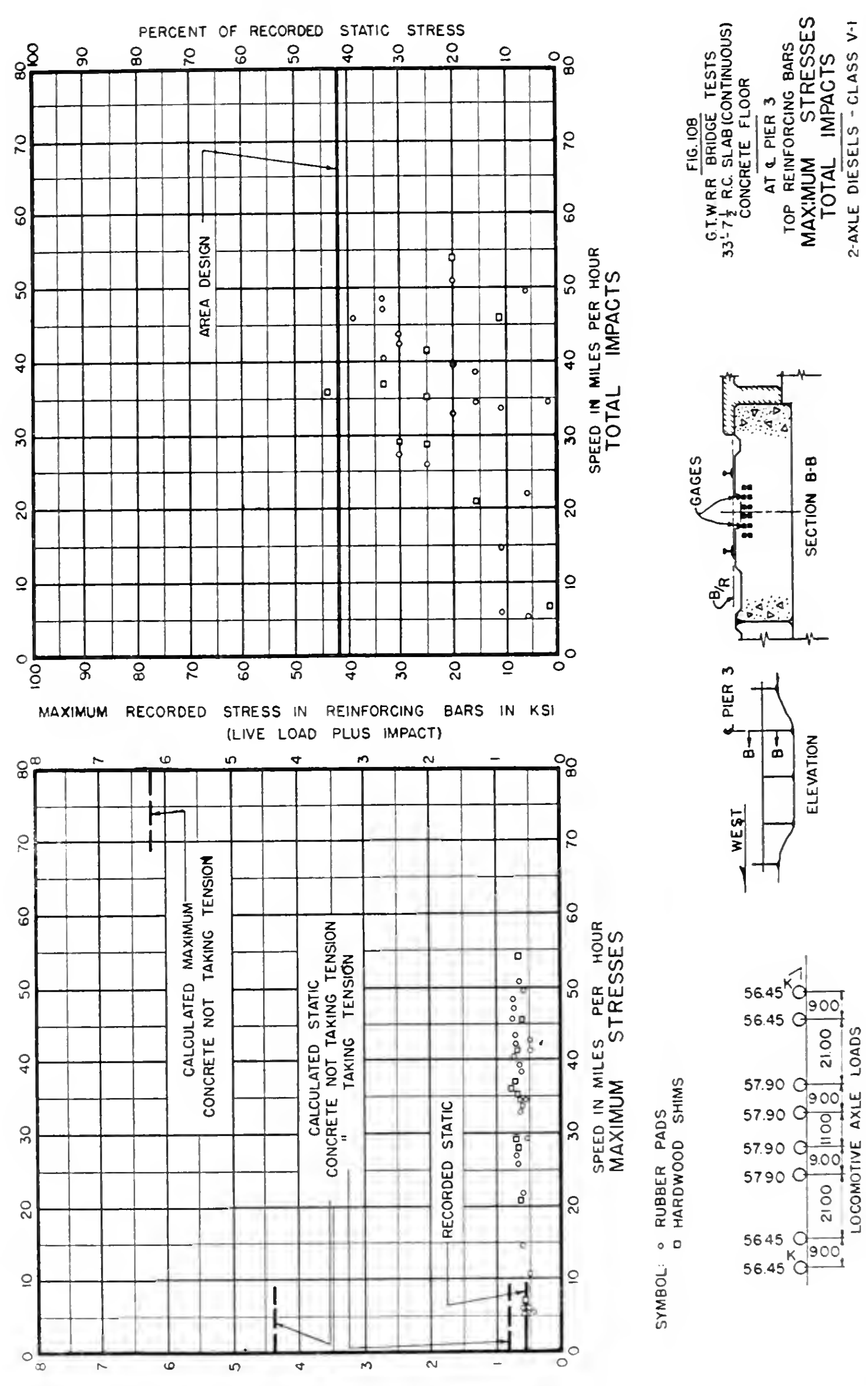


FIG. 108
G.T.W.R.R. BRIDGE TESTS
33'-7½" R.C. SLAB (CONTINUOUS) CONCRETE FLOOR
AT ℄ PIER 3
TOP REINFORCING BARS
MAXIMUM STRESSES
TOTAL IMPACTS
2-AXLE DIESELS - CLASS V-1

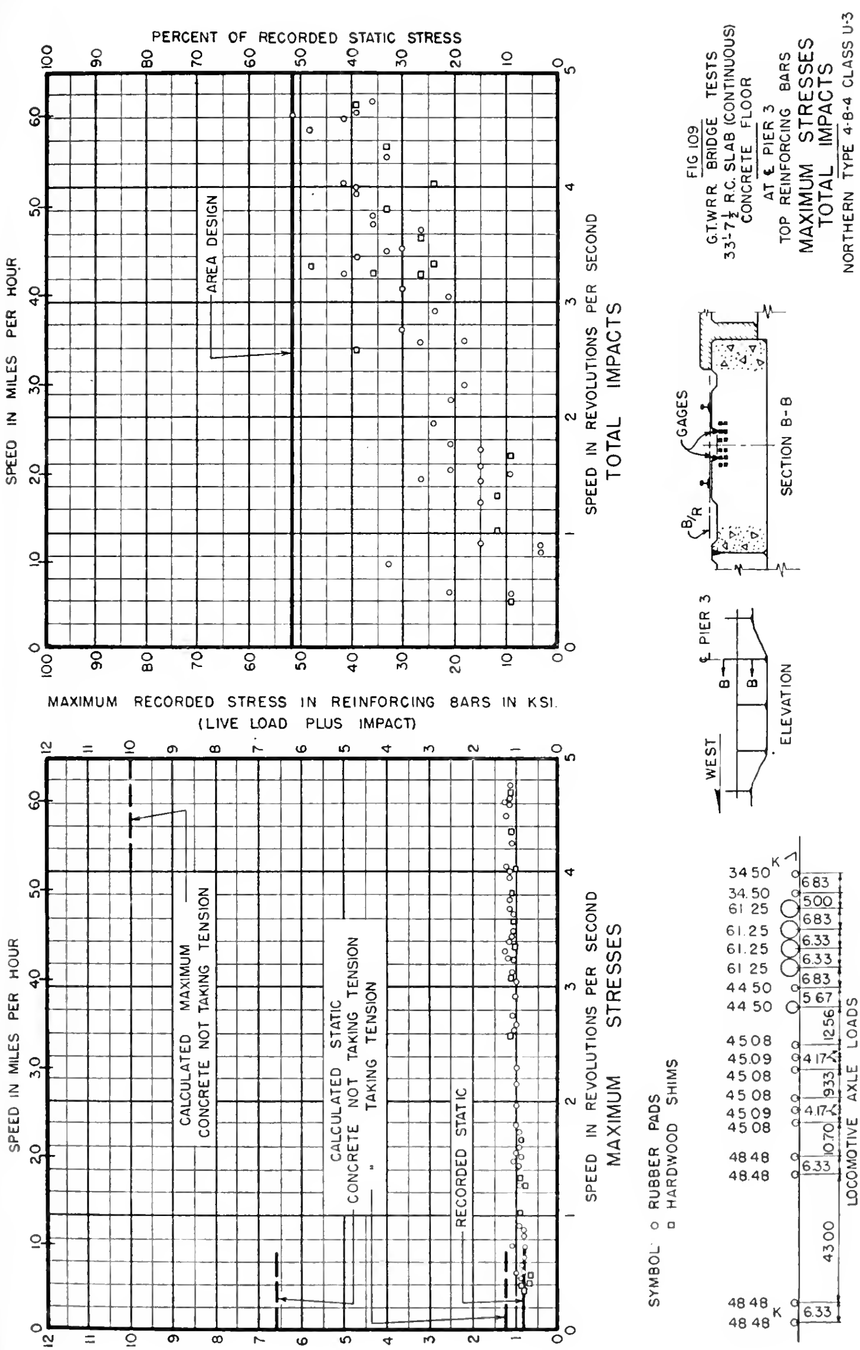


FIG 109
G.T.W.R.R. BRIDGE TESTS
33'-7½ R.C. SLAB (CONTINUOUS)
CONCRETE FLOOR
AT ℄ PIER 3
TOP REINFORCING BARS
MAXIMUM STRESSES
TOTAL IMPACTS
NORTHERN TYPE 4-8-4 CLASS U-3

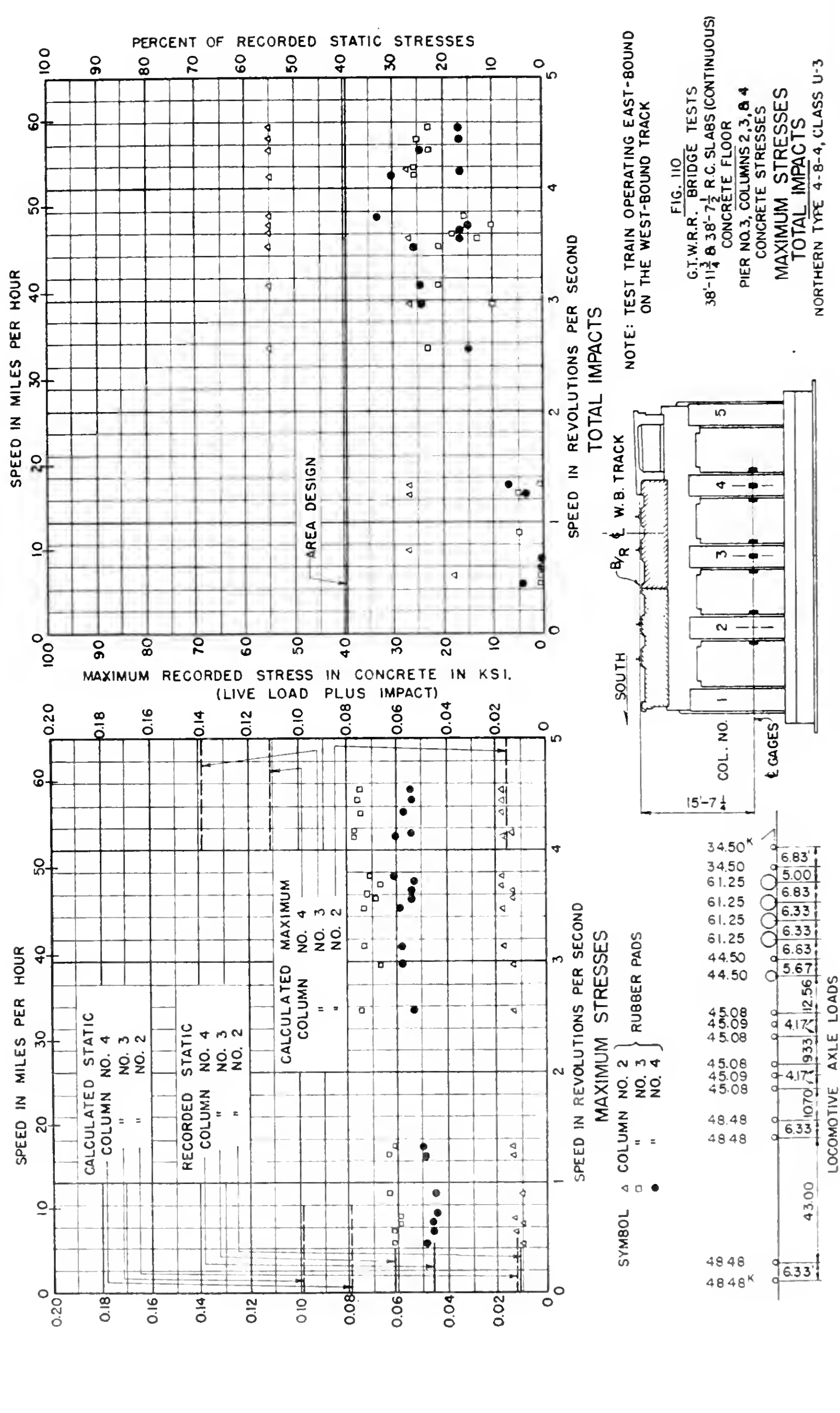
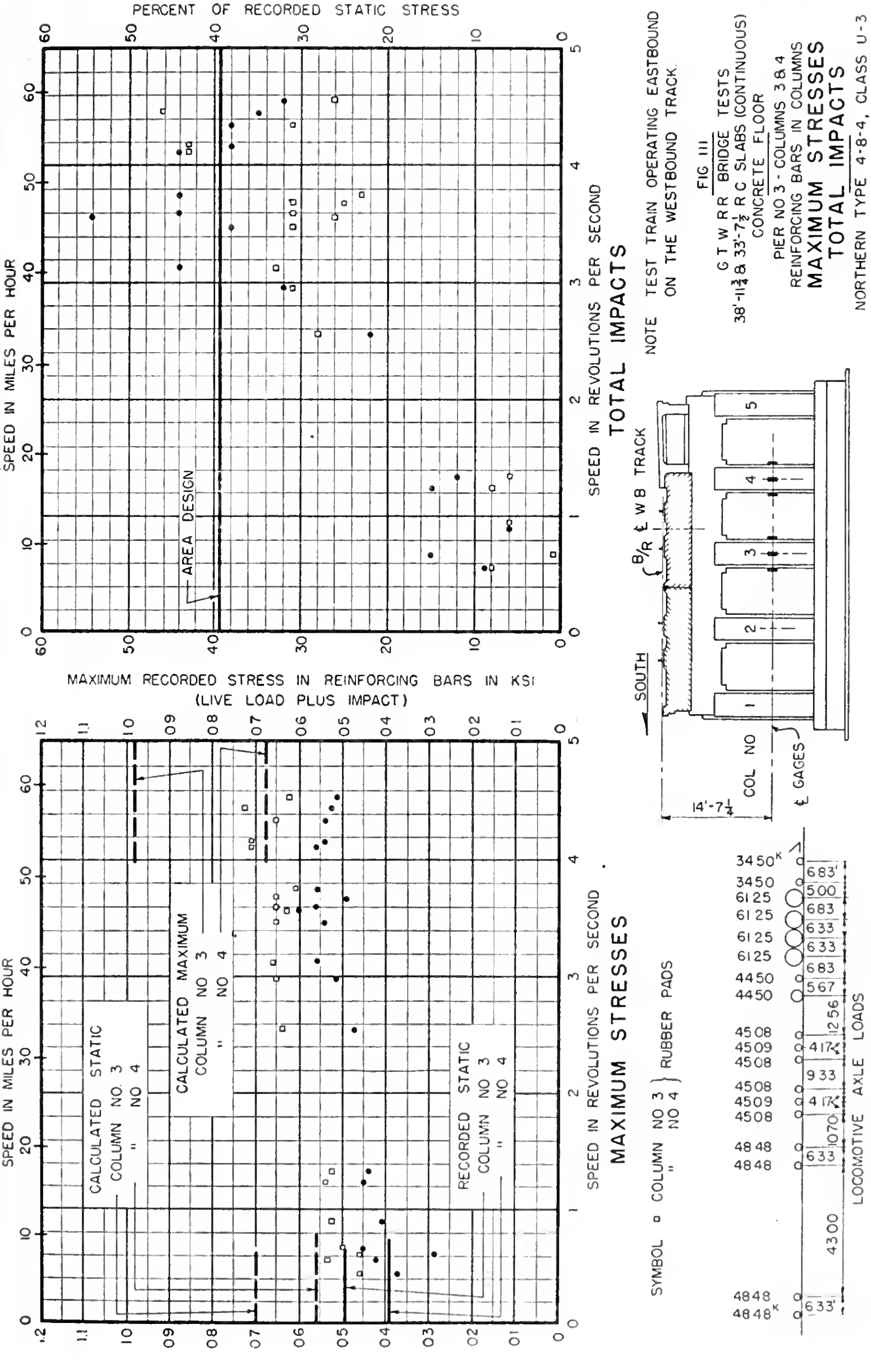


FIG. 110
G.T.W.R.R. BRIDGE TESTS
38'-11¾ & 38'-7½ R.C. SLABS (CONTINUOUS)
CONCRETE FLOOR
PIER NO.3, COLUMNS 2,3,& 4
CONCRETE STRESSES
MAXIMUM STRESSES
TOTAL IMPACTS
NORTHERN TYPE 4-8-4, CLASS U-3



NOTE TEST TRAIN OPERATING EASTBOUND ON THE WESTBOUND TRACK.

FIG 111
G T W R R BRIDGE TESTS
38'-11¾ & 33'-7½ R C SLABS (CONTINUOUS) CONCRETE FLOOR
PIER NO 3 - COLUMNS 3 & 4
REINFORCING BARS IN COLUMNS
MAXIMUM STRESSES
TOTAL IMPACTS
NORTHERN TYPE 4-8-4, CLASS U-3

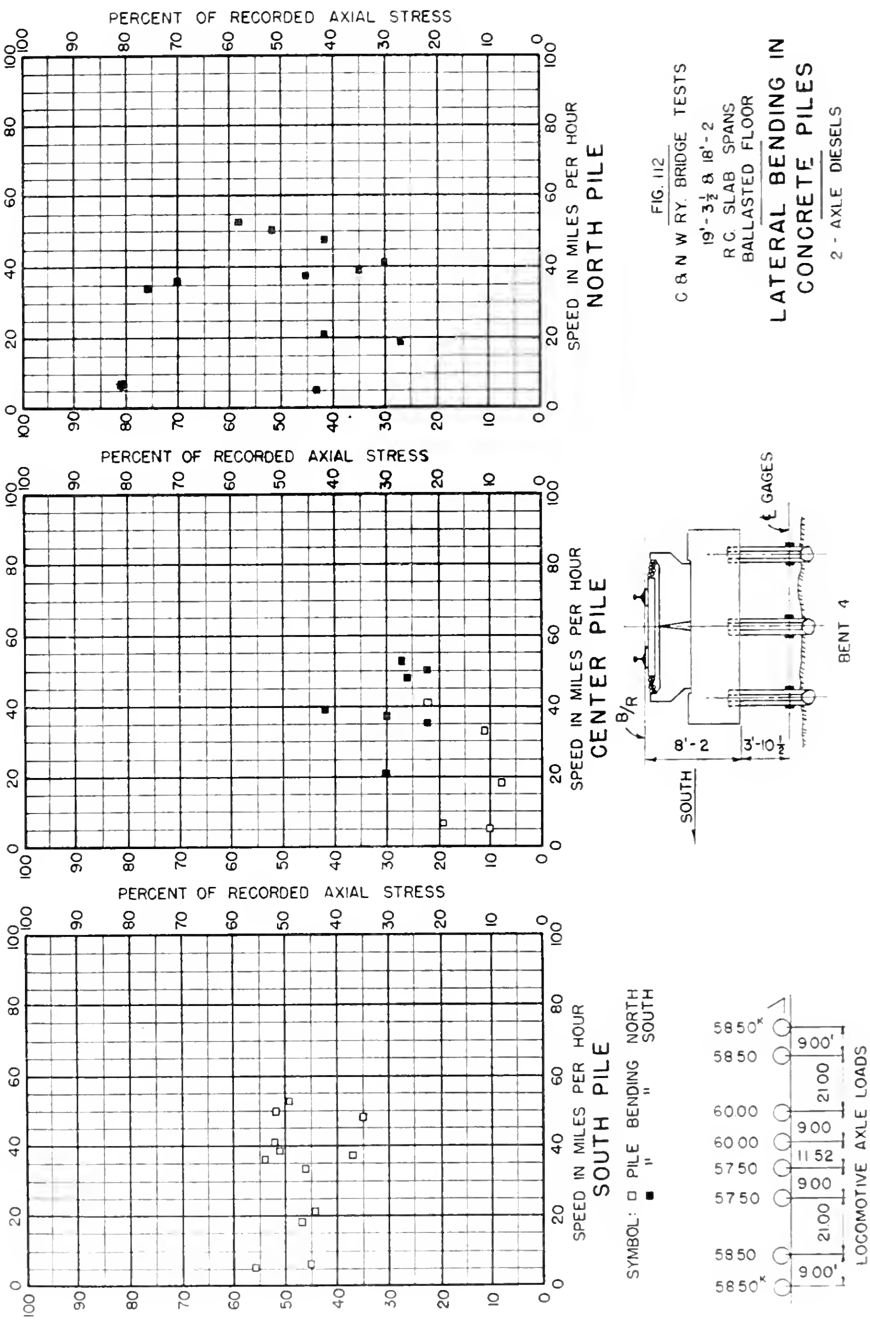


FIG. 112
C & N W RY. BRIDGE TESTS
19'-3½ & 18'-2
R.C. SLAB SPANS
BALLASTED FLOOR
LATERAL BENDING IN CONCRETE PILES
2 - AXLE DIESELS

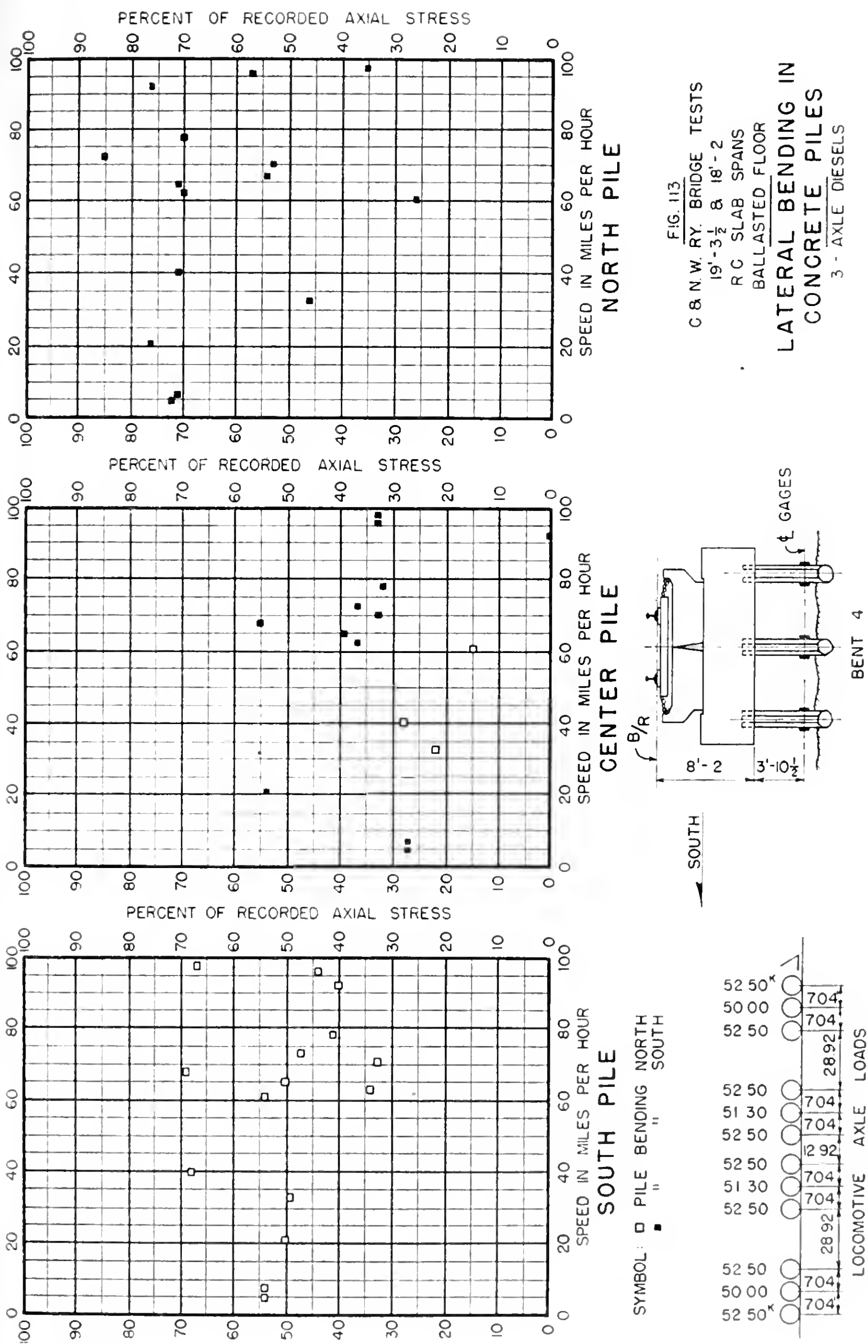


FIG. 113
C & N.W. RY. BRIDGE TESTS
19'-3½ & 18'-2
R C SLAB SPANS
BALLASTED FLOOR
LATERAL BENDING IN CONCRETE PILES
3 - AXLE DIESELS

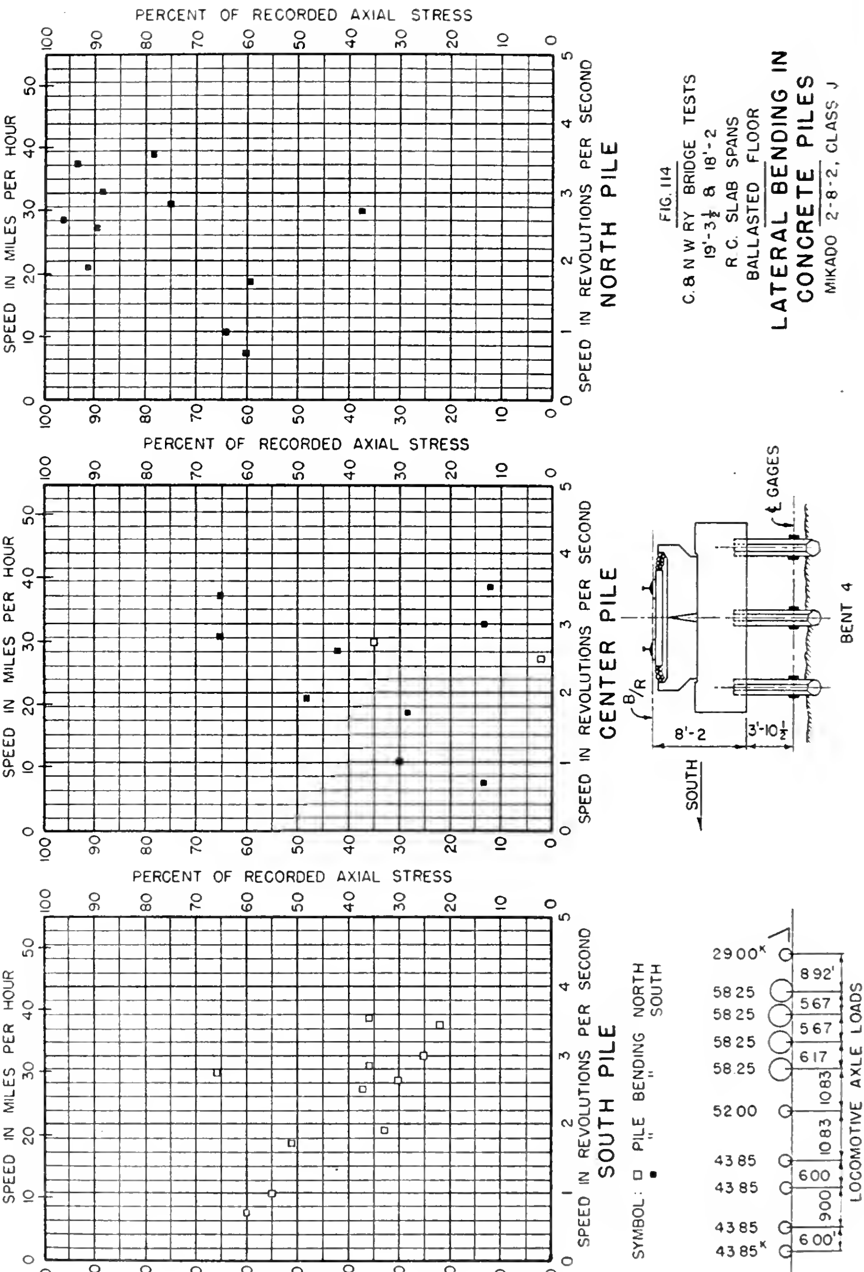


FIG. 114
C. & N W RY BRIDGE TESTS
19'-3½ & 18'-2
R.C. SLAB SPANS
BALLASTED FLOOR
LATERAL BENDING IN CONCRETE PILES
MIKADO 2-8-2, CLASS J

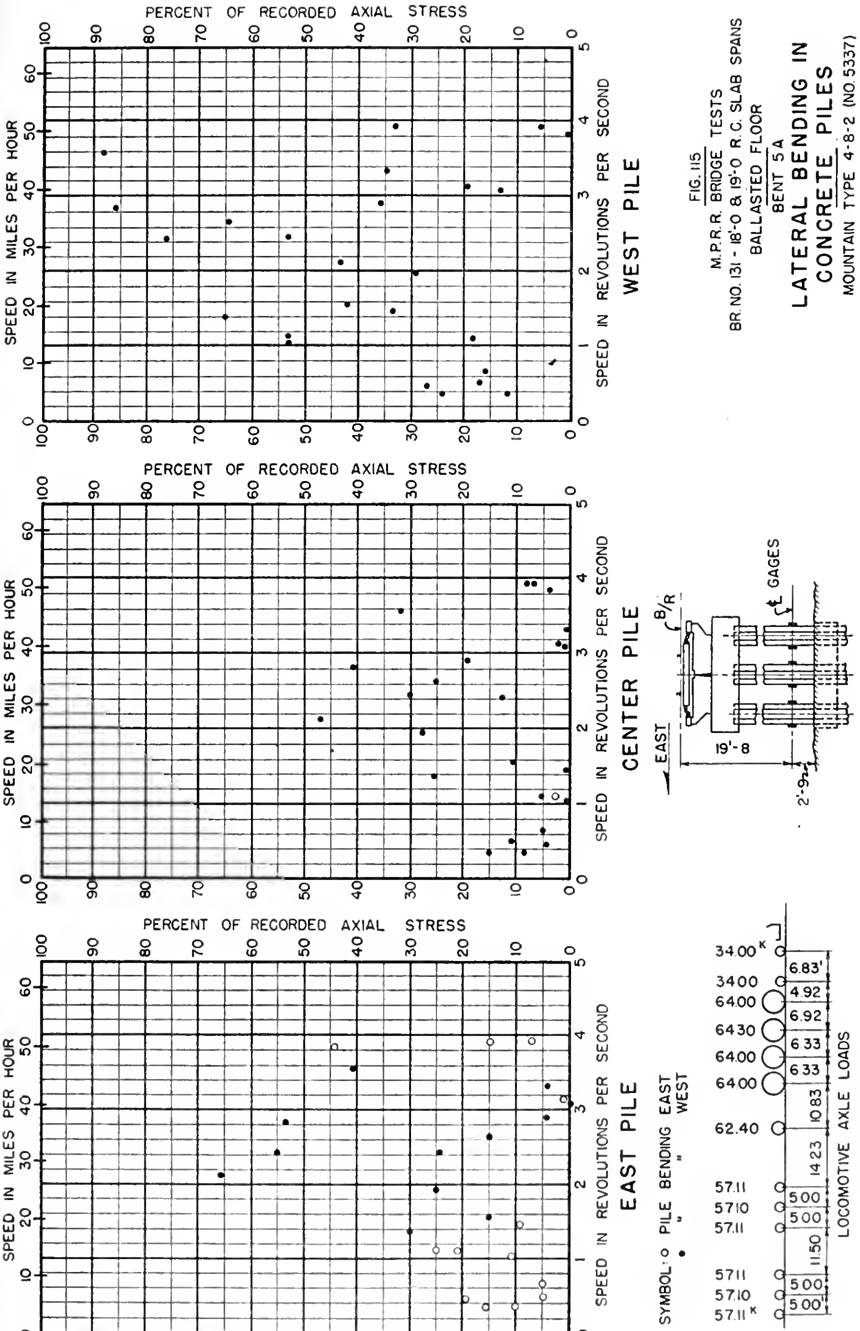


FIG. 115
M.P.R.R. BRIDGE TESTS
BR. NO. 131 - 18'-0 & 19'-0 R.C. SLAB SPANS
BALLASTED FLOOR
BENT 5A
LATERAL BENDING IN CONCRETE PILES
MOUNTAIN TYPE 4-8-2 (NO. 5337)

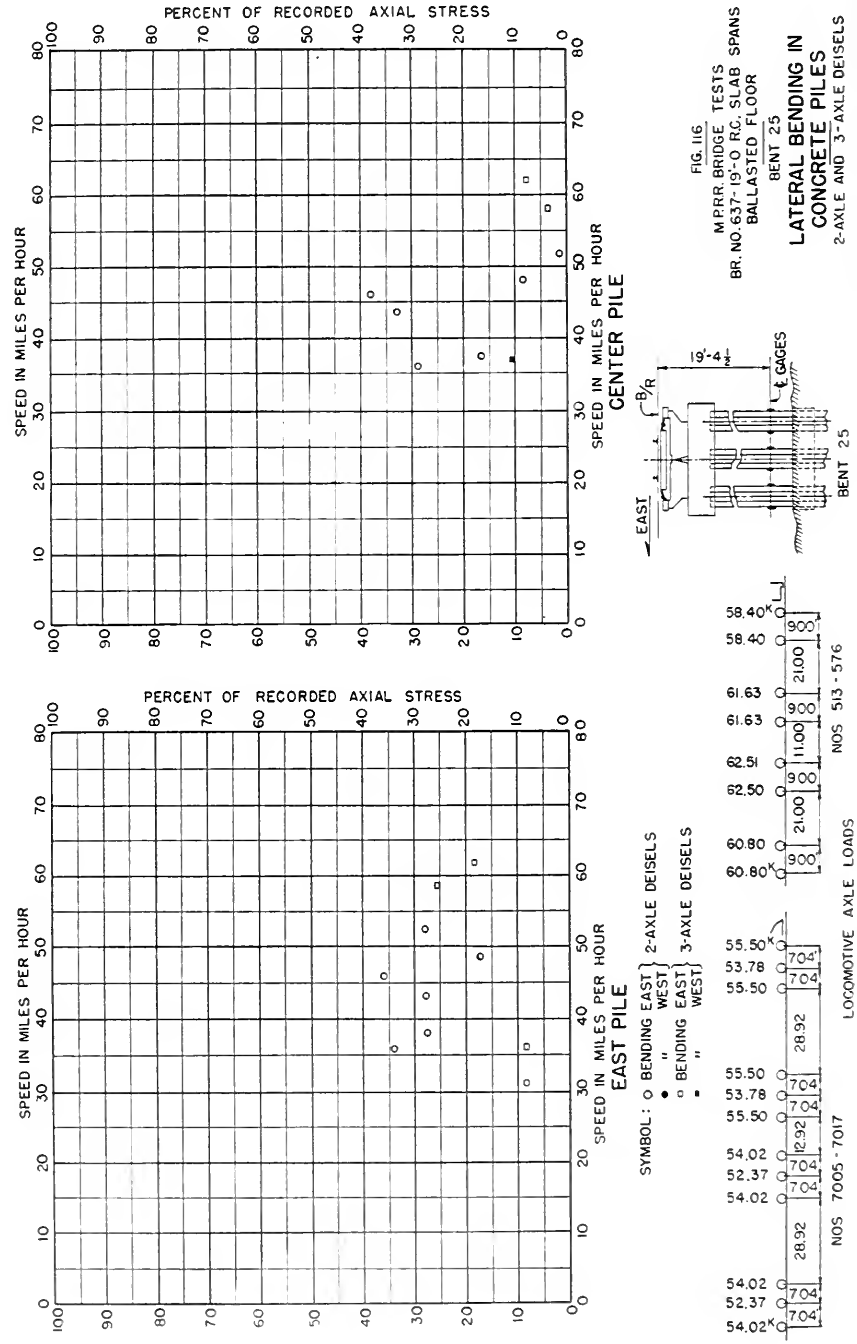


FIG. 116
M.P.R.R. BRIDGE TESTS
BR. NO. 637-19'-0 R.C. SLAB SPANS
BALLASTED FLOOR
BENT 25
LATERAL BENDING IN CONCRETE PILES
2-AXLE AND 3-AXLE DEISELS

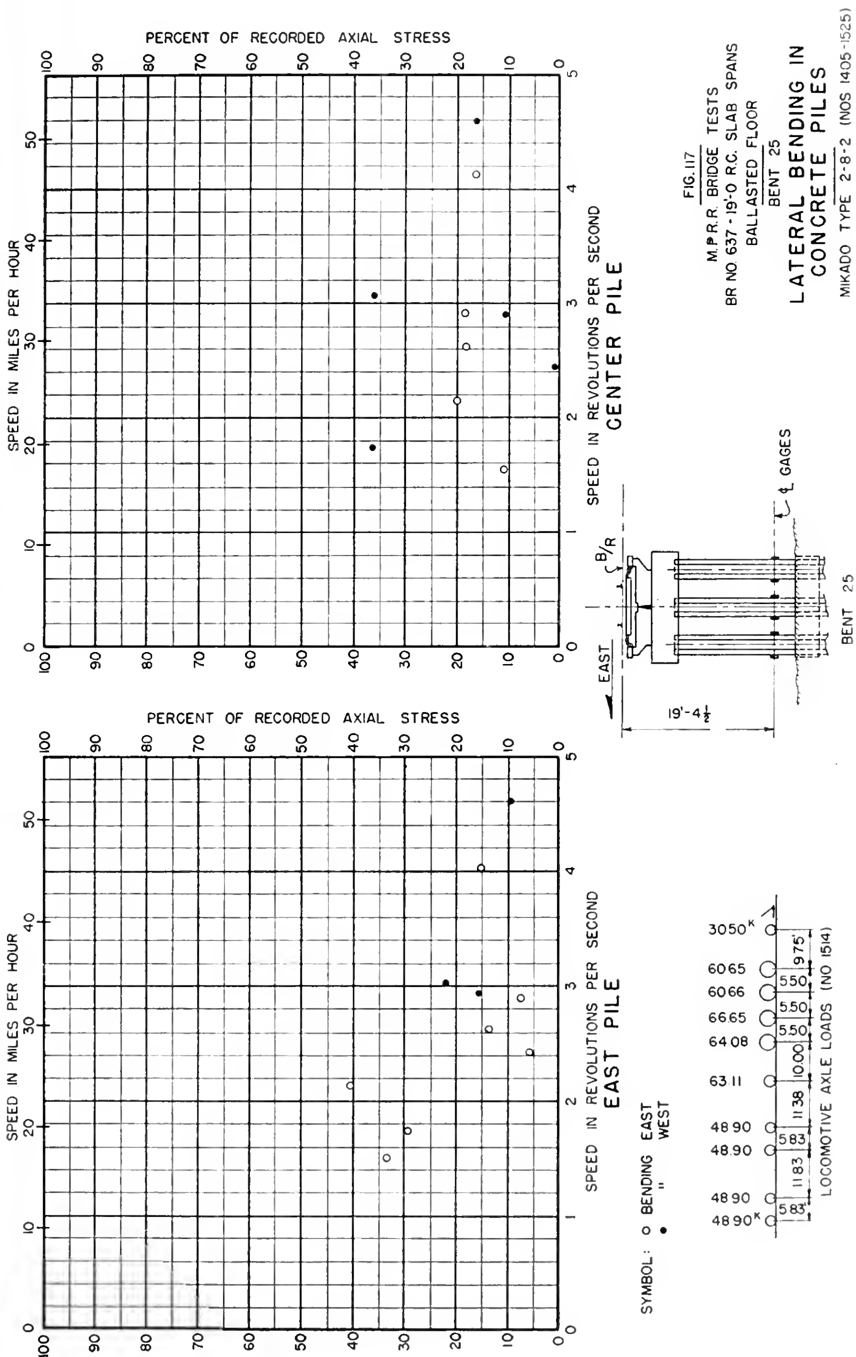


FIG. 117
M. P R.R. BRIDGE TESTS
BR NO 637 - 19'-0 R.C. SLAB SPANS
BALLASTED FLOOR
BENT 25
LATERAL BENDING IN CONCRETE PILES
MIKADO TYPE 2-8-2 (NOS 1405-1525)

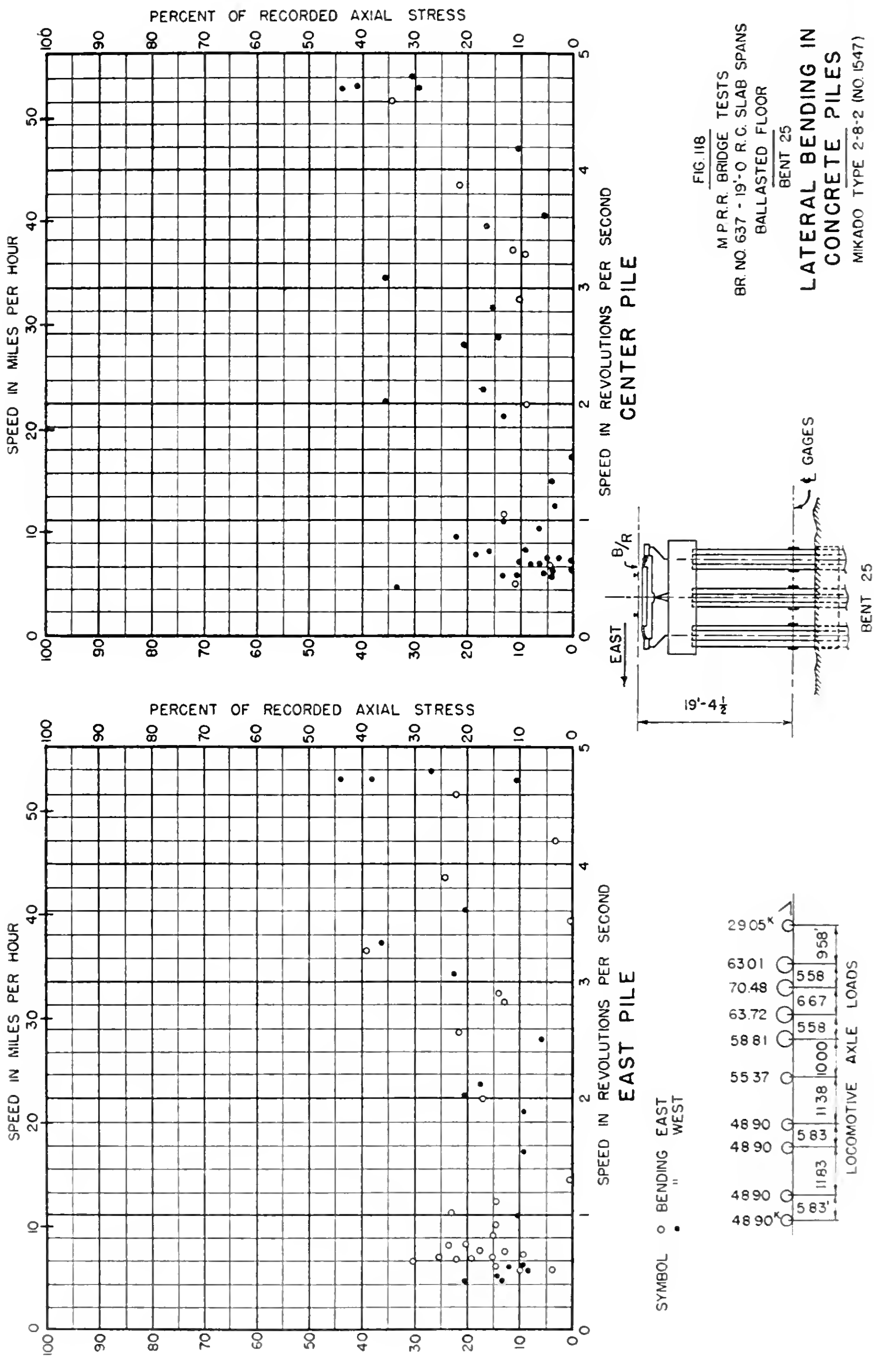


FIG. 118
M.P.R.R. BRIDGE TESTS
BR. NO. 637 - 19'-0 R.C. SLAB SPANS
BALLASTED FLOOR
BENT 25

LATERAL BENDING IN CONCRETE PILES
MIKADO TYPE 2-8-2 (NO. 1547)

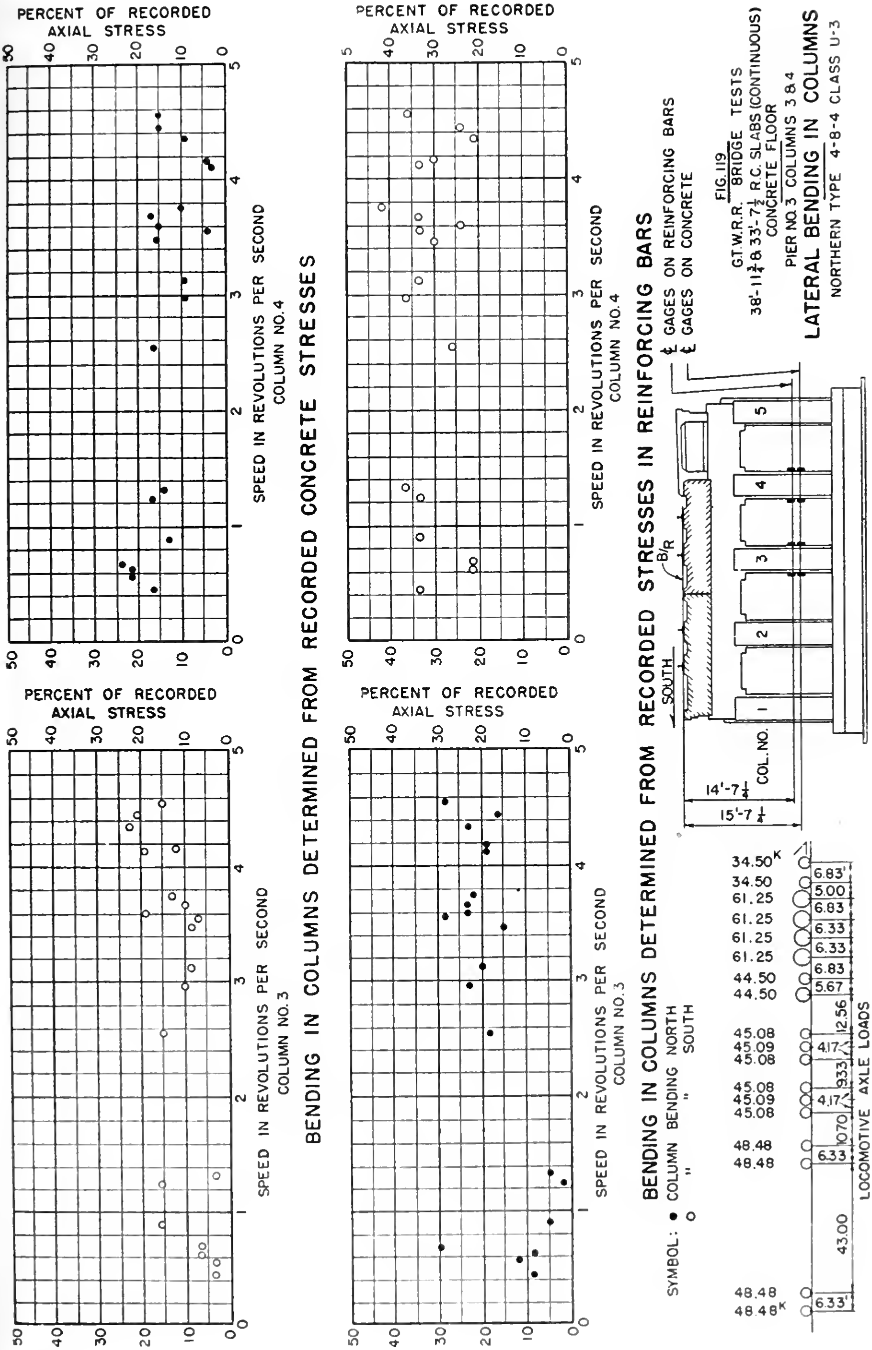


FIG. 119
G.T.W.R.R. BRIDGE TESTS
38'-11¼ & 33'-7½ R.C. SLABS (CONTINUOUS) CONCRETE FLOOR
PIER NO. 3 COLUMNS 3 & 4
LATERAL BENDING IN COLUMNS
NORTHERN TYPE 4-8-4 CLASS U-3

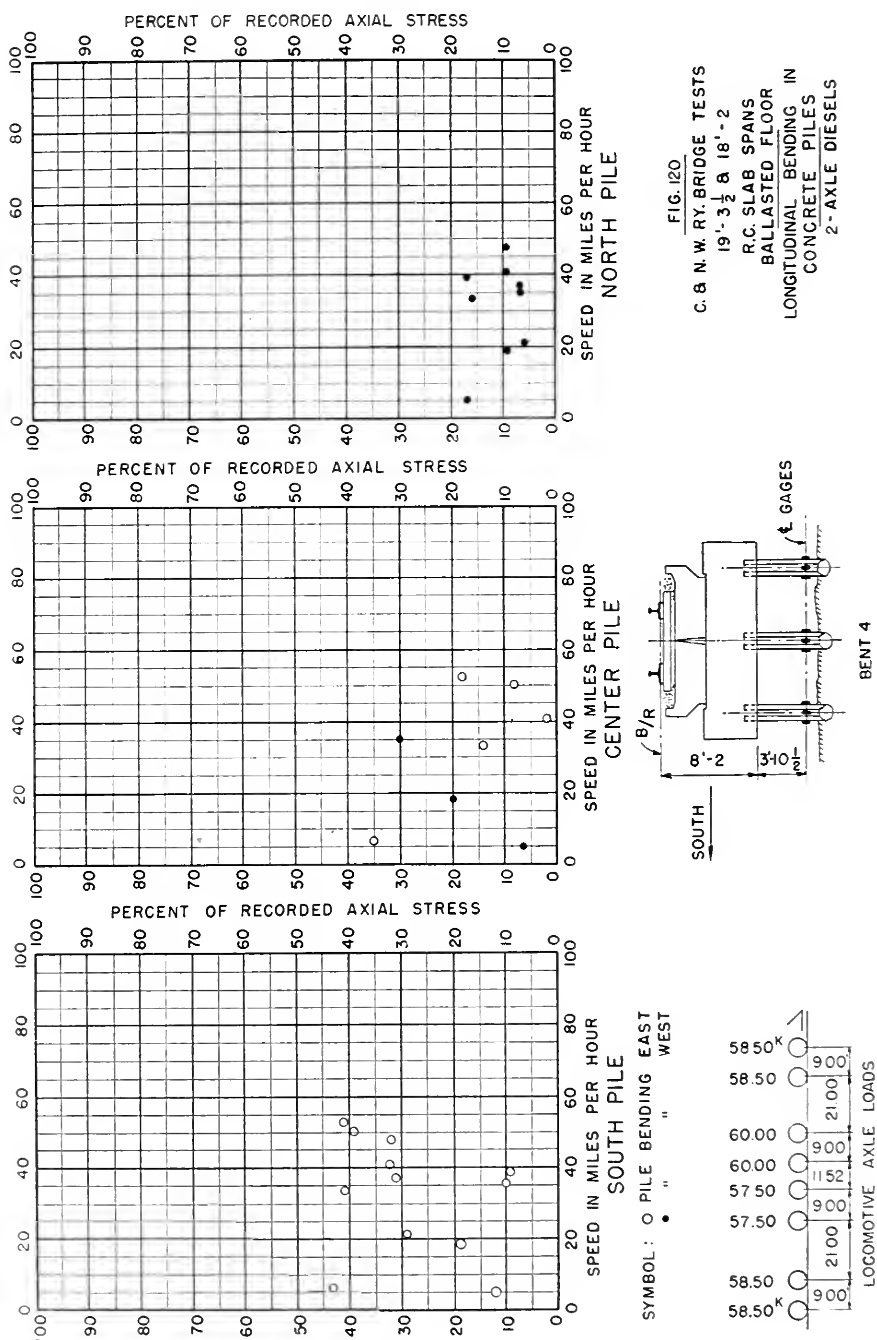


FIG. 120
C. & N. W. RY. BRIDGE TESTS
19'-3½ & 18'-2
R.C. SLAB SPANS
BALLASTED FLOOR
LONGITUDINAL BENDING IN
CONCRETE PILES
2-AXLE DIESELS

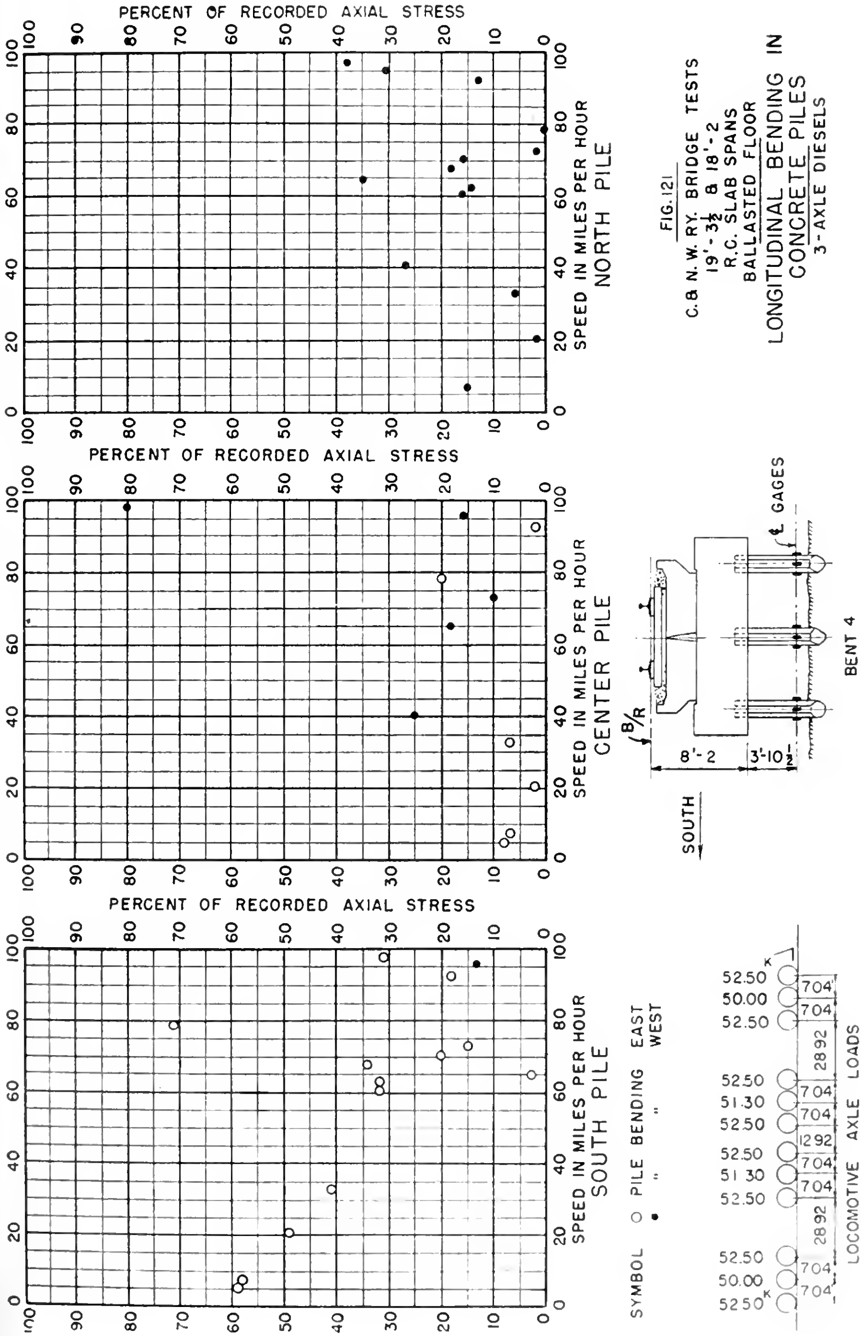


FIG. 121
C. & N. W. RY. BRIDGE TESTS
19'-3½ & 18'-2
R.C. SLAB SPANS
BALLASTED FLOOR
LONGITUDINAL BENDING IN CONCRETE PILES
3-AXLE DIESELS

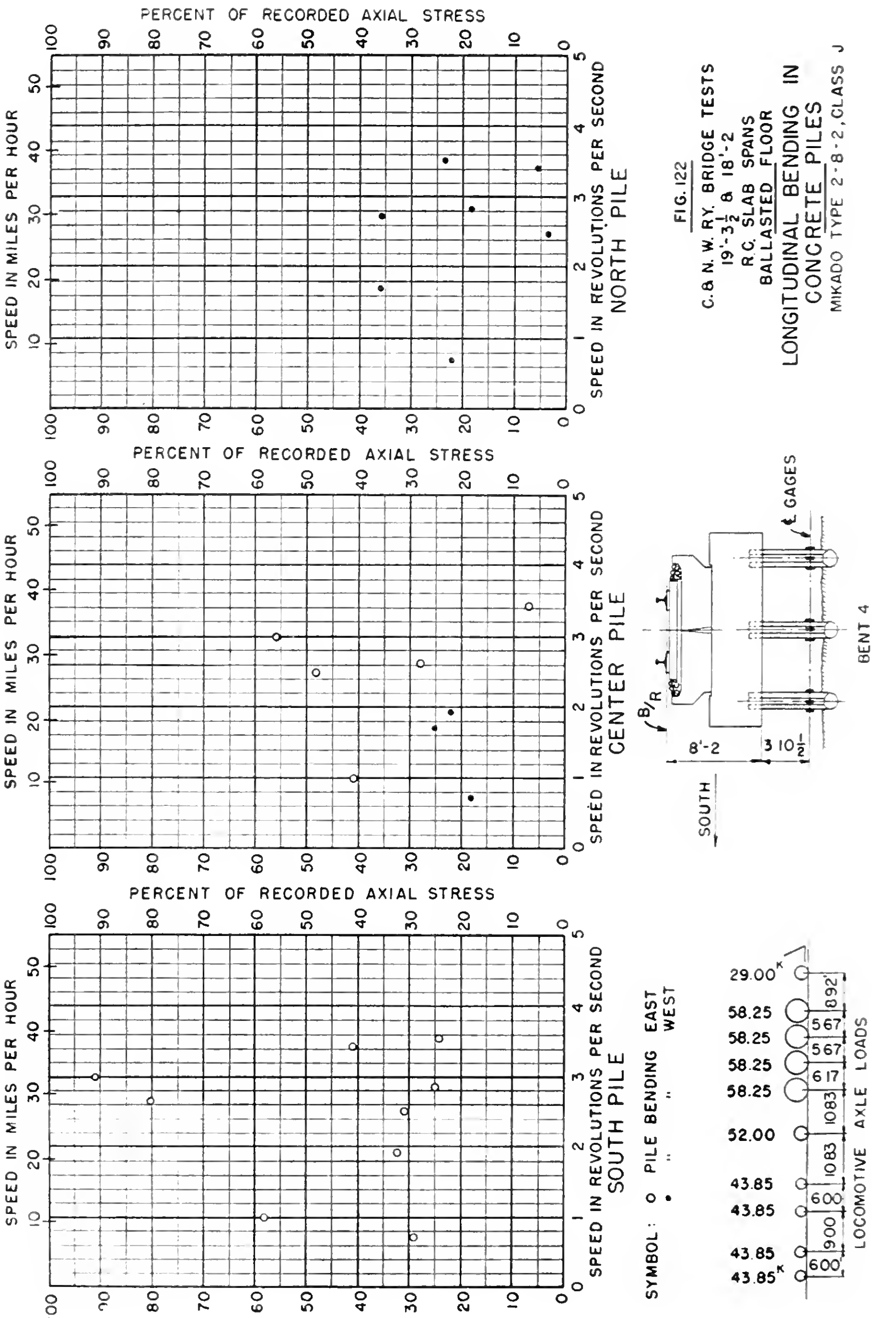


FIG. 122
C. & N. W. RY. BRIDGE TESTS
19'-3½ & 18'-2
R.C. SLAB SPANS
BALLASTED FLOOR
LONGITUDINAL BENDING IN CONCRETE PILES
MIKADO TYPE 2-8-2, CLASS J

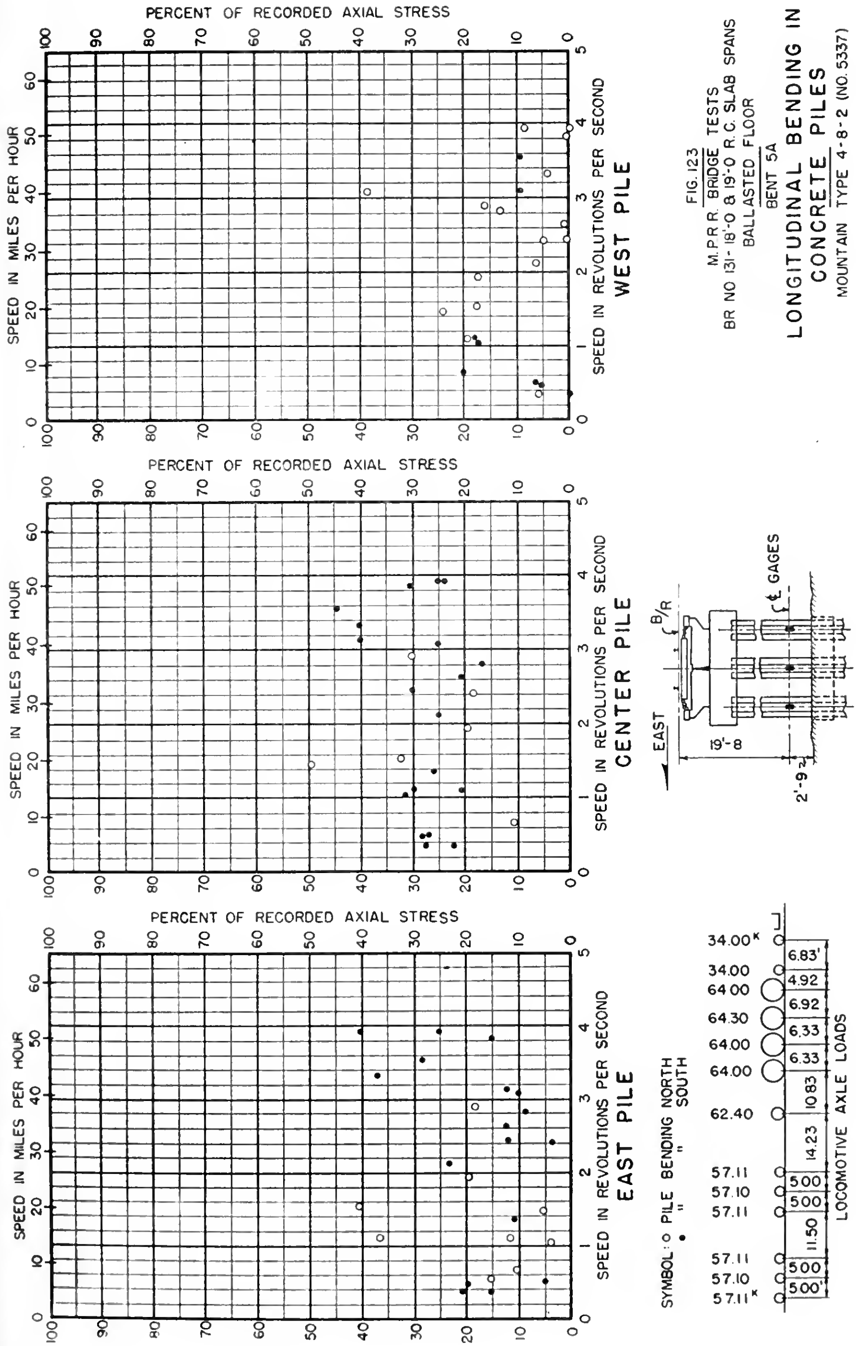


FIG. 123
M.P.R.R. BRIDGE TESTS
BR NO 131 - 18'-0 & 19'-0 R.C. SLAB SPANS
BALLASTED FLOOR
BENT 5A
LONGITUDINAL BENDING IN CONCRETE PILES
MOUNTAIN TYPE 4-8-2 (NO. 5337)

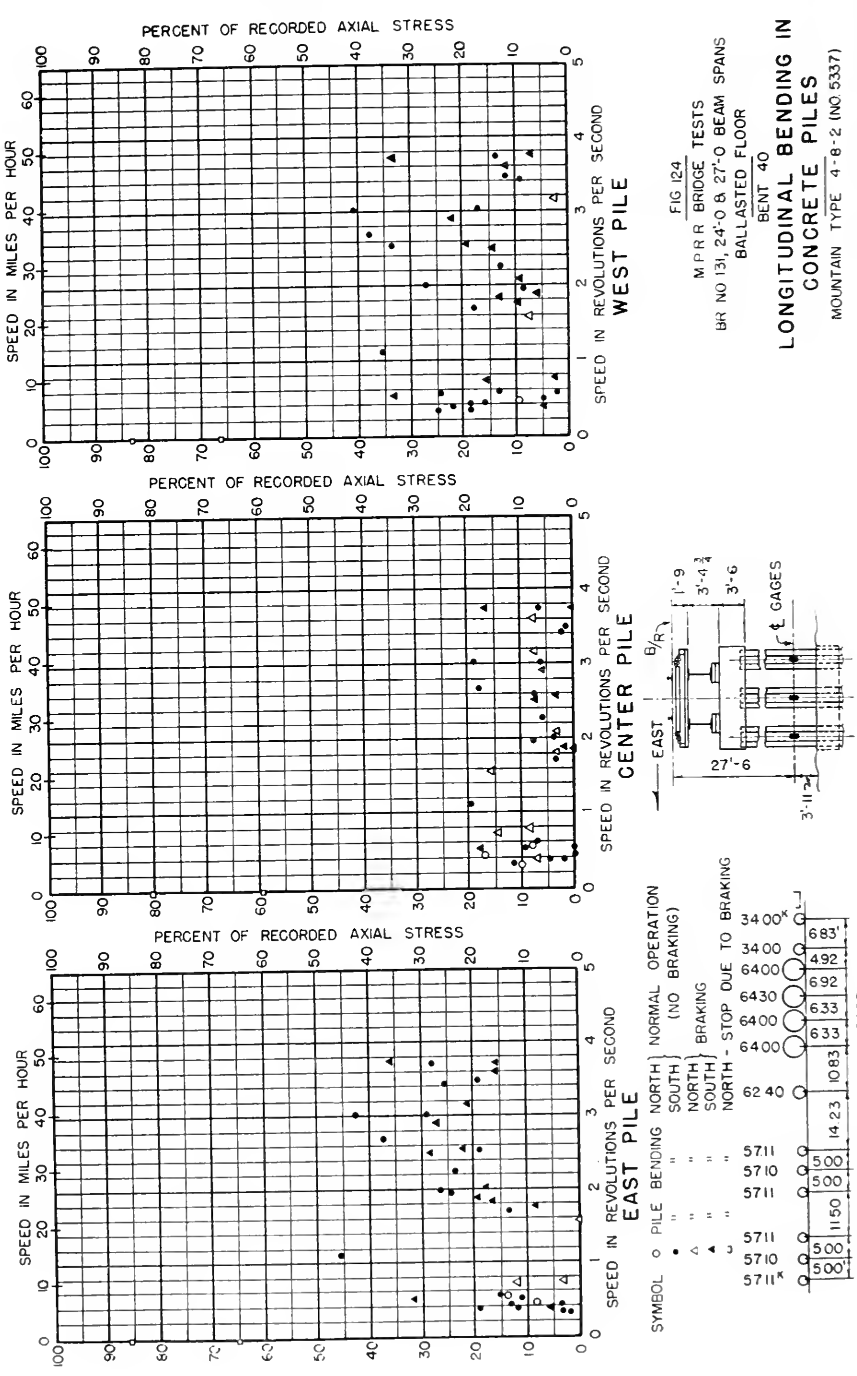


FIG 124

MPRR BRIDGE TESTS

BR NO 131, 24'-0 & 27'-0 BEAM SPANS

BALLASTED FLOOR

BENT 40

LONGITUDINAL BENDING IN CONCRETE PILES

MOUNTAIN TYPE 4-8-2 (NO 5337)

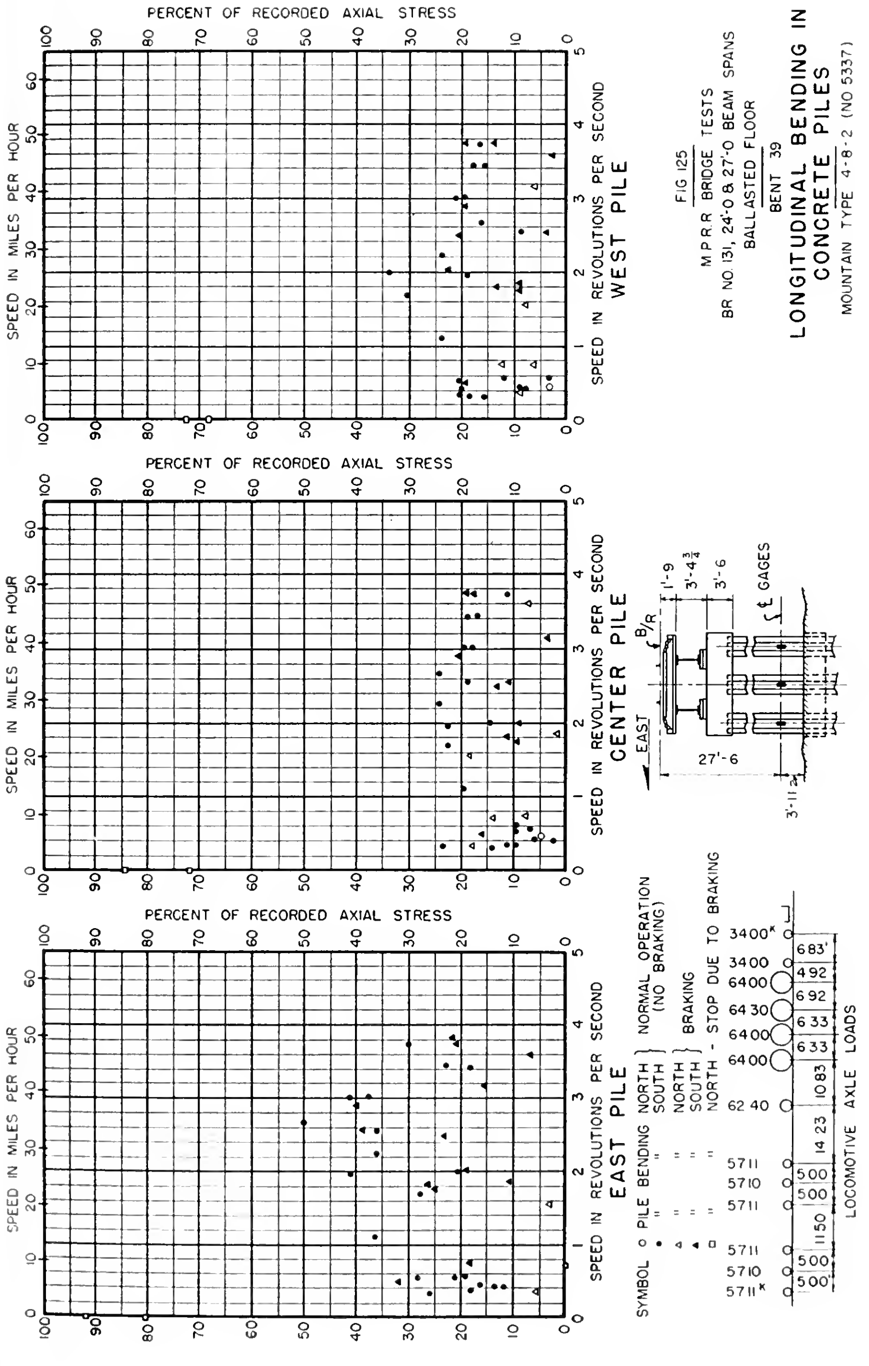


FIG 125

M P R.R BRIDGE TESTS

BR NO. 131, 24'-0 & 27'-0 BEAM SPANS

BALLASTED FLOOR

BENT 39

LONGITUDINAL BENDING IN CONCRETE PILES

MOUNTAIN TYPE 4-8-2 (NO 5337)

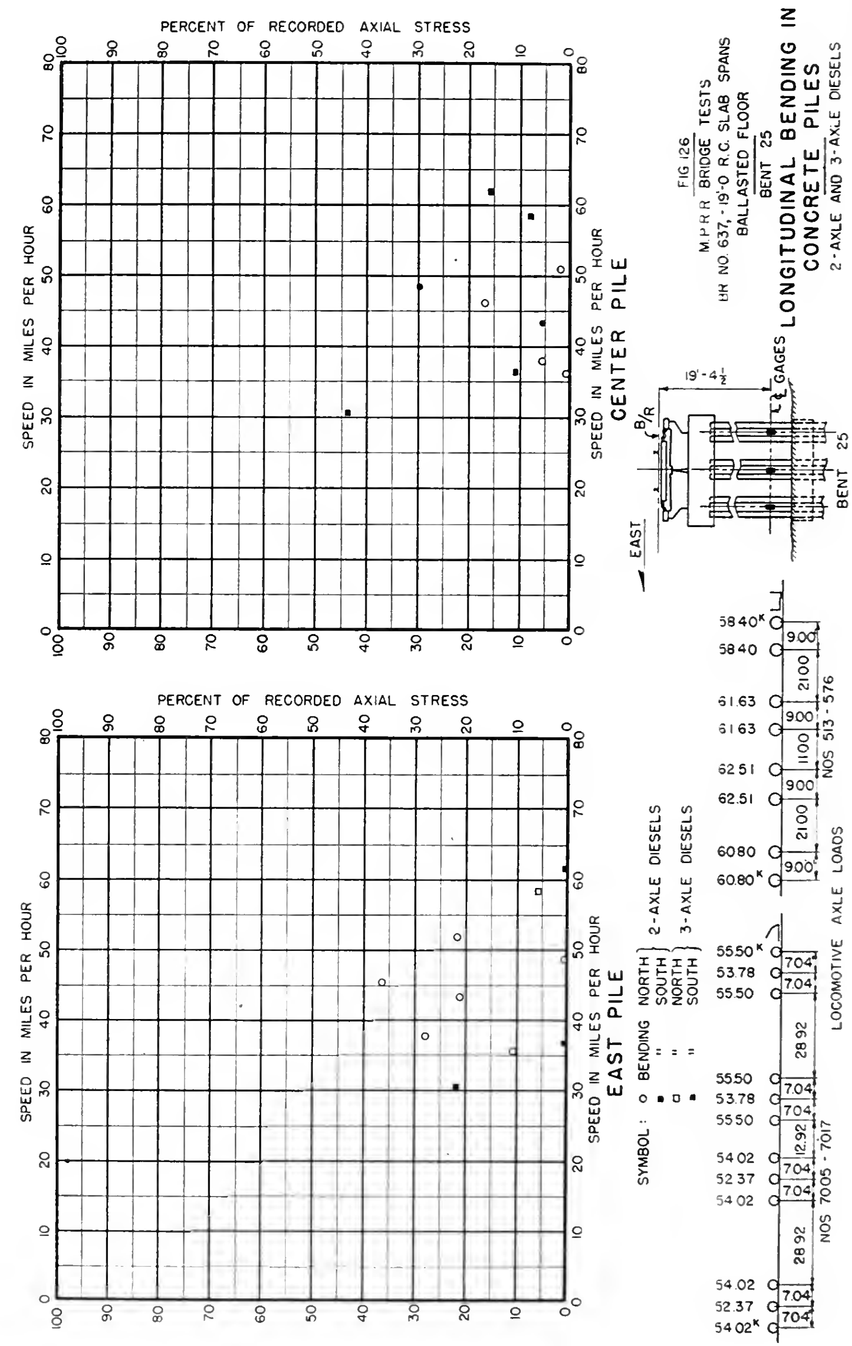


FIG 126
M.P.R.R. BRIDGE TESTS
BR NO. 637, - 19'-0 R.C. SLAB SPANS
BALLASTED FLOOR
BENT 25
LONGITUDINAL BENDING IN CONCRETE PILES
2-AXLE AND 3-AXLE DIESELS

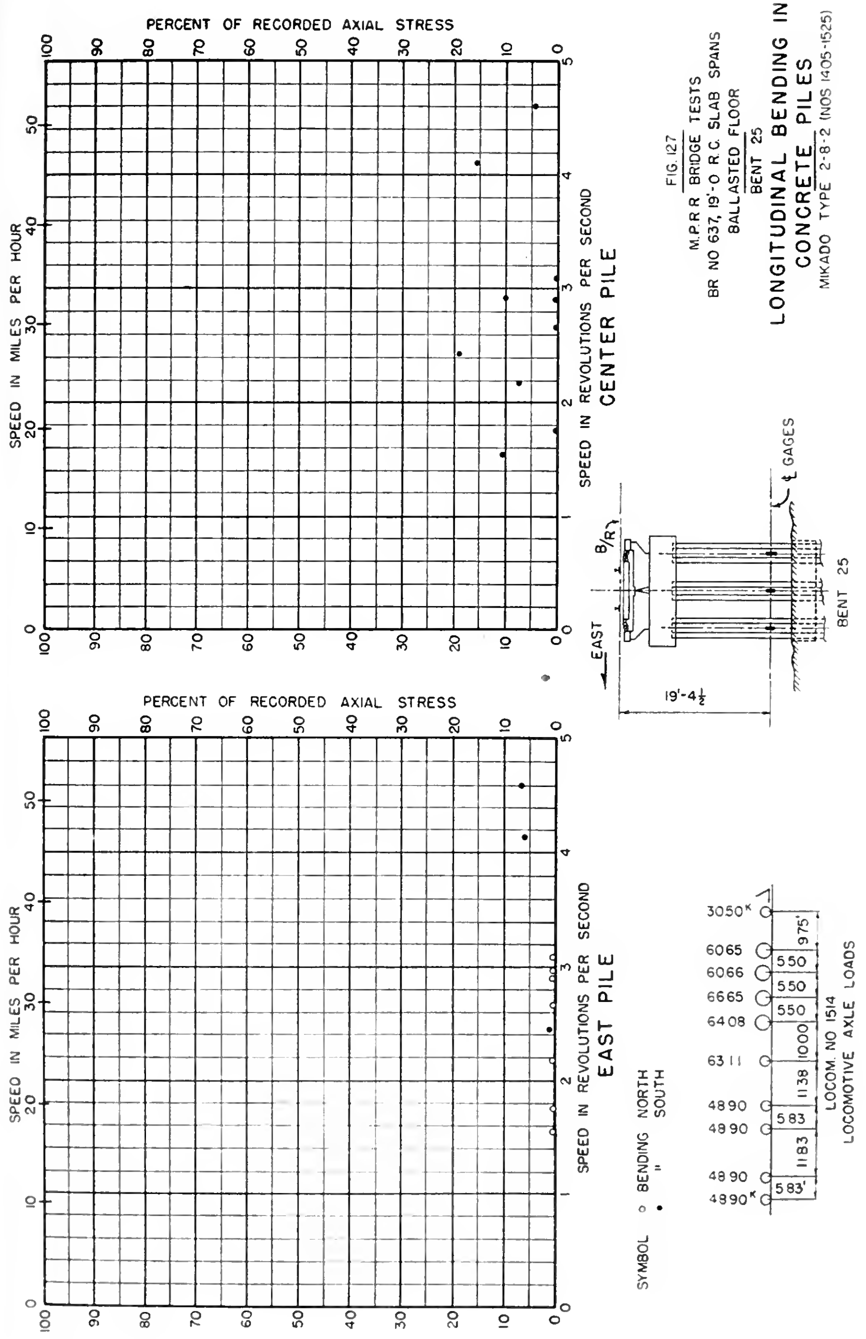


FIG. 127
M.P.R.R. BRIDGE TESTS
BR NO 637, 19'-0 R.C. SLAB SPANS
BALLASTED FLOOR
BENT 25
LONGITUDINAL BENDING IN
CONCRETE PILES
MIKADO TYPE 2-8-2 (NOS 1405-1525)

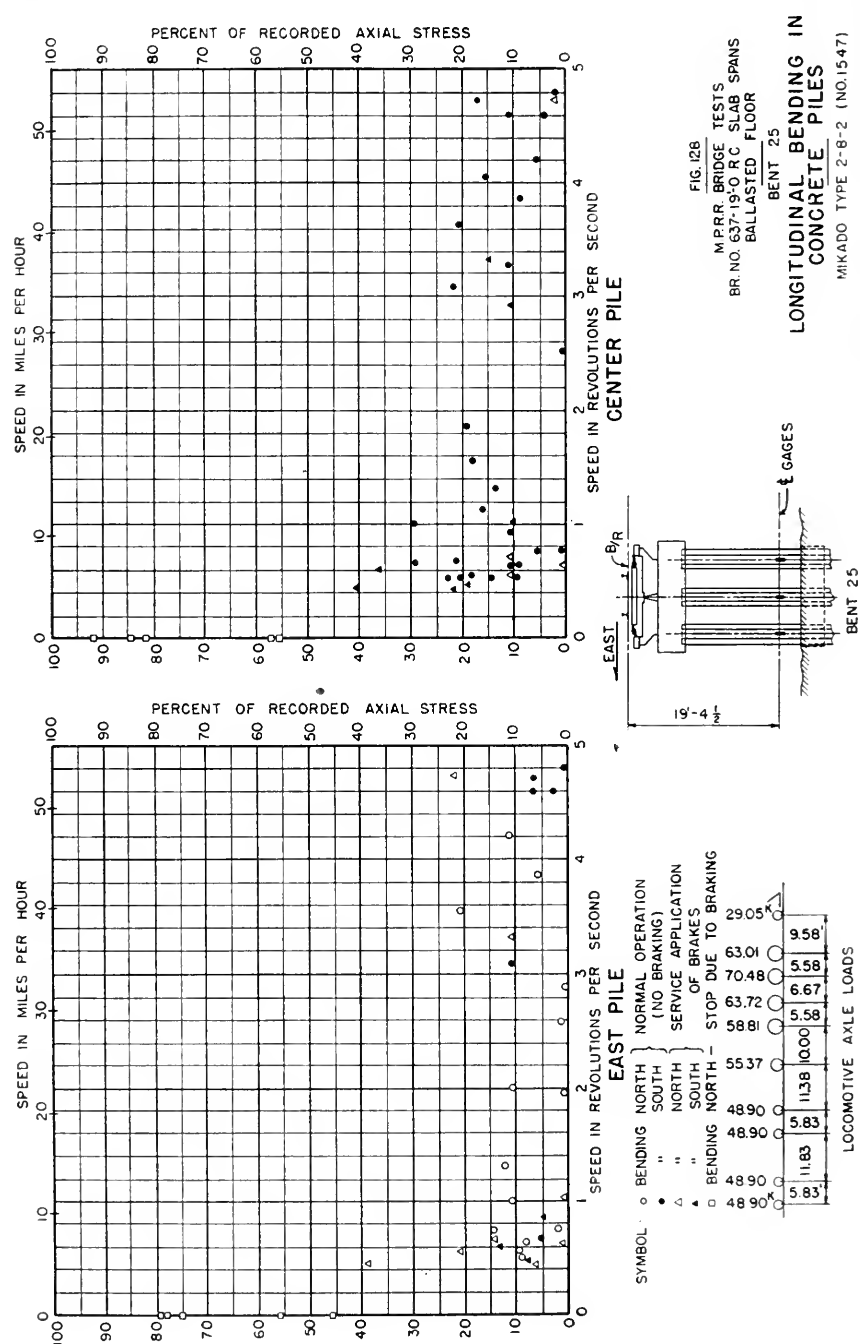


FIG. 128
M.P.R.R. BRIDGE TESTS
BR. NO. 637-19'-0 R.C. SLAB SPANS
BALLASTED FLOOR
BENT 25
LONGITUDINAL BENDING IN CONCRETE PILES
MIKADO TYPE 2-8-2 (NO.1547)

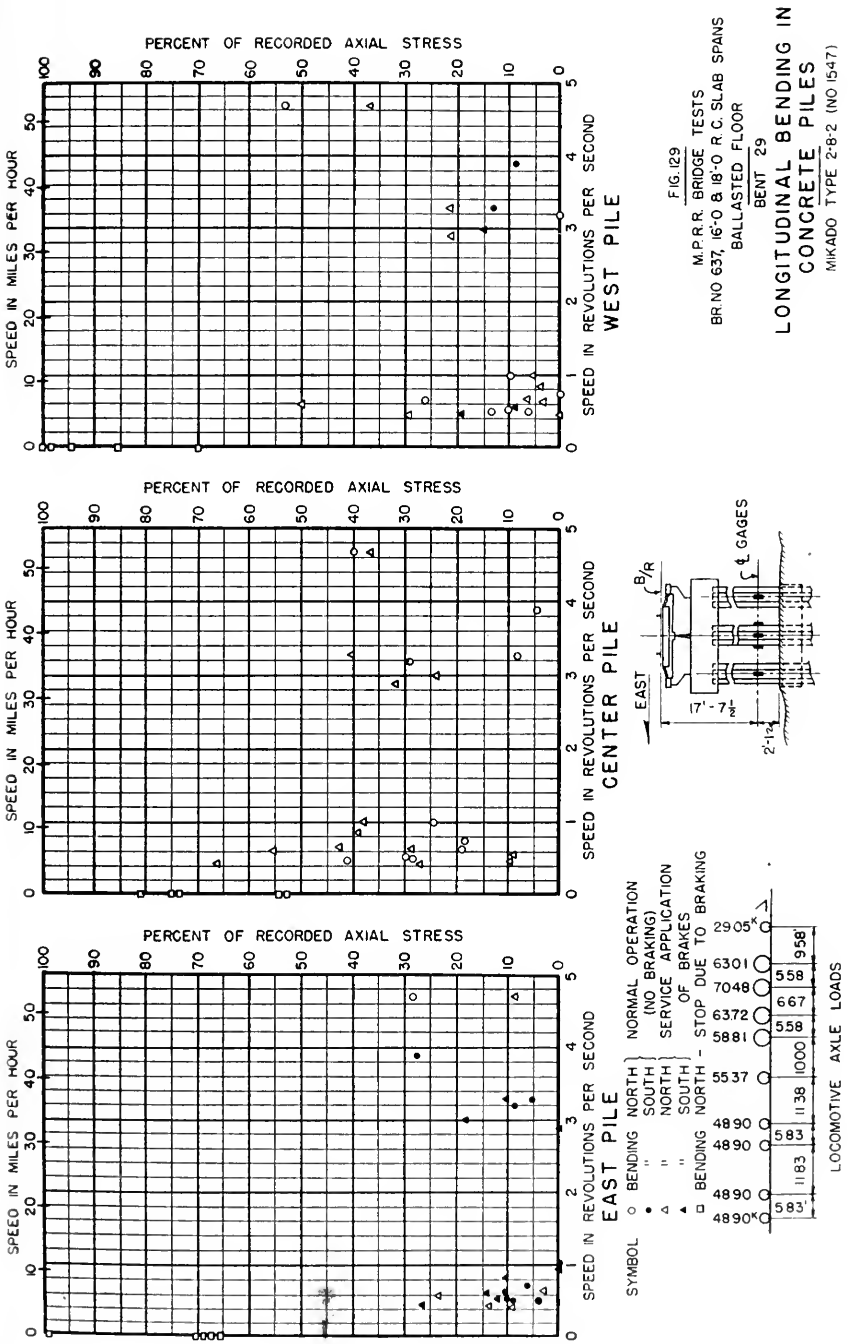


FIG. 129
M.P.R.R. BRIDGE TESTS
BR. NO 637, 16'-0 & 18'-0 R.C. SLAB SPANS
BALLASTED FLOOR
BENT 29
LONGITUDINAL BENDING IN CONCRETE PILES
MIKADO TYPE 2-8-2 (NO 1547)

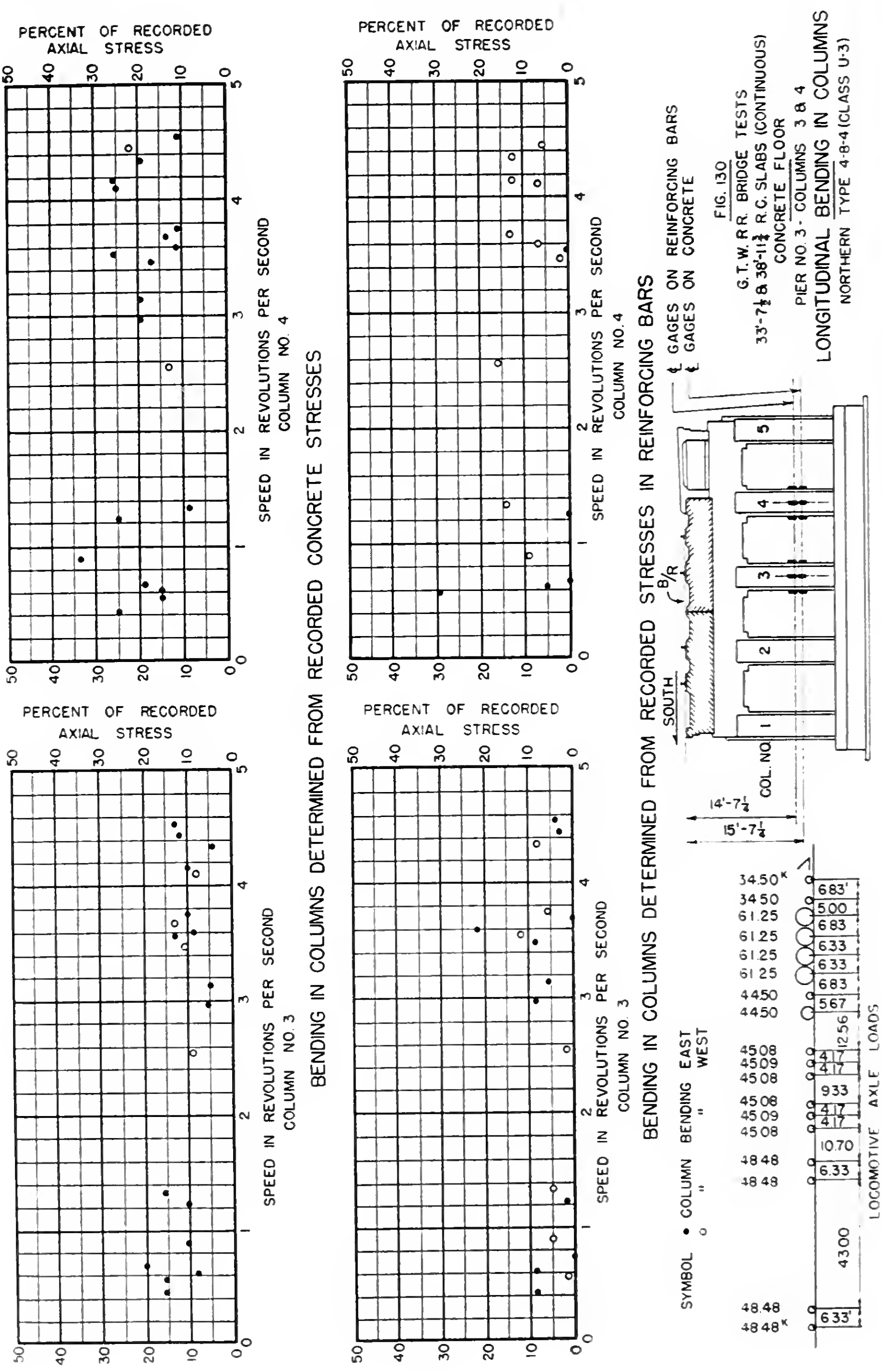
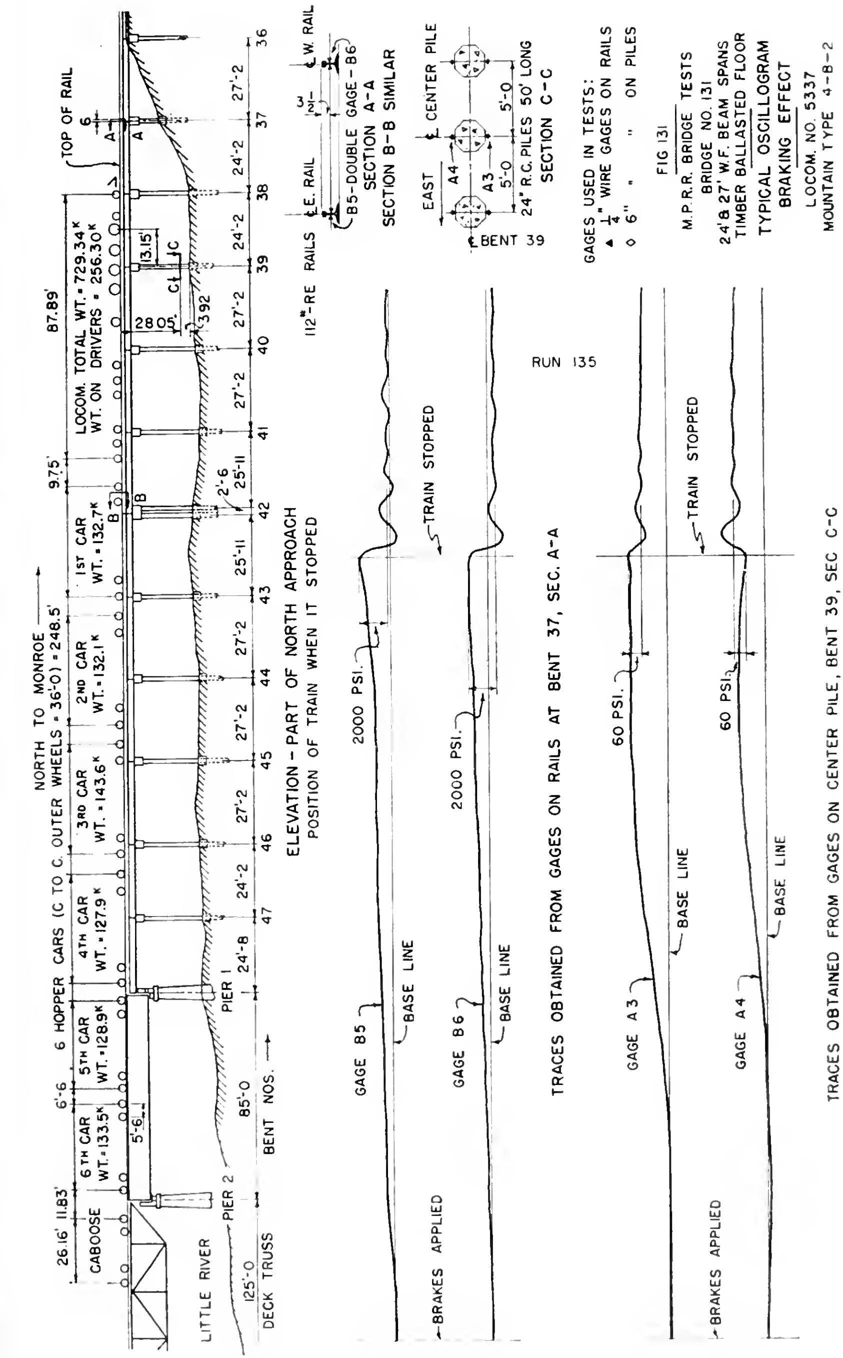


FIG. 130
G.T.W. R.R. BRIDGE TESTS
33'-7½ & 38'-1¼ R.C. SLABS (CONTINUOUS)
CONCRETE FLOOR
PIER NO. 3 - COLUMNS 3 & 4
LONGITUDINAL BENDING IN COLUMNS
NORTHERN TYPE 4-8-4 (CLASS U-3)


NORTH TO MONROE
6 HOPPER CARS (C TO C OUTER WHEELS = 36'-0) = 248.5'
CABOOSE
6TH CAR WT. = 133.5K
5TH CAR WT. = 128.9K
4TH CAR WT. = 127.9K
3RD CAR WT. = 143.6K
2ND CAR WT. = 132.1K
1ST CAR WT. = 132.7K
LOCOM. TOTAL WT. = 729.34K
WT. ON DRIVERS = 256.30K
26.16' 11.83'
6'-6
9.75'
87.89'
TOP OF RAIL
LITTLE RIVER
PIER 2
PIER 1
125'-0 DECK TRUSS
85'-0
BENT NOS.
ELEVATION - PART OF NORTH APPROACH
POSITION OF TRAIN WHEN IT STOPPED
112# RE RAILS
E. RAIL
W. RAIL
B5-DOUBLE GAGE-B6
SECTION A-A
SECTION B-B SIMILAR
EAST
CENTER PILE
BENT 39
24" R.C. PILES 50' LONG
SECTION C-C
GAGES USED IN TESTS:
1/4" WIRE GAGES ON RAILS
6" " " ON PILES
FIG 131
M.P.R.R. BRIDGE TESTS
BRIDGE NO. 131
24' & 27' W.F. BEAM SPANS
TIMBER BALLASTED FLOOR
TYPICAL OSCILLOGRAM
BRAKING EFFECT
LOCOM. NO. 5337
MOUNTAIN TYPE 4-8-2
RUN 135
GAGE B5
GAGE B6
BASE LINE
2000 PSI.
BRAKES APPLIED
TRAIN STOPPED
TRACES OBTAINED FROM GAGES ON RAILS AT BENT 37, SEC. A-A
GAGE A3
GAGE A4
60 PSI.
TRACES OBTAINED FROM GAGES ON CENTER PILE, BENT 39, SEC C-C

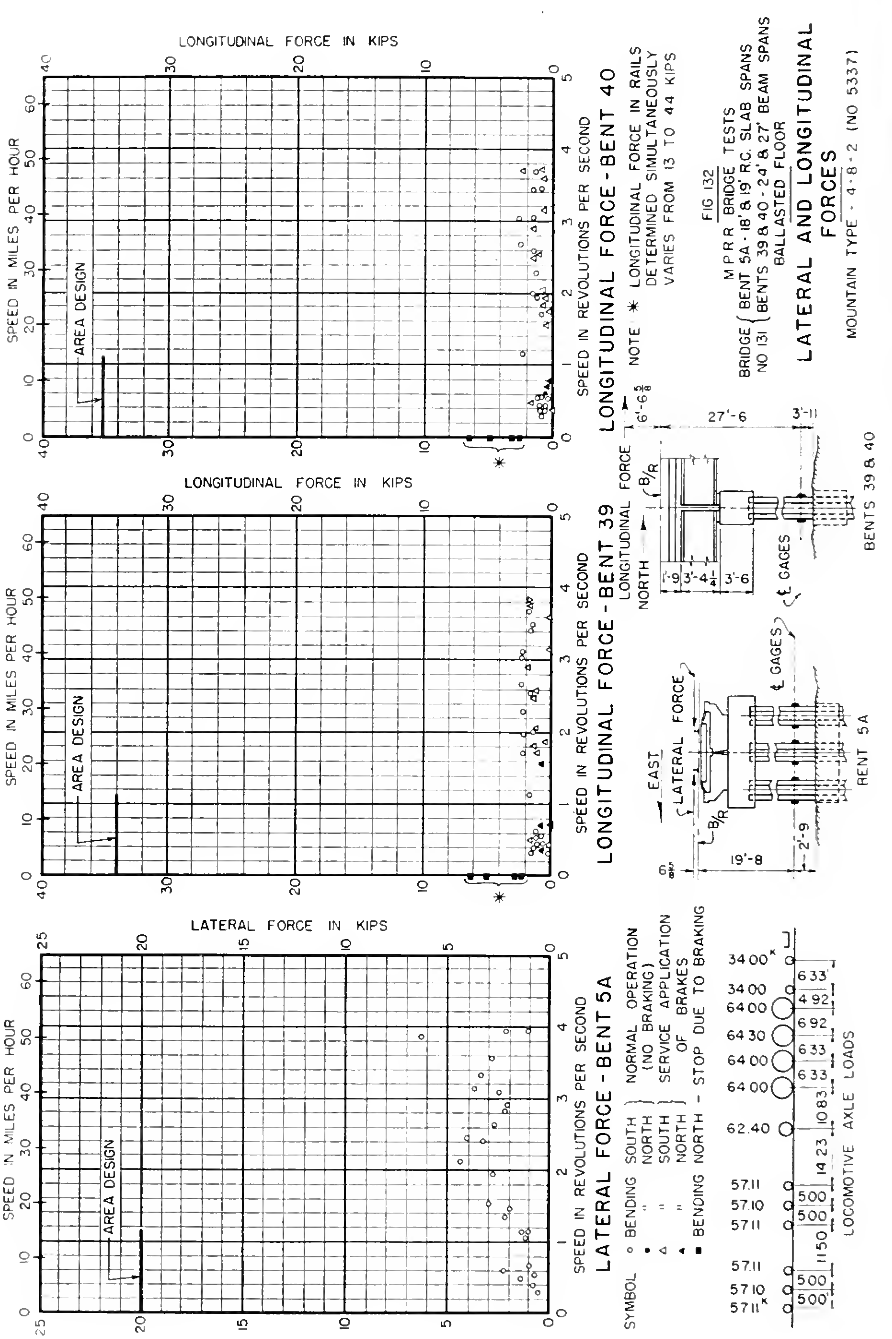


FIG 132

M P R R BRIDGE TESTS

BRIDGE NO 131 { BENT 5A - 18' & 19' R.C. SLAB SPANS; BENTS 39 & 40 - 24' & 27' BEAM SPANS BALLASTED FLOOR

LATERAL AND LONGITUDINAL FORCES

MOUNTAIN TYPE - 4-8-2 (NO 5337)

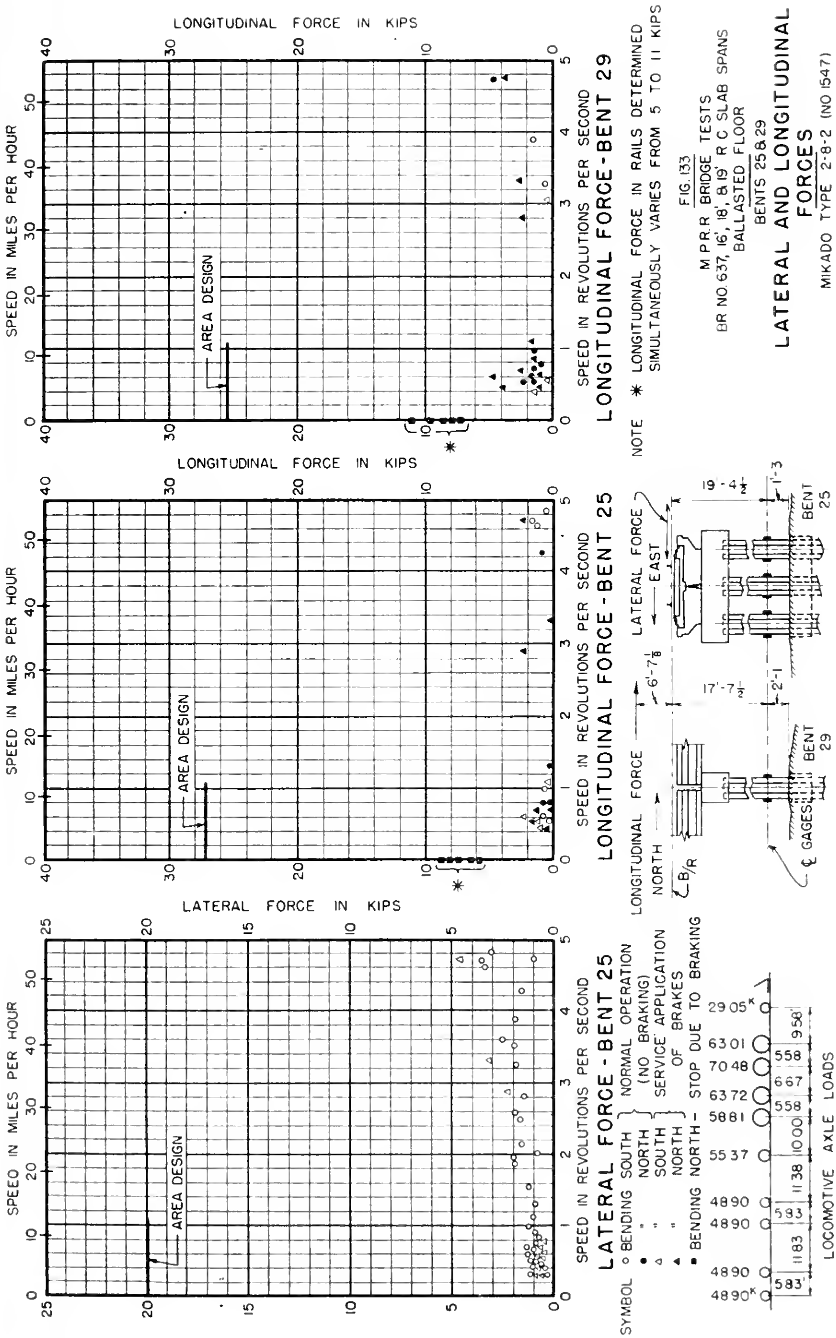


FIG. 133
M P R R BRIDGE TESTS
BR NO. 637, 16', 18', & 19' R C SLAB SPANS
BALLASTED FLOOR
BENTS 25 & 29
LATERAL AND LONGITUDINAL FORCES
MIKADO TYPE 2-8-2 (NO 1547)

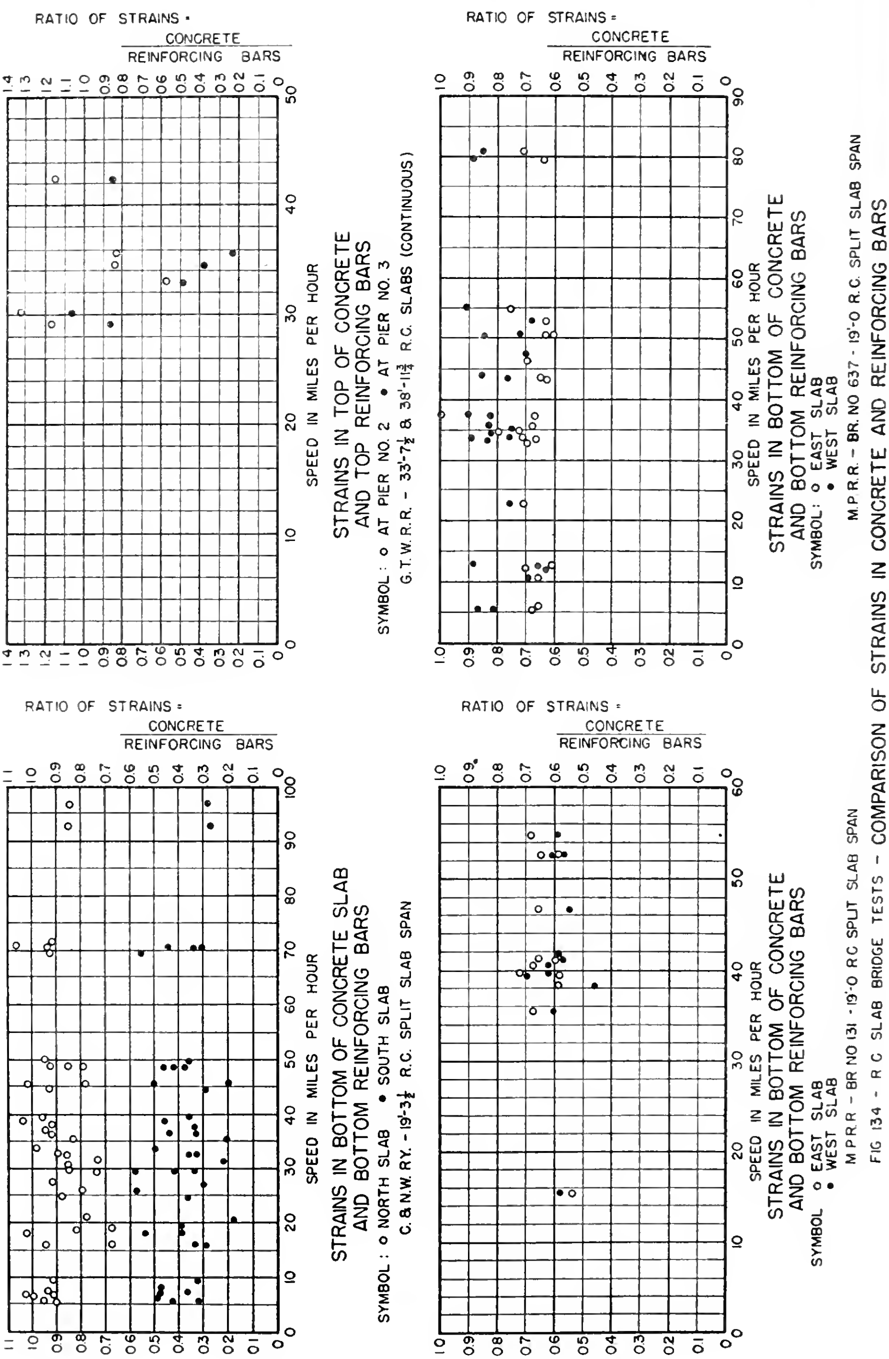


FIG 134 - R C SLAB BRIDGE TESTS - COMPARISON OF STRAINS IN CONCRETE AND REINFORCING BARS

MONOGRAPH

The Federal Valuation of the Railroads in the United States

By B. H. Moore
Valuation Assistant and Accountant
Finance, Accounting, Taxation and Valuation Department
Association of American Railroads

L. C. Card No. A52-9357

FOREWORD

Committee 11—Records and Accounts, American Railway Engineering Association, presents for the information and benefit of its membership this monograph entitled "The Federal Valuation of the Railroads in the United States," by B. H. Moore, valuation assistant and accountant of the Finance, Accounting, Taxation and Valuation Department of the Association of American Railroads. Mr. Moore is a member and secretary of Committee 11, and formerly was secretary of the Presidents' Conference Committee on Federal Valuation of the Railroads in the United States.

The membership of Committee 11 includes valuation engineers of the principal railroads, and for a number of years it has been suggested within the committee that such a history of railroad valuation be prepared. To attain this objective, a special committee was appointed, comprising Messrs. J. H. Roach, now consulting valuation engineer of the New York Central System; F. B. Baldwin, valuation engineer system of the Atchison, Topeka & Santa Fe Railway System; H. T. Bradley, valuation engineer of the Missouri Pacific Railroad Company; and B. H. Moore. Mr. Moore agreed to prepare a manuscript, which has been reviewed by the committee and their suggestions incorporated therein.

In the opinion of Committee 11, the monograph is an outstanding contribution to valuation literature and will be valuable not only to those engaged in valuation work, but also in rate cases, income and ad valorem taxes, and related activities, both as a reference book and as an authoritative statement of the procedures of the Interstate Commerce Commission and its Bureau of Valuation and the carriers in the initial inventory of railroad property and of its perpetuation.

COMMITTEE 11—RECORDS AND ACCOUNTS.

TABLE OF CONTENTS

The Federal Valuation of the Railroads in the United States

A valuation of all railroad property was not proposed until after the formation of the Interstate Commerce Commission in 1887, and the railroads had been placed under its regulation. The Act to Regulate Commerce itself authorized the Commission to require from the carriers annual reports which would show the cost and value of the carriers' property, franchises and equipment. The railroads then in existence had been built over a long period of years and many mergers and reorganizations had taken place. Furthermore, many additions had been made to the properties paid for out of income or appropriated from income. The lack of standardized accounting regulations made it difficult to contrast items appearing on the balance sheet statements of different carriers and, in approving security issues, regulating commissions had no knowledge of the property represented by the securities sought to be issued. In speaking of its difficulties in its second annual report, the Commission, in 1888 (2 ICC 64) stated:

> "Another line of inquiry required by the act relates to 'the cost and value of the carrier's property, franchises and equipment.' For the reasons above stated it is found impossible to satisfactorily obtain immediate information which shall show the cost of the railroad property; the corporate books usually showing the cost to be substantially the amount of capitalization effected to reach the present condition of affairs, the cost standing against capital, and the necessities of double-entry bookkeeping requiring the preservation of a constant balance. The blanks upon pages numerals 8 and 9 contain inquiries which are intended to elicit the desired information so far as the same can be obtained from the corporate records. It is found, however, that very many roads are unable to give the information asked upon these pages.
>
> "In respect to ascertaining the 'value of the carrier's property, franchises and equipment,' an entirely different question arises. The present value of a railroad property is necessarily very largely matter of opinion only; it depends upon a vast number of contingencies and uncertainties, a road apparently of great value today may soon become worthless by the opening of a competing line having superior advantages, or by the competitive struggles of other lines which operate to reduce the income of all; the value of a railroad largely results from the personal characteristics of its officials; the policy pursued by its directors, whether conservative and economical or aggressive and daring, is a great factor in the determination of the current value of the property; a railroad property is not necessarily worth what it would cost to replace it, and, on the other hand, it may be worth very much more than that." * * *

Appraisals of railroad property within their states had been made by a number of the state commissions, notably, New Jersey, Texas, Wisconsin, Minnesota, Nebraska, and Kansas, for their guidance in the approval of security issues and for purposes of taxation and to test the reasonableness of rates.

In 1898, Justice Harlan in the case of *Smyth vs. Ames,* a rate case originating in the state of Nebraska which reached the Supreme Court of the United States, laid down the famous rate-making rule. He said:

> "We hold, however, that the basis of all calculations as to the reasonableness of rates to be charged by a corporation maintaining a highway under legislative sanction must be the fair value of the property being used by it for the convenience of the public. And in order to ascertain that value, the original cost of construction, the amount expended in permanent improvements, the amount and market value of its bonds and stock, the present as compared with the

original cost of construction, the probable earning capacity of the property under particular rates prescribed by statute, and the sum required to meet operating expenses, are all matters for consideration, and are to be given such weight as may be just and right in each case." (169 U.S. 466, 546–547)

In the year 1905, the Department of Commerce and Labor, Bureau of the Census, made a report of the commercial value of railroad property, entitled "Bulletin No. 21, Commercial Valuation of Railway Operating Property in the United States, 1904." This was done under Section 7 of the Act of March 6, 1902, establishing a permanent Census office, and the valuation was made for the purpose of the census. The value of the railway property submitted in the report was determined by capitalizing the net earnings of the individual railways and railway systems. The report stated that three sources of information were utilized in making the appraisal; first, the operating and financial accounts of the railways; second, inter-railway contracts and agreements; and third, the published reports of the stock market. A word of caution was contained in the report that the commercial valuation found could not be used to test the reasonableness of rates, and that the solution of the rate problem demanded a separate valuation of the physical property of the carriers.

In 1910, an act of Congress was passed providing for a commission "to investigate questions pertaining to the issuance of stocks and bonds by railroad corporations subject to the provisions of the Act to Regulate Commerce." The commission appointed was headed by Arthur T. Hadley as chairman, and was known as the Railroad Securities Commission. The other members were Frederick N. Judson, Frederick Strauss, Walter L. Fisher, and B. H. Meyer. In their report, dated November 1, 1911, published as House Doc. 256, of the 62nd Congress, 2nd session, p. 15, in discussing valuation, they stated:

"Physical valuation of railroads in its bearing on capitalization has been to some extent advocated, and to a greater extent opposed, upon the idea that, if undertaken by the United States Government, it will be made a justification for reducing the amount of the outstanding securities of the railroads to the figure thus ascertained, or for preventing them from issuing new securities when the amount of their outstanding stocks and bonds exceeds the physical value of their properties as so determined. Should a valuation of the physical property of railroads be made, it ought not, if properly applied, to involve either of those dangers. An attempt to scale down old securities is clearly out of the question. Apart from the obvious constitutional difficulties of such a course, considerations of public expediency of themselves forbid it. The direct loss from the unsettlement of legal and equitable relations would be very great. The indirect loss from the withdrawal of confidence in American railroad investments would be immeasurable. Such a readjustment would become archaic almost from the outset, because an adjustment of securities based upon the values of today might be totally erroneous tomorrow. It would be equally inadvisable, in cases where outstanding securities were in excess of the physical valuation, to prohibit the issue of new securities until physical value had become equal to the amount of securities outstanding; because this principle, if generally applied, would prevent roads so situated from securing the capital needed for the service of the community.

"Whenever a railroad company acquires new property in return for the issue of its securities, or in expending the proceeds of such securities, every means should be placed at the disposal of the Interstate Commerce Commission to ascertain the value of such property as accurately as possible. A fundamental, though not necessarily a controlling, element in value, is cost of reproduction. This is true of property in general; it has been specifically affirmed of railroad property by the Supreme Court of the United States. Eminent railroad men who have appeared before this Commission have stated that in their opinion cost of reproduction or physical value was the most important single element in determining the true value of the railroad as a whole. Indeed, we believe it to be in the interest of railroads, no less than of those who use them, that the Interstate Commerce Commission should be given broad powers and adequate means for valuation of the physical property of railroads as one element in determining fair value, whenever, in the judgment of that Commission, this is of sufficient importance to warrant such action. This will give the public information which it is entitled to demand, and which can, in our judgment, be better and more economically obtained in this way than in any other. The attempt to oppose a system of physical valuation of this kind tends to give countenance to exaggerated estimates of the amount of water in railroad stocks. * * *

"In so far as the value of the property is an element in rate regulation the outstanding securities are of so little evidentiary weight that it would probably be of distinct advantage if courts and commissions would disregard them entirely, except as a part of the financial history of the property, and would insist upon direct evidence of the actual money invested and of the present value of the properties. For this and other reasons discussed in the body of the report, your Commission recommends that the Interstate Commerce Commission should have authority and adequate funds to make a valuation of the physical property of railroads wherever the question of the present value of these roads is, in the judgment of that Commission, of sufficient importance. It is hardly necessary to add that your Commission does not believe that the cost of reproduction of the physical properties, however carefully computed, is the sole element to be considered in determining the present value of a railroad, or that the outstanding securities could or should be made to conform to any such arbitrary standard."

Not until 1903 did the Interstate Commerce Commission begin to urge a physical valuation of railroad property, and thereafter repeated its recommendation in practically every subsequent annual report until the passage of enabling legislation. Among the reasons given was the judicial requirement that in fixing rates, regulating commissions must give consideration to the fair value of the roads whose rates were the subject of complaint. In its annual report for 1908 the Commission said: (*22 ICC* pp. 83–85)

"A second consideration which leads the Commission to urge upon Congress provision for an authoritative valuation of railway property is the importance which the question of capitalization has assumed in recent years. No one at the present time can say whether railways are undercapitalized or overcapitalized, or should objection be made to that way of putting the question, no one can say, with the information in hand, which of the roads are undercapitalized and which are overcapitalized. A valuation adequate to the problem in hand should not apply with the simple statement of an amount; on the contrary, it should analyze the amount ascertained according to the sources from which the value accrues and show the economic character as well as the industrial significance of the several forms of value. In no other way is it possible to arrive at an intelligent understanding of that complex situation suggested by the phrase 'railway capitalization.' "

In 1909 the commission said: (*23 ICC* p. 6)

"There is, in our opinion, urgent need of a physical valuation of the interstate railways of this country. In the so-called 'Spokane Case' the engineers of the Northern Pacific and Great Northern Railways estimated the cost of reproducing those properties in the spring of 1907. In the trial of pending suits brought by the above companies to enjoin certain rates upon lumber which the Commission had established from the Pacific Coast to eastern destinations, these same engineers have again estimated the cost of reproduction in 1909. The estimates of the latter year exceed the estimates for 1907 by over 25 per cent.

> "There is no way by which the Government can properly meet this testimony. Even assuming that the valuation of our railways would be of no assistance to this Commission in establishing reasonable rates, it is still necessary, if those rates are to be successfully defended when attacked by the carriers, that some means be furnished by which, within reasonable limits, a value can be established which shall be binding upon the Courts and the Commission."

While the Valuation Act of 1913 as passed contained no declared purpose for which the valuations were to be used, it appears from the hearings or debates in both Houses of Congress while it was pending, that the various and repeated recommendations made by the Commission and others had been considered and that the controlling reasons for the enactment of this legislation were:

(a) To obtain a trustworthy estimate of the relation existing between the present worth of railroad property and its cost to its proprietors;
(b) In determining whether rates as fixed by the Government are confiscatory;
(c) In connection with railway taxation;
(d) In the ascertainment of a proper depreciation reserve;
(e) In testing the accuracy of the balance sheets of the carriers;
(f) In the organization of railway statistics in general;
(g) In determining whether the railroads are under or overcapitalized.

Some of the railway executives who appeared before the Senate Committee, however, did not seem to share fully in the views of the advocates of the bill, but thought the principal benefit from the valuation, if fairly made, would be its justification of the capitalization of the railroads, and that its principal value would be educational, as it would show that the railroads, taken as a whole, were not overcapitalized. Illustrative of this is an excerpt from a statement submitted by Frederick A. Delano, president, Wabash Railroad, at one of the hearings:

> Mr. Delano: "This valuation is going to cost the railroads a good deal of money, and it is going to cost the Government a good deal of money, and the only benefit that the railroads expect to get out of it is in allaying the feeling that seems to be so general that railway property is very much overvalued. Railway men do not think that is so. They feel perfectly confident that a fair valuation will show that it is not so. But we do not want to spend our money without results. We want to see our money spent and the Government's money spent in a way that will show the truth, the whole truth, and nothing but the truth. I think that is all I care to say."
>
> (Hearings before Senate Committee, February 11, 1913, p. 45, Senate Report 1290, 62nd Congress, 3rd Session.)

PROVISIONS OF THE VALUATION ACT

The Railroad Valuation Act (Section 19a of the Act to Regulate Commerce, approved March 1, 1913, as revised to November 1, 1951), is reproduced hereafter as Appendix B (see page 83). It provided:

First, that the Interstate Commerce Commission should ascertain and report the "value of all property owned and used by every common carrier" subject to the provisions of the Act to Regulate Commerce, and to enable the Commission to do this, it was authorized to employ such experts and other assistants as might be necessary, and to appoint examiners with power to administer oaths, examine witnesses and take testimony. The Commission was also required to make an inventory which would list the property of the carriers in detail and show the value thereof as therein provided, and further to classify the property as nearly as practicable in conformity with its classification of expenditures for road and equipment. It was to ascertain and report in detail as to each piece of property other than land owned or used for common carrier purposes; the original cost to date; the cost of reproduction new; the cost of reproduction less depreciation, and an analysis of the methods by which these several costs were obtained and the reason for their differences, if any. It was also to report separately other values and elements of value, if any, of the property, with an analysis of the method employed and the reason for any difference between such values and each of the foregoing cost values.

The report was to state in detail and separately from improvements, the original cost of all lands, right-of-way and terminals used for common carrier purposes, and the present value of the same; also the original and present cost of condemnation and damages or of purchase in excess of such original cost and value. "The original cost and present value of property held for purposes other than those of a common carrier were to be reported separately, with an analysis of the methods of valuation employed."

Provision was made for a report upon the history and organization of the present or any previous corporation operating the property for the ascertainment of the amount and value of aids, gifts, grants and donations, as well as the value of any concession and allowances made by a common carrier to the Government of the United States, or any State, county or municipal form of government in consideration of such aid.

In its investigation the Commission was required to show the value of every common carrier as a whole, and separately the value of its property in each of the several States, classified and in detail as required by the Valuation Act.

The carriers were directed and required to cooperate with and aid the Commission (at the carriers' expense) in the work of the valuation of its property in such particulars and to such extent as the Commission might require and direct, and provision was also made for keeping the valuation up to date.

The Valuation Act provided that a tentative valuation was first to be made and the Commission should give notice to the said carrier and others in interest, stating the valuation placed upon the several classes of property. Thirty days were allowed within which a protest could be filed with the Commission. It was further provided that all final valuations should be prima facie evidence of the value of the property in all proceedings under the Act to Regulate Commerce, and in judicial proceedings for its enforcement. The Valuation Act also provided that if upon the trial of any action involving final value, evidence should be introduced which was found by the court to be different from that offered at the hearing before the Commission, the court, before proceeding to render judgment, should transmit a copy of the evidence to the Commission and stay further proceedings for such time as the court should determine. Upon receipt of such evidence the Commission was required to consider the same, after which it might fix a final value different from the one fixed in the first instance, or alter, modify or rescind any order which it had made involving final value and then report its subsequent action to the court.

In the underlying reports upon which the tentative and final valuations were founded, the estimated cost of reproduction was based on certain assumptions, on so-called 1914 prices, which were in fact average prices for five or ten years preceding that date. The cost of reproduction less depreciation was an estimate of the condition percent of the property based on estimated average service lives; the land value reported was the so-called "present value" of the right-of-way, etc., as ascertained from the values of adjacent land, and without any allowance for severance or damages on account of cutting up an owner's holding.

The valuations fail in most instances to report the original cost to date as required by the Valuation Act. It should be noted, however, that since reproduction costs have increased with the lessened purchasing power of the dollar, the Commission finds for the same properties an estimated original cost, the method being outlined later in this memorandum.

In its first tentative valuations of the Texas Midland Railway Company and the Atlanta, Birmingham & Atlantic Ry. Co. and others, the Commission failed in numerous respects to comply with the terms of the Valuation Act, particularly in failing to report "the value" of the carrier property, although it reported the value of the non-carrier physical property. It said: "While it may be questioned whether or not the act requires the finding of a single sum as the value of the property, we are of opinion that it authorizes the finding of such value *for purposes under tl.e act to regulate commerce,* and it is our purpose ultimately to make *such findings* as to each property." The Commission later made some reports with a finding of this kind, but subsequently changed the language, terming it a *"value for rate-making purposes."*

ORGANIZATION OF THE BUREAU OF VALUATION OF THE ICC

On April 26, 1913, the Commission announced that a Division of Valuation (later changed to the Bureau of Valuation) had been created as a part of the Interstate Commerce Commission. Mr. Charles A. Prouty, a member of the Commission, resigned to accept the appointment of director of valuation, to supervise the work. Engineering, Land, and Accounting Sections were organized to conduct the work.

As the Valuation Act provided that an inventory should be made of the property to be valued, and that the Commission should ascertain and report, among others, the cost of reproduction new and the cost of reproduction less depreciation, this required the identification and examination of the property by the engineers of the Commission. all of which was a work of great magnitude and detail.

The country was divided into five districts, each of which embraced approximately 50,000 miles of railway. The Commission appointed five engineers, who were placed in immediate charge of the engineering work of these districts. These five engineers constituted an Engineering Board, to formulate general plans for the prosecution of the work and to supervise the execution of these plans in order to procure the necessary uniformity of method and procedure. A land attorney and a district accountant were appointed for each district in charge of the land and accounting work, respectively.

The Land Section was assigned to ascertain and report the "present value" of the lands devoted to common carrier purposes; also the lands held for other than common carrier purposes. Present value was defined as follows:

> "Present value as reported by the Commission is nearly synonymous with market value. What is done is to ascertain the number of acres of carrier land. to determine the market value of similar land adjoining or in the immediate vicinity per acre, and to apply that price to the number of acres. If the land has any special value for railroad purposes that is also taken into account." (75 ICC 167)

In addition, there was separately reported the present value of lands which had been donated or granted to the carrier by the Government and others.

The Accounting Section was assigned to investigate the records of each individual carrier, of its predecessors and construction companies, or such other records as would enable it to report the origin and development of the railroad and it was to show, where information was available, the original cost to the present owner and to its predecessor corporations. This the Commission decided could not be ascertained except in a few cases where the carriers were built after 1914, and only to a more or less limited extent for the other carriers. The Accounting Section was also to outline the financial and corporate history of the carrier, the development of its fixed physical property, and the history of its corporate financing, and to state its general balance sheet and its investment in road and equipment as of valuation date, with separate statements as to the costs of lands and equipment, investment in other companies, and the aids, gifts, grants and donations received, etc., and amount and value of any concessions granted in consideration therefor.

The Accounting Section was later also placed in charge of the administration of Valuation Order No. 3, which was issued to comply with the provision in the fifth paragraph of the Valuation Act, which required the recording and reporting of all changes from the date of the original inventory.

COOPERATION BY CARRIERS

Under the terms of the Valuation Act every carrier subject thereto was required to furnish to the Commission, as it might require, maps, profiles, contracts, reports of engineers, and any other documents, and to cooperate and aid the Commission in the work of the valuation of its property in such particulars and to such extent as the Commission might require. Under this provision of the act, 25 valuation orders were issued. These orders required the carrier, as part of the cooperation, either to fill out forms prescribed thereunder, or otherwise to compile data or make returns or reports of various kinds as specified. This was all done at the carriers' expense.

These orders were as follows:

Valuation Order No. 1—Specifications for Maps and Profiles.
" " " 2—Abandoned Property.
" " " 3—Regulations to Govern the Recording and Reporting of all Extensions and Improvements or Other Changes in Physical Property.
" " " 4—Inventory of Materials and Supplies.
" " " 5—Modifying Map Order No. 1.
" " " 6—Modifying Map Order No. 1.
" " " 7—Schedules of Land.
" " " 8—Schedules and Cost of Equipment and Machinery.
" " " 9—Transportation of ICC Employees, Supplies and Cars.
" " " 10—Modifying Order No. 2. Abandoned Property.
" " " 11—Inventory of Records.
" " " 12—Industrial Tracks.
" " " 13—Schedules of Fixed Property Except Land & Equipment.
" " " 14—Prices of Materials and Rates of Compensation Paid Employees.
" " " 15—Privileges and Leases.
" " " 16—Aids, Gifts, Grants and Donations.
" " " 17—Prices of Materials and Rates of Compensation Paid Employees by Telegraph Companies.

" " " 18—Prices of Materials and Rates of Compensation Paid by Telephone Companies.
" " " 19—Prices of Materials and Rates of Compensation Paid by Railways for Telegraph Property.
" " " 20—Corporate History and Chart.
" " " 21—Maps, Charts and Schedules of Telegraph Property.
" " " 22—Modifying Valuation Order No. 4—Materials and Supplies.
" " " 23—Modifying Map Order No. 1.
" " " 24—Recording and Reporting Changes Affected by Construction, Transfer, Lease or Abandonment of Property.
" " " 25—Bringing Accounting Reports to Date.

The only valuation orders currently in effect are:

Valuation Order No. 1—Revised Map Order.
" " " 3—Second Revised Issue and Supplement 4—List of Units of Property for Use on Completion Reports and Supplement 5—Reporting on BV Form 588—Changes in Property and Their Costs.
" " " 7-8—Cost of Land and Equipment and Machinery. (Applicable to New Companies)
Revised Valuation Order No. 14 —Prices Paid for Selected Items of Material Used in Construction. (Required from 46 Class I Carriers)
Valuation Order No. 24—Recording and Reporting Changes Affected by Construction, Transfer, Lease or Abandonment of Property.

With the view of promoting cooperation, the railroads appointed a committee, known as the Presidents' Conference Committee, to act in an advisory capacity on behalf of the railroad companies. The personnel of the Presidents' Conference Committee was comprised of the Presidents of the larger railroads of the three territorial groups, viz., Eastern, Southern and Western.

Each of the three groups employed counsel who formed a Committee of Counsel. As the counsel selected were eminently qualified in valuation procedure, their opinions and interpretations found their place in the basic principles and methods under which the valuation work was conducted. Counsel appeared on behalf of the railroads at many of the conferences, hearings and arguments held before the Interstate Commerce Commission and prepared arguments and briefs in support of the carriers' position.

Each group likewise employed a group engineer and land attorney, and such other assistants as were required as the work progressed. A general office of the committee was maintained in Philadelphia, Pa., under the direction of the chairman of the Presidents' Conference Committee, the vice-chairman and secretary. The expenses of the committee and the group offices were defrayed from funds secured from the Class I railroads, each railroad contributing in proportion to its gross revenues.

The Presidents' Conference Committee authorized the appointment of working committees known as the Engineering Committee and its sub-committee, the Equipment Committee; the Land Committee; and the Committee on Preparation of Financial Histories and Accounts. The membership of these committees was drawn from the railroads and the representatives selected were the officers best qualified to serve on the committee to which they were named.

Most of the active cooperation of the Presidents' Conference Committee was naturally performed by the Committee of Counsel and by the Engineering, Land, Accounting and Equipment Committees, or appropriate subcommittees thereof, either through joint conferences with representatives of the Bureau of Valuation, or through reports to the vice chairman of the committee. These reports were brought to the attention of the chairman and members of the Presidents' Committee for their information and any required action. The committee, on behalf of the carriers, presented the views of the railroads as to the basic principles which the Commission should follow in the work of valuation at numerous conferences, hearings, and oral arguments, and prepared circulars of advice and instruction for the guidance of carriers. From time to time the secretary issued statements of developments, circulars, transcripts of hearings, and reports of committees for the carriers' benefit in order to coordinate the valuation work and keep the expense at the minimum.

To carry out effectually the task imposed on it by the Valuation Act, practically every carrier organized what was known as a Valuation Committee, which was usually composed of a valuation engineer, valuation attorney, land appraiser, and a valuation accountant, with an executive officer of the company acting as chairman. This organization was responsible for the actual conduct of the valuation inventory and of complying with the valuation orders and other requirements of the Valuation Act.

THE ENGINEERING INVENTORY

An engineering inventory was made by the Commission's engineers, with the cooperation and assistance of the carriers.

The Commission organized its field forces into different branches:

(1) The road and track party was to measure and inventory the roadway and all structures connected therewith, except bridges over 12 ft in length, and buildings. It was to measure the actual length of the road. The roadbed was to be cross-sectioned for the purpose of determining and classifying the quantities of material which were moved in its construction. Ties in two 600-ft sections of each mile were to be counted and the kind of tie observed. It was assumed that these sections would fairly represent the entire mile. The amount of ballast was to be determined by having the carrier dig test pits. Where subsidence occurred, this could be measured, by borings and cross-section ditches, to be made by the carrier.

The records of the carriers were to be observed and used so far as they seemed to indicate in a reliable way the actual quantities.

(2) The bridge branch was to inventory bridges with a span of over 12 ft, and elevated structures, crossings and signs, wharves and docks.

(3) The building branch was to inventory all buildings and similar structures, such as water and fuel stations.

(4) The signal branch was to inventory interlocking plants and signals of all kinds.

(5) The mechanical branch was to inventory equipment of all kinds and shop tools and machinery. Electrical appliances in the Eastern District were to be handled by a separate branch.

(6) The telegraph and telephone branch was to inventory the telegraph and telephone property of railway carriers.

The carriers assigned engineers to cooperate in the field with the engineers of the Bureau of Valuation. These railroad representatives, ordinarily known as pilots, accompanied the Commission's parties over the property. It was their duty to point out property to be inventoried and to see that it was properly measured, inventoried and classified, and also to call attention to hidden quantities and other features that might not be readily observed by the field parties and to furnish such data as the government parties might desire.

Carbon copies of the field notes were furnished to the carriers under an agreement which provided that, unless objection was made within 60 days, the field notes should be taken as correct. The purpose of this was to obtain an inventory about which as little dispute as possible could arise. Such objections as were made were investigated and frequently adjusted, and, to a considerable extent, eliminated in the field. The carriers generally accepted the physical inventory, although protesting that there were many errors therein.

As the Valuation Act required an inventory in detail of each piece of property, the Commission decided that the units to be selected should be those which were commonly used in the purchase of materials or in construction contracts. For example, ties were bought by the piece, therefore the single tie should be the unit; for rails, bought by the gross ton, that was the unit; for equipment, a single car or engine was selected as the unit. Buildings were reported by individual structures. Bridges with a span of over 12 ft were reported separately. For the purpose of inventorying and of grouping the items in underlying reports, the mileage of each railroad was divided into many valuation sections. To comply with the Valuation Act, which required that the various costs and values were to be reported by States, State lines were observed in all cases in determining valuation sections.

A date of valuation, or inventory date, was selected for each road, which was as near the time the field party would reach that road as could be estimated. These dates of valuation were all as of June 30th, but varied for different railroads, ranging from June 30, 1914, and ending with June 30, 1919. In some cases the field inventory was spread over many months, or even years, but was adjusted to the selected valuation dates from records of property changes.

Instead of applying to the inventory of each railroad prices as of its valuation date, the Commission decided to use a uniform level of prices for all railroads, and selected prices said to be normal as of June 30, 1914. In this respect the appraisal of land was handled differently, the land values for each railroad being as of its date of valuation.

The engineering report dealt with the estimated cost of reproduction new and the cost of reproduction less depreciation of the physical carrier property other than land based upon an inventory in detail. In it the property was grouped in accordance with the Classification of Investment in Road and Equipment for all items of roadway and structures, for equipment, and for general expenditures. Its purpose was to present the estimated costs of reproduction of the elements of the road also, and to show the reproduction costs depreciated by applying thereto condition percents calculated by the straight-line method. Certain property, such as relay rail, was priced in the second cycle of use, and other items of property purchased second hand were priced accordingly. The reports contain only the property which was used by the carrier for its purposes as a common carrier, and the reproduction estimates were shown separately by valuation sections, and classified as to whether wholly or jointly (1) owned and used, (2) owned not used, (3) used not owned, and aggregated for (4) total owned and (5) total used.

Non-carrier real estate and non-carrier structures, such as buildings, tracks, etc., appeared in the report of the Land Section, while stocks, bonds and other property of that character were listed in the accounting report.

In making the inventory the existing topographical conditions were assumed, except as they had been altered by the construction of the road itself, and it was further assumed that the general condition of the country as to the forests, tilled land, drainage, etc., was that of the inventory date, but no addendum was made to unit costs for that reason. The reproduction program which was adopted was based on the assumption that the existing property was reproduced by a single continuous impulse and without consideration of ability of area to supply labor and material for such continuous impulse, and the historical conditions under which the road was created were generally disregarded. No attempt was made to show the cost of reproducing the property as it was historically produced, excepting as that cost might be shown, to some extent, under original cost to date. The statements and summarized assumptions are substantially derived from the Statement of Methods which appears in the report of the Commission in the Texas Midland Case, 75 ICC 108.

Unit Prices

After consideration it was decided by the Commission that the only proper basis upon which to establish prices was the experience of the past. The Commission therefore issued Valuation Orders Nos. 14 and 19, requiring carriers to report the prices paid by them for most of the materials entering into the construction of the railroad, for five years and, in some instances, ten years, preceding June 30, 1914; also the cost of certain kinds of labor. These average prices paid furnished the basis of the unit prices applied by the Commission and termed by them "normal prices as of June 30, 1914." To aid the Commission in determining the unit prices which would reflect the cost of the items in place, the carriers furnished the Commission a great number of reports, giving in detail the cost of various projects. The railroads organized three group offices in charge of a group engineer, in the Eastern, Western and Southern Districts, under the guidance of the Presidents' Conference Committee or their appropriate committees, to assist in the analysis and presentation of the data to the Commission's engineers. As a consequence, cost data studies were made involving practically every kind of facility in the railroad plant, both by the carriers and the Commission's engineers. Although early attempts to agree upon reproduction prices between the carriers and the district engineers were made in an endeavor to reduce the time and expense of formal hearings, it was not, however, until a late stage in the work that the carriers were permitted to cooperate and participate in the discussion of the prices to be applied.

Contingencies

No separate amount was reported in the reproduction estimate for contingencies as such. The Commission stated that more reliable results would be obtained by giving due weight to this element of doubt for each specific class of property where such extra cost could be proved, instead of reporting an amount therefore applicable to practically the entire inventory.

Engineering (Account 1)

After investigation of a large number of construction projects, the Government engineers were instructed to compute engineering as a percentage of the road accounts 3–47, which excludes Accounts 1 (Engineering) and 2 (Land for transportation purposes), and that the percentage adopted should not be less than 2 nor more than 5 percent, except in unusual cases. The estimate included nothing for reconnaissance or preliminary surveys, on the assumption that in reproducing the road its exact location is already known without having to spend any money to determine it.

General Expenditures (Accounts 71–75 and 77)

After a detailed study it was decided that general expenditures (Accounts 71–75 and 77), exclusive of interest during construction (Account 76), should be treated on a percentage basis, and that the percentage should be applied to the road accounts. (Accounts 1–47, exclusive of Account 2, Land). In almost all cases a percentage of 1.5 was used, although in the case of a few larger carriers 1 percent was applied.

Interest During Construction (Account 76)

In estimating interest during construction, it was assumed that the credit available when the property was being reproduced would, in all cases, be equally good and the same; that money could be obtained at the same rate, and supplies purchased on equally advantageous terms. An examination of the sale of bonds by operating and going railroads for the five years preceding June 30, 1914, persuaded the Commission that the rate of 6 percent would be ample to cover not only the interest on the money, but also any brokerage which would be chargeable for the obtaining of the money, so that, in estimating the cost of reproducing the property it was assumed that 6 percent would cover interest and all costs of obtaining money without inquiring how it was to be secured. In the reports, interest was computed upon the road accounts, except land, and upon the general expenditures accounts, except interest during construction, for one-half the construction period, plus three months, and upon the equipment accounts, in ordinary cases, for three months. No allowance was made for interest and taxes on land while the roadbed, tracks and buildings were being constructed

Construction Period

The method of fixing the estimated length of the construction period was as follows:

No estimate whatever was made of the preliminary period. The construction period as determined by the Commission's engineers was said to represent, not the shortest period of time in which the railroad could be constructed, but rather that period within which the work could economically be done. The usual small delays which occurred in normal times were assumed, but other delays, such as financial and troubles which had occurred peculiar to individual properties, were not considered. All existing means of transportation, aside from the property which was under reproduction, were assumed to exist. This generally enabled the engineer to proceed with the hypothetical reproduction at several different places at the same time. This assumption generally reduced the period allowed for reproduction materially below that historically required for the building of the property. The Commission did not extend its construction period to cover all the permanent ballasting or construction of all industry tracks, or of all minor buildings.

Cost of Reproduction Less Depreciation

The depreciation reported under this title was defined as "the lessening in cost value due to the smaller number of service units in the property as found than in the same property new." It was assumed that the loss in these units of service was evenly distributed throughout the entire life of the unit or article.

In this connection the Engineering Board adopted Memorandum No. 226, which described in detail the method which was to be used in determining this so-called depreciation of service life. Briefly, it requires those undertaking to determine this to estimate the remaining lives of the units of property. The determinations were generally made in the office instead of by the enginers making the inventories. The cost of reproduction less depreciation thus reported, is briefly, an estimate based upon the straight-line method. The carriers objected to the method adopted by the Commission.

Appreciation

The Commission concluded that no attempt should be made to estimate and state, in dollars, the amount of appreciation, because they reported there was no known method of ascertaining it or of measuring it in the property, even though they had made an estimate of the theoretical depreciation or unexpired service lives. This, notwithstanding the fact that the Valuation Act specifically required a separate report on "other values and elements of value," and that the railroads suggested methods of estimating such values. While the valuations state that appreciation was considered, they do not state specifically what was included for this element.

REPORT OF LAND SECTION

In making its land report, the Bureau of Valuation determined which lands were used for transportation purposes and which were non-carrier. The Bureau generally followed the accounting classification of the Commission, which, under Account 2—Land, described land used for transportation purposes as follows:

> "This account shall include the cost of land of necessary width acquired for roadway; the cost of land for station, office, shop, and other grounds; for ingress to or egress from such grounds; for borrow pits, waste banks, snow fences, sand fences, and other railway appurtenances; and for storage of material adjoining the right of way; the cost of land for wharves and docks and the cost of riparian or water rights necessary therefor; * * *"

When the field inspection was made, the carriers were permitted to state their claims for classification and, in doubtful cases, the burden of proof was put upon the carrier. The carrier was required to report under one of the valuation orders of the Commission, separately as to carrier and non-carrier lands, all grants of land. These were separately valued in the land report. Under a ruling it was assumed that in cases where the deed contained a nominal consideration and the carrier could not show satisfactory evidence of an actual consideration, such a conveyance should be reported and valued as a grant.

The Valuation Act originally required the Commission to report as to land "the original and present cost of condemnation and damages or of purchase in excess of such original cost and value." This the Commission failed to do, stating that original cost of acquisition was unknown and declining to estimate present cost of acquisition, although what it reported as "present value" was necessarily an estimate. After a mandamus action by a carrier, and following a decision of the Supreme Court on March 8, 1920, (Kansas City Southern Ry. Co. vs. ICC 252 U.S. 178) that the Commission should abide by the mandate of Congress, the Commission did, for a short period, report the cost of acquiring carrier lands as of valuation date. Carriers and the Bureau of Valuation cooperated in an expeditious method of typing the lands and developing multiples for this purpose. While the estimated cost of acquisition was reported, no weight was given it in the findings of value. Later, upon the recommendation of the Commission, Congress, on June 7, 1922, repealed this requirement of the Valuation Act, whereupon the Commission ceased reporting re-acquisition land costs.

Carriers were required to report, under one of the valuation orders of the Commission, (No. 7), the original cost of both carrier and non-carrier land.

To determine the "present value" of land, the Bureau of Valuation sent its land appraisers into the field. Printed Instructions, both "Office" and "Field," were issued for the guidance of these forces. The appraisers made personal inspection of the property and all relevant facts were assembled which had a bearing on the value. The right-of-way was divided into zones, each zone containing land substantially similar in character and value. The appraiser, having laid out his zone, proceeded to determine the market value of the adjoining and adjacent lands. For this purpose all recent sales in the immediate vicinity were assembled, and the assessed value of such lands and the opinions of well-informed persons as to such value were further ascertained. Purchases of land by the government were usually disregarded, the prices paid being thought too high. From a consideration of these sources of information the (unit or market) value was determined per square foot or per acre.

The valuations of the occupation of streets and the crossing of streets and highways were the subject of special instructions, as well as the appraisal of special rights in both public and private lands. For these the Commission allowed as rights what the carrier or its predecessor could prove had been paid. Nothing additional on account of changed conditions or enhanced values was allowed.

The results of the land appraisal finally emerge in a land report which shows for each valuation section the number of acres of carrier land and the present value assigned, divided between urban and rural land and classified as to use, whether wholly or jointly (1) owned and used, (2) owned not used and (3) used not owned. The value assigned to rights in public domain and rights in private lands is also reported in the same detail. The number of acres and the present value of land classified as non-carrier are separately reported, together with the value of structures thereon. The number of acres and the present value of donated lands are also shown.

REPORT OF THE ACCOUNTING SECTION

The Commission's accountants dealt with the records of the carrier and the report of that section embraces everything called for by the Valuation Act which is derived from an examination of books of account and other records and documents. Special instructions were issued to the district accountants outlining the subjects to be included in the accountant's report for each existing and predecessor company. This gave the company's corporate history, the development of fixed physical property, the history of corporate financing, the aids, gifts, grants and donations, the results of corporate operations, an analysis of the investment in road and equipment account, the original cost to date of road and equipment for a very few railroads, improvements on leased railway property, miscellaneous physical property, investments in other companies, the materials and supplies, and leased railway property. The same information was reported as to all its predecessor companies, where available.

The Valuation Act requires that original cost to date be reported in detail as to each piece of property. This the Commission interpreted to mean that original cost should be reported in all reasonable detail, and that the words referred to various sections of the railroad rather than the individual ties, rails and similar elements. However, information as to the original cost of land and equipment, where known, was reported by the carriers in response to valuation orders of the Commission.

In its decision in the Texas Midland case, the Commission said:

> "Original cost to date will be reported as fully as it can be ascertained from the best evidence which is practically available in each particular case, and which seems to us to carry weight as establishing the fact called for by Congress. If it is not possible to show original cost to date for all of the carrier property, but it can be ascertained for a portion of the property, that fact will be reported. In the event that it is impossible to identify the cost of any portion of the property, the total amount on the books of the carrier properly assigned to the road and equipment account will be shown, with an explanation that the authenticity of the amount can not be verified. Whenever the original cost of the greater portion of the property can be ascertained, and as to minor parts can not be ascertained from records, we shall within comparatively narrow limits estimate the original cost of such minor portions so as to show original cost of the whole property as closely as may be, and the maximum limit, stating fully the method pursued." (75 ICC 8)

Although this procedure was followed in a few cases, in the great majority the Commission found that original cost to date could not be definitely ascertained, and it refused to resort to estimates.

When the rise in prices increased their reproduction estimates (in recapture and other valuations made as of later years) the Commission commenced reporting a so-called original cost. The methods followed by the Commission in making these estimates are described in a later section.

WORKING CAPITAL

The first valuations of the Commission reported as working capital the sum of the materials and supplies and cash on hand, as shown by the general balance sheet on valuation date. As the work progressed, however, a theory was developed under which it was argued that fares and freight charges are generally paid a little in advance of operating expenses and that, therefore, but very little cash working capital is required from carriers' own funds. Consequently, most of the cash on hand was classified as "non-carrier" property.

THE TENTATIVE AND FINAL VALUATION REPORTS

One of the terms of the Valuation Act required the Commission, upon the completion of a tentative valuation, to give notice to the carrier, the Attorney General of the United States, the Governor of the state in which the property was located, and other additional parties as the Commission might prescribe, stating the valuation placed upon the property, and to allow 30 days in which protest could be filed. If no protest were filed, the valuation became final as of the date thereof. If a protest were filed, the Commission was required to fix a time for hearing the evidence which might be presented in support thereof. If, after the hearing, the Commission was of the opinion that its valuation should not become final, it was to make such changes as were necessary, and issue its order making such corrected tentative valuations final as of the date thereof. All final valuations were to be published and were to be *prima facie* evidence of the value of the property in all proceedings under the Act to Regulate Commerce as of the date of the fixing thereof.

Value was not defined in the Valuation Act of 1913, and nothing was contained therein describing the use to be made thereof. One of the first issues presented to the Commission by the carriers was the definition to be given to the word "value," the carriers' position being that it was the value in condemnation or their true constitutionally protected value which the Commission should find and report.

In 1916 the Commission served its first notice of tentative valuation upon two small carriers, and these notices referred to accompanying reports of the Engineering, Land and Accounting Sections, similar to those described heretofore.

The carriers objected that many things called for by the Valuation Act had been omitted from the first tentative valuations, including the finding of a "value" of the property owned or used, an analysis of the methods of valuation employed, allowances for other values and elements of value, appreciation, and other facts required to be reported. Subsequently the Commission announced that it would find the value of the property, define the value which it would report as, *"the value for rate-making purposes,"* and publish an analysis of methods and principles adopted in making the valuation.

As nearly as can be determined and expressed in the way of a general formula applicable to all primary valuations, the *"value for rate-making purposes"* reported by the Commission as of the respective valuation dates, was the sum of the estimated cost of reproduction less depreciation on the 1914 pricing level, the then value of the carrier lands and rights, and the amount of working capital, plus a small additive (which, expressed as a percentage for all valuations aggregated 5½ percent of the cost of reproduction less depreciation, but varied somewhat between individual carriers).

OTHER VALUES AND ELEMENTS OF VALUE

Paragraph first of the Valuation Act provided that "The Commission shall, in like manner, ascertain and report separately other values and elements of value, if any, in the property of such common carrier, and an analysis of the methods of valuation employed and of the reasons for any differences between any such value and each of the foregoing cost values."

Although the language of the tentative valuation says, "after careful consideration of all facts herein contained, including appreciation, depreciation, going concern value. working capital," there was nothing in the tentative valuation or the underlying reports to show anything whatever had been considered with respect to appreciation and going concern value. The reports contain a statement: "no other values or elements of value to which specific sums can now be ascribed are found to exist."

PROTESTS BY THE CARRIERS AGAINST THE RULES, METHODS AND PRINCIPLES EMPLOYED BY THE COMMISSION

The Valuation Act contained a proviso that when a tentative valuation had been completed, the Commission should serve a copy upon the carrier and all other interested parties named. Thirty days were allowed to the parties in interest in which to file their objections. The Commission was required at a later date to hear and decide the issues raised. The decision of the Commission in the proceeding became the "final valuation" required by the Valuation Act. Thus Congress in the Valuation Act placed the responsibility of making the valuation upon the Interstate Commerce Commission; the Commission sitting as a tribunal and passing upon the work of its own Bureau of Valuation.

After the first few valuations had been completed and the protests filed and hearings held, the Bureau of Valuation, in 1918, inaugurated the practice of submitting informally for the carriers' review and criticism, copies of what were termed preliminary engineering, land and accounting reports, prior to the formal service of the tentative valuation. This was for the purpose of endeavoring to eliminate any differences in an informal way, thus reducing the volume of the record which was made when formal service of a tentative valuation was made and a protest filed.

Practically all of the Class I carriers filed a protest against the methods and principles employed in making the tentative valuations. In due course, after the service of the tentative valuation and the filing of a protest, hearings were held upon the issues raised thereunder.

The Commission appointed examiners and attorneys to hear and conduct these cases. These hearings were carried on generally under the rules of the Commission, but were restricted to the issues of fact raised under the protest. Questions challenging the principles, rules, methods and assumptions adopted were heard by the Commission or by Division One after the close of the hearing before the examiner. Following the hearings, briefs were filed on behalf of the carriers and the Bureau of Valuation; and these were followed later by reply briefs and oral arguments before Division One of the Commission. As might be expected, owing to the many details involved, the hearings were conducted over long periods, at great expense to the parties in interest, and greatly added to the cost of the work.

In an attempt to reduce the issues and shorten the procedure, in 1924 a plan was devised for holding conferences on such questions as inventory quantities and prices in advance of the hearings, and this greatly reduced the time consumed at the later hearings.

The Valuation Act contained no provision for a court review of the principles finally adopted by the Commission, the final valuations being made "prima facie" evidence of the value of the property in all judicial proceedings to enforce or restrain the enforcement of the orders of the Commission under the Act to Regulate Commerce. While all the primary valuations have been completed and published by the Commission, an opportunity has not yet been available for a court review of the many principles which have been disputed by the carriers. How well the Commission sustained its own work may be gathered from the following statement, which shows the amounts reported in the tentative and final valuations, respectively, of the steam railroads. The figures shown in this statement, however, are not all-inclusive, because as a result of the practice in tendering preliminary reports and of holding informal conferences thereon prior to the service of a tentative valuation, the changes made therein are not reflected in this statement.

Total Used Property

One Thousand and Forty-Six (1,046) Final Valuations

	Tentative and Supplemental Tentative Valuations	*Final Valuations*	*Net Increase or Decrease*	%
Total cost of reproduction new	$15,336,211,480	$15,515,471,955	+$179,260,475	1.17
Total cost of reproduction less depreciation	12,124,645,102	12,302,414,725	+ 177,769,623	1.47
Total present value of land, including rights	2,574,309,936	2,646,578,622	+ 72,268,686	2.81
Total final value	15,745,357,893	16,032,268,982	+ 286,911,089	1.82
Total working capital	427,699,080	412,742,376	— 14,956,704	—3.50
Total final value, less working capital	15,317,658,813	15,619,526,606	+ 301,867,793	1.97

+ Increase.
— Decrease.

The carriers in their protests, generally, objected to the findings of "value," and contended that the Commission failed to state the methods by which it determined the "value," and failed to report the "other elements of value," including appreciation and going concern value as required by the Valuation Act. A further contention was that no statement was made of the weight ascribed to the depreciation reported in the determination of value.

The carriers protested the failure to find the original cost to date and the attempt to report as a substitute the investment in road and equipment, which was restated on the basis of the 1914 classification of accounts, which investment account was not intended to show original cost to date but only the expenditures made to acquire properties and the value at the time of acquisition of donated properties, and contended that the investment account did not reflect the cost of property paid for out of income or appropriated from income. Protest was made that in its restatement of the Investment in Road and Equipment account on the basis of the 1914 classification, the Commission omitted large sums which were properly chargeable thereto at the time the entries were made in other accounts.

Under the heading of cost of reproduction new, the protests of the carriers were directed against the erroneous methods and principles followed, by the exclusion of costs which should have been included, by the failure to list in the inventory all the owned or used property, by the use of inadequate unit prices and by improper classifications. Many items of property owned and used, owned but not used, and used but not owned, for common carrier purposes were excluded. The objection was made that many costs incurred in the original construction of the properties were omitted in the reproduction program, such as the cost of moving highways; to compensate abutting owners of property for damages by reason of such changes; to alter the course of streams; to construct drainage ditches beyond the bounds of railroad property in order to provide a proper right-of-way; to remove in some instances the tracks of other railroads to new locations, and other similar costs.

The valuations omitted the value or cost of reproduction of contracts, rights, interests and privileges owned or used by the carriers, such as contracts and leases for the use of stations, terminals, elevators and warehouses, telegraph and telephone lines, wharves and wharfage rights, trackage and operating rights over the lines of other carriers, contracts for the use of rolling stock and various other rights of occupation, use and ownership. As to this latter objection, the Commission ruled that when a carrier gives another carrier a qualified use in common with itself, such as the right to use its tracks, the facts will be described in the inventory of both the owner and the user, but the value of the property will be reported in the inventory of the owner solely. (75 ICC 1, 24) This conclusion of the Commission not to report the value of trackage rights was challenged by the New York, New Haven & Hartford Railroad in a mandamus action brought against the Commission. When the case reached the Supreme Court, the writ of mandamus was denied, the court holding that the requirements of the Valuation Act were too vague to be enforced by a mandamus, but that in later controversies the question might be pertinent and it would be time enough then to dispose of the question.

The carriers protested that the valuation omitted the cost of developing the common carrier property beyond certain inadequate initial costs of reproducing them new, and also the cost of developing the business of the carrier of the volume and character existing on valuation date. The carriers objected that the Commission's methods did not follow a consistent rule or principle for the assumption of present-day conditions or of historical construction, but arbitrarily used first one and then the other with the result that the cost of reproduction reported was a purely speculative estimate developed on an inconsistent basis. As an example, in Account 12, tracklaying and surfacing costs are limited to an estimate of the costs of new slow-speed track when first made ready for operation, and are insufficient to cover the cost of reproducing the seasoned tracks of the carrier as they existed on valuation date.

The method followed by the Commission in determining depreciation was vigorously protested, the carriers' position then being that the railroad is a continuing property and is maintained by what is known as the replacement method under which, as the service life of any part or piece of the physical property expires, a new part is replaced as a simple cost of operation, and that what was ascertained and deducted as depreciation by the Commission was but a speculative estimate of a future operating cost and was not depreciation at all.

The value of the land reported was objected to as not being its true value or its cost of acquisition, but an estimate of the market value of the adjoining or adjacent land applied to the area of the carriers' land. Protest was made that nothing is allowed for severance or damages to property through which a strip of right-of-way is purchased, and nothing is allowed for the assemblage of parcels into one continuous strip which, experience shows, costs money. Protest was also made of the failure to include in the inventory of carrier lands, areas longitudinally occupied in streets and alleys in which the carrier owns valuable easements and rights-of-way by virtue of grants, franchises or permits for a long term of years, areas occupied in street or alley crossings which are owned by the carrier, and areas owned or used by virtue of contracts or rights in what the Commission has denominated industry tracks.

In addition, there were many items of protest peculiar to individual carriers, but in a narrative of this nature, space does not permit their recital here; nevertheless, many of them amounted to large sums and considerable detail was presented to the Commission in support of these claims.

RESULTS OF THE VALUATION

The Valuation Act was approved March 1, 1913. Not until 1934, or 21 years later, was the last "final valuation report" covering its primary valuation program, based on 1914 prices, issued by the Commission. While a judicial review of the methods followed is still for the future, it is of interest to survey the results shown by the valuations. There is presented a summary abstracted from a pamphlet issued by the Bureau of Valuation on November 1, 1934, entitled "A Summary of Valuations of the Steam Railways of the United States as of the Years 1914–1921, and 1927–1928, made by the Interstate Commerce Commission under Section 19a of the Interstate Commerce Act." (It should be noted here that the 1914–1921 valuations were priced with 1914 prices, and that the 1927–1928 valuations, which included a number of small roads built since the original valuation inventory, were priced with 1927 prices). The summary includes only the 1914 valuations.

TOTAL OWNED PROPERTY

Mileage: Main tracks	274,032
All tracks	379,853

Investment in road and equipment as recorded on valuation date	$18.954,806,466
Cost of reproduction new—1914 prices except land	16,112,634,796
Cost of reproduction less depreciation—1914 prices except land	12,811,086,725
Value of carrier land and rights as of valuation dates	2,733.589,642
Value of non-carrier land and rights and structures (as of valuation dates)	535,999,887
Value "for rate making purposes" of carrier property, excluding working capital	16,245,191,820
Working capital	431,919,400

From the summary it will be seen that the—

"Value for rate-making purposes" of carrier property owned, as of valuation dates, was	$16,245,192 000
Working capital	431.919,000
Total of Carrier Property	$16,677,111,000
Non-carrier lands, rights and structures	536,000,000
Total	$17,213,111,000

In addition to the "values" here reported, the carriers owned securities in non-transportation companies, with a book value of $700,000,000, and also had "non-carrier" working capital (being the difference between what was allowed for working capital and the amount shown in their balance sheets) in the amount of $400,000,000. This, added to the values reported, would make a total of $18,300,000,000.

Total railway capital in the hands of the public on December 31, 1916, average valuation date, was calculated by the Interstate Commerce Commission ("Statistics of Railways in the United States, 1916," page 37) as $16,333,000,000 for all railways, except switching and terminal companies. Switching and terminal companies reported a total or gross outstanding capital of $329.235,000 on that same date. The net capitalization of all railway companies in the United States in 1916 was not greater than the sum of these two totals, or $16,662,000,000.

Therefore, as of the dates of their several official valuations by the Interstate Commerce Commission, the railroads of the United States were not over-capitalized. The value determined by the Commission was at least 1½ billion dollars in excess of their net capitalization. Thus, the ghost of "watered stock," about which so much had been written for these many years, was forever laid to rest. By the same token, the ardent advocates of a valuation of railroad property lost interest, and it soon became a difficult problem to secure funds or even to find advocates to continue railroad valuation work as it seemed apparent the only beneficiaries were the railroads themselves.

By the same measurement, the aggregate of the property investment accounts, which the Commission had so bitterly attacked at every opportunity, were found to be supported by the valuation of the property in existence on primary valuation dates. The following tabulation is presented in support of this statement. Due to differences in valuation estimates and investment accounts, adjustments are necessary to make a proper comparison. Differences also exist in the historical method as carried in the investment accounts and the hypothetical reproduction assumptions which make a proper comparison difficult.

BILLIONS OF DOLLARS

Investment	
Accounts 701–702	$18.9
Account 705	0.3
	$19.2
Less Amounts Written Out in Reorganizations Between 1914—1933	0.5
Total	$18.7

Valuation	
Cost of Reproduction New, 1914 prices	$16.1
Estimated Present Value of Land	2.5*
Estimated Present Value of Non-Carrier Land	0.5
Difference in Pricing of Property Installed After 1914 and Inventory Date	0.5
Total	$19.6

* Original Cost of Land (carrier and non-carrier) estimated to be $1,750,000,000.

Another authoritative study on the relation of railway capital to valuation has been prepared by the Bureau of Statistics of the Interstate Commerce Commission. In 1933 that Bureau issued a statement, No. 3339, entitled, "Comparison of Capitalization (Par value of net funded debt and stock) with adjusted property value." The purpose of the study was to show the extent to which Class I steam railways are over or under-capitalized. A careful analysis was made of the net assets behind the net capitalization of each system as of December 31, 1931. The method followed was, in the words of the Bureau of Statistics:

> "A direct unadjusted comparison of property value and capitalization cannot properly be made because some of the bonds or stocks have been issued to acquire securities that represent property other than that included in the I.C.C. valuation for each road. In this study the gross funded debt or stock of each operating system was first reduced by the amount of the securities of system corporations held within the system to get the net system capitalization representing investments either in system property or in other enterprises, railway or nonrailway. To the primary I.C.C. value of the system properties adjusted to December 31, 1931, on the basis of annual reports, there was added the sum of the reporting carrier's investments in other than system securities as shown by the balance sheet, the sum being intended as an approximation of the net assets behind the net capitalization. The percentages are shown separately for stock and debt. Operating system as here used means the Class I operating carrier and its lessor or proprietary roads constituting a part of its operated mileage. It does not refer to system in the sense of a group of operating Class I roads. The results worked out for each railway separately have been aggregated by regions. For all of the roads the assets are bonded to the extent of 48.31 per cent and the stock is 34.63 per cent of the assets. The sum, 82.94 per cent indicates that the roads as a whole, under normal conditions, were conservatively capitalized.
>
> The results were as follows:

Net assets	$25,764,883,000
Net capitalization:	
Capital stock	8,921,351,000
Funded debt	12,446,969,000
Total	21,368,320,000
Ratio to net assets of:	
Capital stock	percent 34.63
Funded debt	percent 48.31
Total capitalization	percent 82.94"

Still another authority in the matter of a comparison of railway capitalization and valuation was Joseph B. Eastman, Federal Coordinator of Transportation. In his first report to the Congress as Federal Coordinator, printed as Senate Document No. 119, Seventy-third Congress, second session, at page 3, Mr. Eastman made the following statement:

> "Contrary to much popular impression, the railroads are not in the aggregate over-capitalized, in the sense that the par value of outstanding securities exceeds the money invested in the properties. The Bureau of Valuation of the Interstate Commerce Commission has estimated that the original cost of railroad carrier property, other than land, as it existed on December 31, 1932, plus land valued as of June 1, 1933, and plus allowances for working capital, was in the neighborhood of $26,232,000,000. Original cost of lands is not known, but it was probably materially less than the value as of June 1, 1933. Making all due allowance for this fact, however, the original cost of railroad carrier property would not fall below $24,000,000,000. On December 31, 1932, the total railroad capital actually outstanding was $23,573,556,588, made up of $10,226,070,233 in stock and $13,347,486,355 in funded debt. Allowing for intercorporate holdings, the net capitalization outstanding in the hands of the public was $19,489,062,256, made up of $7,150,374,952 in stock and $12,338,687,304 in bonds. * * *"

In other words, Coordinator Eastman found that, as of December 31, 1932, the original cost of only the carrier property was 4½ billion dollars more than the par value of stock and bonds outstanding in the hands of the public. He continued:

> "Viewed from the standpoint of rate-making value, the situation is less favorable. The Bureau of Valuation has estimated the cost of reproduction new less depreciation of railroad carrier property, other than land, existing on December 31, 1932, at prices as of June 1, 1933, plus land value as of June 1, 1933, plus working capital, at about $20,971,000,000. While this is less than the aggregate of outstanding securities, it is more than the net capitalization with intercorporate holdings eliminated, and, moreover, the railroads own much non-carrier property not included in the above value. It may be doubted, however, whether the Bureau made sufficient allowance for the depreciation due to obsolescence. On the other hand, nothing is included in the above figure for so-called intangible elements of value."

COST OF THE VALUATION WORK TO GOVERNMENT AND CARRIERS

This outline of the valuation work would not be complete without mention of the expense incurred by the Government and by the railroads in making the appraisal. Up to June 30, 1935, the cost of the valuation work to the Government was approximately $48,000,000; and the cost to the Class I carriers $152,000,000.

The difference between the estimates of what the valuation would cost and what it finally did cost are illustrated by the following excerpts from the discussions in the

Senate when a bill providing for the valuation of railroad property was being considered several years prior to the passage of the Valuation Act, and other statements quoted hereafter:

> (Cong. Record p. 7140—May 31, 1910—61st Cong. 2nd session) *Mr. Gallinger:* "I will ask the Senator from Wisconsin if I am correctly informed, or approximately so, when certain gentlemen who claim to know a good deal about this matter, say it will cost $8,000,000 or $9,000,000 to do this work." *Mr. La Follette:* "I think I am able to make a fairly authoritative answer to the question of the Senator from New Hampshire. I have referred before to the very careful valuation of the physical properties of the railroads made by the Wisconsin Commission. Their engineers, contractors, bridge builders, architects, real estate experts, have been sent to inspect every detail of the property. * * * They have gone step by step over every inch of this ground, and I can say to the Senator from New Hampshire that at an expense, not exceeding $10.00 per mile, or $2,400,000 for the entire mileage of the United States, we can learn the value of the physical properties of the railroad companies of this country engaged in Interstate Commerce.
>
> "I undertake to say further, Mr. President, that if we will expend that amount of money enabling us to bring railway rates to the proper basis as fixed by the Supreme Court, and as applied in the State of Wisconsin, we will be saved in railway transportation charges in twelve months more than a hundred and fifty times the cost of making the valuation of the physical properties of the railroads of the country."

Director Prouty, in speaking of the estimated cost of the work at the 26th Annual Convention of the National Association of Railway Commissioners, November 17, 1914, said:

> "I see no reason to depart from the first estimate which I made before the Committee on Appropriations, which was that this work would require, before it was completed, an expenditure of not less than twelve millions, nor more than twenty millions of dollars."

Later, at the 29th Annual Convention, in 1917, Director Prouty said:

> "The first time I ever appeared before the Appropriations Committee I told that committee that in my opinion it would cost to do this work not less than $12,000,000 and not more than $20,000,000. Conditions have radically changed since then. The cost of doing this work is certainly 25 per cent more today than it was then, but I still hope and expect that the Government expense will be kept within the maximum then stated, and that it will not exceed $20,000,000."

Again, on February 3, 1919, at a hearing before the House Committee on Appropriations, Director Prouty said:

> "We have asked for $2,500,000 this year, and my general thought has been that my original statement that this work would cost somewhere in the neighborhood of $20,000,000 was not far from right. It may cost a little more; it may cost $1,000,000 more."

These estimates probably referred to the cost to the Government, and it should be stated that had the war not intervened, disrupting the work, and the general increase in the wage level taken place, the primary valuation, no doubt, could have been completed during a shorter period and at somewhat less expense.

Under the plan followed by the Commission, the carriers were required to do much of the work. The cost of complying with the valuation orders of the Commission, and of furnishing the information required by its representatives was considerable and was greatly increased in preparing for and conducting the hearings before the examiners of the Commission as a result of the issues raised under the protests made against the valuations served. In addition, much of the expense in later years has been incurred in recording and reporting the changes in the properties since the date of the original appraisal, as required by the Commission's Valuation Order No. 3. The expense of bringing the valuations to date for recapture purposes, and of conducting conferences and hearings in the issues involved, also added to the expense of valuation, both for the Government and the railroads.

To summarize the expenses by the various stages of the work, and without adjusting for overlapping items, it is estimated that the expenses by the Government and the railroads would subdivide as follows:

	Government	*Railroads*
(a) From inception of the work in 1913 until the end of the inventory period in 1921 (9 years)	$22,120,743	$ 54,120,957
(b) 1922 to the end of 1933. Hearings on protests, recapture proceedings and reporting property changes under Order No. 3. (12 years)	24,550,097	93,409,238
(c) 1933 to 1949, incl., after conclusion of hearings and repeal of recapture; which would cover only current valuation work and reporting of property changes on B. V. Form 588 (17 years) .... (Covers railroads to 12/31/49 and I.C.C. to 6/30/50)	11,727,515	14,522,895
Grand total	$58,398,355	$162,053,090

With the 250,000 miles of road in the valuation program, the inventory cost the Government approximately $100 per mile and the railroads $200 per mile.

KEEPING VALUATIONS CURRENT

In order that the valuations once determined should be kept current, the Valuation Act originally required the Commission, *"in like manner,"* to keep itself informed of all extensions and improvements or other changes in the condition and value of the properties of the carriers, and to revise and correct its valuations and report the same to each regular session of Congress. Carriers were required to make such reports and furnish such information as the Commission might require.

Recognizing the impracticability of complying with this provision, and in response to repeated requests of the Commission, the Emergency Transportation Act of 1933 changed this requirement so as to read:

> "(f) Upon completion of the original valuations herein provided for, the Commission shall thereafter keep itself informed of all new construction, extensions, improvements, retirements, or other changes in the condition, quantity, use, and classification of the property of all common carriers as to which original valuations have been made, and of the cost of all additions and betterments thereto and of all changes in the investment therein, and may keep itself informed of current changes in costs and values of railroad properties in order that it may have available at all times the information deemed by it to be necessary to enable it to revise and correct its previous inventories, classifications, and values of the properties; and when deemed necessary, may revise, correct, and supplement any of its inventories and valuations.
>
> "(g) To enable the Commission to carry out the provisions of the preceding paragraph, every common carrier subject to the provisions of this act shall make such reports and furnish such information as the Commission may require."

In compliance with the valuation orders of the Commission, the carriers have been obliged to keep available the information necessary to enable the Commission to revise and correct its previous inventories and valuations, and, since 1928, have been reporting this information to the Bureau of Valuation on what is known as B. V. Form 588, stating thereon the units added and retired and their costs since the original valuation date. This information is segregated by valuation sections and by primary accounts, and is individualized by structures for the structural accounts and aggregated for the mass accounts, such as grading, tracks, ballast, etc.

Current Engineering Inventory

The information reported on B. V. Form 588 will enable the Bureau of Valuation to prepare reproduction estimates as of any new date of valuation determined upon.

To the units of property thus reported by primary road and equipment accounts, added or retired, the Bureau of Valuation applies its prices on the 1914 pricing level used in the original valuation for each carrier, and the total dollars on the 1914 pricing level resulting are added to the original estimate of the 1914 cost of reproduction new. This gives the Commission an estimate of the units of property currently in place, priced with 1914 prices. To this estimate may be applied on short notice price multipliers to bring the estimate to a current price basis. These multiplers are determined as follows:

The Engineering Section of the Bureau of Valuation, through reports of purchases of railroad materials by carriers and through inquiries of manufacturers, and from analysis of recent construction projects, secures information from which to determine current prices.

Whenever a valuation is desired for a particular carrier, current period reproduction prices for some selected period on items applicable to its property are compiled by the bureau. The period selected ends with the latest year but does not always include the same number of preceding years; in other words, the length of the selected period may vary. These period prices, divided by the 1914 prices used for that carrier in the original engineering report, gives multipliers to be applied to the total 1914 money already at hand. By this method, present-day reproduction costs are quickly produced.

For those years where current 588's are not available, it is the practice of the Bureau of Valuation to use annual charges and credits to the carriers' investment account to bridge the gap between the last 588 return and the current valuation date, adjusting these figures to the 1914 pricing level, and to add the money to their base figures.

The method has been fully described by the Bureau of Valuation in the Statement of Methods attached to Exhibit 119 in Ex Parte 175, from which the following is quoted:

Cost of Reproduction New

"The starting point in estimating cost of reproduction of each carrier is the basic engineering report underlying the Commission's final valuation of the carrier. Additions to and retirements from the properties in the basic report are reported to the Commission under Valuation Order 3, which requires carriers to report annually changes in property items. To insure accuracy these property changes should be verified by the Bureau of Valuation, and then be carried forward into continuous inventories. But due to very limited personnel, field inspections and pricing of detail quantities have fallen far behind. In making current estimates the Bureau has, over a period of several years, had to resort to the short-form method in which gross charges and credits are used, instead of detail quantities, and factors applied to convert them to costs which were normal as of 1914.

"There were applied to the quantities in the basic reports and to all capital additions and retirements subsequent thereto, normal prices as of 1914, except as noted above. The purpose is to keep all carriers on a comparable and uniform basis, so that adjustments may be made by use of corrective factors which take into account changes from normal prices as of 1914. The procedure thus outlined produces totals as of January 1, 1951, but priced at normal prices as of 1914. By the use of multipliers, reflecting the price relationship between 1914 and 1950 period prices, these totals have been brought to the 1950 period prices level.

"Period prices as of January 1, 1951, have been applied. They are based on an investigation of prices over a period of years, giving appropriate consideration to the usual transitory nature of inflated prices occurring because of labor, material, or food shortages during a war or post-war period. Primary consideration has been given not only to prices prevailing during the immediate pre-war and war periods, but also to those prevailing in subsequent years, and a long-term forecast was made of the more permanent future price trends, based on a consideration of the action of prices following other major wars. The established level of these period prices contemplate 'tunnelling through' the post-war price peaks substantially above the 1936–1940 depression pre-war level and approximately 20 percent below the 1950 spot price levels. On many items of railroad property, comprehensive analyses of price data have been made and joint agreements on yearly prices have been reached with carriers' representatives. Supporting these agreements are reports of major carriers concerning purchases of certain items in each year, abstracts of contracts or final estimates on all important railroad construction work, statements of equipment costs furnished by the purchasing carriers, and, in addition, manufacturers' quotations and data contained in various trade journals."

Cost of Reproduction Less Depreciation

"As to the items priced in detail, appropriate rates of depreciation have been applied on a straight-line basis in accordance with the established practice of the Commission. In those cases where charges and credits were used, for expediency composite rates reflecting the individual rates of the various items have been applied, on the straight-line basis. Because of deficiencies in the force available, field inspection has not been made for verification of condition of properties."

The depreciation determined in the original valuations is extended down to current dates. As the straight-line method is followed, based on service lives, it naturally follows that the depreciation has been increased with the age of the property. The depreciation percentage determined in the original valuations approximated 21 percent, and this has now been increased to approximately 35 percent.

The work of repricing the inventory is not yet on a current basis for every carrier, but the Bureau of Valuation, by the use of investment account figures, has prepared exhibits and introduced them in many general rate cases; such as Ex Parte 103, Docket 26,000, Docket 26,592, a Divisions Case involving Eastern and Southwestern carriers, Ex Part 115, Ex Parte 123, Ex Parte 148, Ex Parte 162, Ex Parte 168, and Ex Parte 175.

It should be noted that by its methods practically all the principles employed in making the original valuation are contained in the valuations brought forward to the new dates; thus practically all of the exceptions taken by the carriers to these principles and methods used in the original valuation would have equal weight today.

Bringing Land Values to Date

By utilizing reports of carriers as to parcels of land purchased or retired, and also as to changes in classifications of carrier or non-carrier lands, the Bureau of Valuation has kept its land report current as to areas and classifications. The field forces of the Land Section have investigated sales and assessments or other changes in values, and have taken the original zones and have corrected their estimates of land valuations accordingly for each individual carrier. The method is described by the Bureau of Valuation in the Statement of Methods in Exhibit 110 in Ex Parte 175 as follows:

LAND AND RIGHTS

"The estimates of land values as of January 1, 1951, are based upon the land reports underlying the Commission's final valuations, the land reports prepared in connection with recapture proceedings, exhibits prepared by carriers on reorganization proceedings under Section 77 of the Uniform Bankruptcy Act, and reports submitted by the Bureau to the Commission in various other proceedings.

"The Bureau has revised its basic statement of areas and classifications to reflect changes in the quantity and use of railroad real estate to varying dates, generally recent, to which has been applied the latest available unit values. The Bureau has brought the values forward to January 1, 1951, by the use of charges and credits in money for the period intervening between the date to which the inventory was posted and January 1, 1951.

"Rights in lands were generally carried forward at amounts used in the latest complete land report, although in important instances of rights granted for limited periods, values were recomputed to reflect unexpired portions of the tenures."

Estimated Original Cost to Date

In the original valuations the Commission reported that it was unable to find the original cost to date of the carriers' property and refused to report an estimate. In more recent valuations an estimate is made of the original cost to date, (exclusive of land) which consists of the cost of reproduction new (exclusive of equipment and machinery) determined in the original valuation, priced with 1910–1914 prices, plus net additions and retirements made since the date of the original valuation. In the case of equipment and machinery, the cost found by the Commission under Valuation Order No. 8 is used in lieu of the cost of reproduction new. This is termed the "original cost to date."

In this connection Director of Valuation E. I. Lewis' statement at a hearing December 6, 1933, before the House Committee on the Independent Offices Appropriation Bill for 1935, may be noted:

> "One of the most difficult problems that the Bureau has had to deal with is the ascertainment of the original cost of property dedicated to public service and now in use. This can readily be understood. Railroad construction began in this country more than 100 years ago and in more than four fifths of that time, there was no uniform recording of costs. Many records, such as they were, were lost or destroyed. Under the valuation act the Commission has required the carriers to report annually all changes in property that have occurred since the original inventory and primary valuation. It happens that in that period the railroads have been largely reconstructed. The result is that in charging out the old and charging in the new, and following the changes in the property in all other respects, we have come into possession of actual recorded costs.
>
> "Fifteen years ago the percentage of original cost unknown was probably 85 per-cent of the whole. But in following the changes in the property, the field of the unknown as to original cost has been narrowed to approximately 30 per cent. With the changes now in prospect, it can reasonably be expected that the known original cost of a property will be narrowed down to permanent property; that is to say, largely used rights of way, tunnels, etc., that do not change. Original cost is one of the elements listed in the famous *Smyth v. Ames* decision of the Supreme Court to be taken into consideration in the ascertainment of value." (p. 176)

In the Statement of Methods of the Bureau of Valuation in Exhibit 119 Ex Parte 175, the derivation of original cost estimate is stated to be as follows:

ORIGINAL COST (EXCEPT LAND AND RIGHTS)

"Basic original cost was determined by adoption of cost of reproduction new at 1914 price levels as of basic valuation dates for properties (other than land and rights) that were in existence at the time of original valuation and that remained in use on January 1, 1951, but for which properties no record or proof of original cost was then or is now available. This follows the Commission's previous conclusion, often stated, that 'reproduction cost at normal prices as of 1914, arrived at by consideration of cost data covering periods of five or ten or more years previous to June 30, 1914, produces, by and large a fair average of the cost of constructing railroads in most parts of the country during * * * years [antecedent to 1914] when the great bulk of railway property then in use had come into existence or was brought to modern form.' At the present time, due to the additions, replacements, and retirements of property since the dates of basic valuations, the major portion of the original cost of the physical property (other than lands and rights) owned by Class I carriers is represented by actual cost.

"Adjustment of the original cost figures, as so estimated, to January 1, 1951, was made by summarization of costs as recorded and reported for all additions, replacements, and retirements of property made subsequent to basic valuation dates, as filed by each carrier in compliance with the Commission's Valuation Order 3 and Supplements thereto, showing property units with costs, with such adjustments as were necessary resulting from examinations and test checks made by field and office accountant and engineer examiners. However, due to continued lack of staff of field and office examiners of adequate proportions, the Bureau has been forced to use numerous carrier prepared reports for property changes which were not tested or checked. Costs so estimated will be subject to such adjustments as may be found necessary when the accounts are tested and checked in accordance with Commission approved rules. In the case of certain carriers which delayed filing their reports of property changes by units and costs for some of the late years, use was made of statistical reports recording changes in dollars only."

Working Capital

The Bureau of Valuation's method of determining working capital in their latest valuation (Statement of Methods, Exhibit 119, Ex Parte 175) has been stated by them to be:

Working Capital

"Working capital has been determined in accordance with the principles stated in *Northampton and Bath R.R. Co.*, 149 I.C.C. 244, 263–272, and other valuation cases.

"The basic data used for determining invested working capital as an element of value were obtained from an analysis of the current assets, current liabilities, operating revenues, operating expenses, and taxes, reported in carriers' annual reports to the Commission for the year 1950.

"Working capital found in form of materials and supplies represents the balance shown in the annual reports, adjusted to exclude scrap or obsolete material, and the part held for additions and betterments."

Current Tentative and Final Valuations

As the amendment to the Valuation Act relieved the Commission of the necessity of correcting its valuation until needed, in only two cases has a new valuation been made and served on the railroads which contained a finding of "value." These were in the cases of the Southern Pacific Lines in Texas and Louisiana, and the Rock Island Lines, which were prepared as of December 31, 1932. Many valuation figures for individual railroads have been furnished in response to requests of the state commissions, the Reconstruction Finance Corporation, and others. In practically every reorganization case, the Bureau of Valuation prepared a report containing its elements of value as of current dates for the information of the Commission and all parties of record.

AGGREGATE AND RECAPTURE VALUATIONS MADE UNDER SECTION 15a OF THE ACT TO REGULATE COMMERCE (1920–1951) AND THE O'FALLON DECISION

While Section 19a of the Interstate Commerce Act provided for the valuation of the property of the carriers, the Valuation Act did not state what use was to be made of the valuations when determined, except that all final valuations should be published and should be prima facie evidence of value of the property as of the date thereof in all proceedings under the Act to Regulate Commerce. In its frequent recommendations to Congress for a valuation of the railroads, the Commission evidently had in mind primarily the use of valuations for rate cases.

The Transportation Act of 1920 contained a new rule of rate-making, embodied in Section 15a, which provided that the commission should prescribe rates so that the carriers as a whole should earn a fair return upon the aggregate value of the railway property held for and used in the service of transportation, and fixed 5½ percent as a fair rate of return which the Commission, in its discretion, could increase ½ of 1 percent to provide for additions and betterments, and that the Commission should from time to time determine the aggregate value of the property of the carriers and could utilize the results of its investigation under Section 19a (the Valuation Act) insofar as deemed by it available, and should give due consideration to all the elements of value recognized by the law of the land for rate-making purposes. The property investment accounts of the carriers were only to be given that consideration which, under the law, it was entitled to in establishing values for rate-making purposes.

Section 15a also provided that any carrier that received in any year a net railway operating income in excess of 6 percent of the value of the railway property held for and used by it in the service of transportation, should place one-half of the excess in a reserve fund and the other half should be paid to the Commission for the purpose of establishing and maintaining a general railroad contingent fund, to be used by the Commission in furtherance of the public interest, either by making loans to carriers or to refund capital securities or purchase equipment and lease the same to carriers. This was the so-called "recapture" provision.

Recapture Valuations

To carry out the mandate of the Transportation Act of 1920, relating to the recapture provisions, in order to determine whether the individual carriers had earned a 6 percent return upon the value of their properties, the Commission issued general orders requiring the carriers to file annual reports showing the value claimed by them for the property used in the service of transportation during the year, the net railway operating income for this period, and other information for the determination of excess income. In addition, the carriers' accounting records were policed and checked by the Commission's representatives.

As a result of its investigations, in those cases where it appeared that a carrier had net railway operating income in excess of the statutory return, the Commission prepared a valuation as of each of the recapture years and issued a report, which contained an order directing the carrier to pay over the money which it found to be due under the recapture clause. This valuation was based upon the information gathered in preparing its valuation under Section 19a. Reproduction cost new, and less depreciation, were estimated as of the recapture years. Due to the higher price levels, reproduction cost figures had increased, and the Commission commenced finding and reporting original cost, estimated in part, which, of course, was substantially less than the post-

A

war reproduction cost. Value of the carriers' lands was determined as of the new date, a new and greater estimate of the amount of depreciation was made, and the amount of working capital was determined by the use of a formula used in the original valuations. Thereafter, the Commission's tentative and final recapture reports stated values which approximated the average of the cost of reproduction less depreciation and the original cost depreciated, plus the land values and working capital.

In order to determine the basic principles which should govern in the recapture valuations, the Commission completed its report and found the value upon the St. Louis & O'Fallon Railroad, a small coal railroad in East St. Louis, Ill., for the recapture years, 1920, 1921, 1922 and 1923, and made a final report and order upon the carrier to pay the amounts due. In arriving at its figure of value, the Commission took its finding of final value under Section 19a, priced with 1910–1914 prices, and added thereto the net amount of additions and betterments to the new dates, thereby failing to give any weight to the then shrunken dollars of the kind composing the income upon which it was levying recapture. There were other grounds raised in the protest of the carrier, but this was the principal one.

The case was carried to the Supreme Court of the United States, and the court found that the Commission had erred in not giving consideration to current reproduction costs in making its valuation. The opinion concluded with the following words:

> "In the exercise of its proper function this Court has declared the law of the land concerning valuations for rate-making purposes. The Commission disregarded the approved rule and has thereby failed to discharge the definite duty imposed by Congress. Unfortunately, proper heed was denied the timely admonition of the minority—'The function of this commission is not to act as an arbiter in economics, but as an agency of Congress, to apply the law of the land to facts developed of record in matters committed by Congress to our jurisdiction.'
>
> "The question on which the Commission divided is this: When seeking to ascertain the value of railroad property for recapture purposes, must it give consideration to current, or reproduction, costs? The weight to be accorded thereto is not the matter before us. No doubt there are some, perhaps many, railroads the ultimate value of which should be placed far below the sum necessary for reproduction. But Congress has directed that values shall be fixed upon a consideration of present costs along with all other pertinent facts; and this mandate must be obeyed. * * *" (279 U.S. 461, 487).

In all, it was estimated by the Commission that there was involved in recapture an amount of $360,000,000. Up to the signing of the Emergency Act of 1933, the Commission had completed 169 reports, demanding the payment of $101,265,000. These reports were protested by the carriers and hearings on the protests were held in some instances, and final valuations made as of the recapture dates, and demand was made of the carrier to pay the amount due. Court proceedings were instituted in one or two cases, but were never concluded, owing to the repeal of recapture.

The Emergency Act of 1933, already referred to, repealed the recapture provisions of the Transportation Act of 1920 *ab initio,* and directed that all sums paid in by carriers under those provisions should be returned to them. The new rate-making rule adopted in 1933 and further amended September 18, 1940, eliminated all reference to a fair return on an aggregate value and is shown in Appendix B. The declaration of "National Transportation Policy" added September 18, 1940, is likewise shown in Appendix B.

Ex Parte Rate Case Valuations

In practically every general rate case prior to the passage of the Valuation Act in 1913, the Commission had lamented they had no authoritative valuation of railroad property to test the reasonableness of rates, nor had it a clear mandate to fix rates so as to yield a certain amount in net earnings. The opinion of the Commission covering the rate of return in the Eastern Advance Rate Case of 1911, included in Appendix A hereafter (see page 47), summarizes very aptly the difficulties the Commission labored under in not having the results of the valuation work. Great stress was laid on the necessity of having the present cost of construction as compared with the original cost The Valuation Act of 1913 and the Transportation Act of 1920 gave the Commission the working tools and the necessary authority.

In Appendix A there is presented in tabular form, on pages 48, 49 and 50, tables which contain the elements of value and the findings of approximate aggregate value in the various ex parte freight rate cases which came before the Commission, beginning with Ex Parte 74 in 1920. For convenient reference there is also shown the findings as to the elements of value for the aggregate of all *primary valuations* of the Class I railways. Also included in Appendix A are abstracts from the opinions in these ex parte cases which cover the valuation or rate base portion.

It is not the purpose of this article either to justify or criticize the extent or nature of the increases granted or denied, but to contrast the aggregate rate base findings in the light of current price levels in effect at the time of the decision and the use of the elements of value found. No one knows the workings of the judicial mind, but in combining or weighting the elements in a consistent manner in all of the cases during the period 1920—1951, certain facts become apparent.

In *Ex Parte 74,* decided July 29, 1920, the Interstate Commerce Commission first determined the aggregate value of railroad property, utilizing the results of its valuation as it had thus far progressed. The value found was approximately 17.5 billion dollars for the Class I railroads, exclusive of working capital, contrasted with 19.0 billion dollars appearing on the carriers' books. Adjusting the basic valuation findings for reproduction cost to price levels existing in the five-year period prior to 1920 (170) and adding the increase in investment account produces the total of approximately 27.2 billion dollars for reproduction cost in 1920; depreciating it gives the cost of reproduction less depreciation of 21.5 billion dollars. By adding the increase in property to the reproduction cost found in the basic valuations, 1914 prices, produces 16.3 billion dollars as an estimated original cost. Adding land value aggregating 2.6 billion dollars gives 18.9 billion dollars. Deducting accrued depreciation on carriers' books amounting to 1.0 billion dollars leaves 17.9 billion dollars, or just about the value found. Thus, the first time an aggregate value of railway property was determined, the Commission adopted the original cost basis as its valuation method and ignored giving any weight to reproduction cost at current price levels. Had they used reproduction cost and weighted it, following the methods used in later cases, the figure they would have found in Ex Parte 74, which was the genesis of their rate base findings, would have been not less than 22.0 billion dollars. Thus, 4.0 billion dollars was removed from all consideration in their first rate base findings.

In *Ex Parte 115 and 123,* decided 1938, the Commission actually used all of its elements of value. Reproduction cost at period prices and original cost were weighted, land values and allowance of working capital added, which produced the aggregate value found. In these cases the five-year period price level was 139. Cost of reproduction new of 25.0 billion dollars was found, and depreciated reproduction cost was 18.0 billion dollars; estimated original cost 22.0 billion dollars; land and working capital 2.6 billion dollars. These figures weighted gave 19.9 billion dollars, the aggregate value found. It will be noted how much closer together the figures for reproduction cost and original cost were than was the case in 1920.

In *Ex Parte 162,* decided in 1946, when the period price level was 181, the Commission added only the net increase in property investment to its prior findings in 1938 when the price level was 139, and again reverted to its prior practice of ignoring current reproduction cost.

In *Ex Parte 166, 168 and 175,* the Commission's method of deriving value, as explained by them, consisted of adding to the estimated original cost the present value of land and working capital and deducting the amount of depreciation and amortization accrued on the carriers' books; thus, without equivocation, reproduction cost was denied any weight in arriving at its rate base findings. The five-year period price level in Ex Parte 166 was 220, in 168 was 252, and in 175 was 271. Had the Commission weighted the elements followed in Ex Parte 115 and 123, it would have found a rate base value in Ex Parte 175 of approximately 26 billion dollars, which more realistically approaches the facts than the finding of 22 billion dollars stated in its decision. Thus, again, the carriers have been denied a return on an additional 4 billion dollars of property to which, under all rules of economics, they are justly entitled.

It has been demonstrated that in the aggregate the property investment accounts of the carriers were justified by the results of the Commission's valuation. Taking the total of the investment accounts on dates of basic valuation, which amounted to 18.3 billion dollars (some of which were reduced in reorganization proceedings to the amount of approximately 500 million dollars), leaves on valuation date an investment account restated of 17.8 billion dollars. On December 31, 1949, the same investment accounts kept all during this period, under the rules of the Commission, aggregated 29.1 billion dollars, or over 11.3 billion dollars increase in the property investment account.

Examination of the Bureau of Valuation's reproduction costs as of valuation date shows they found a total of 15.6 billion dollars for Class I railways. Today, the property in existence, priced at the same level of prices (viz. 1914) as the Bureau used in applying to the basic valuation inventories, aggregates 19 billion dollars, or an increase of 3.4 billion dollars in units of property at 1914 dollars. Subtracting this from 11.3 billion dollars increase in property investment account leaves practically 8 billion dollars which has been added to the investment account. This amount, therefore, represents dollar values that now appear on the books as the result of increases in unit prices, without any corresponding increase in property.

What has resulted was anticipated by a large railroad when the Commission changed its accounting rules in 1907 to provide that property retired, except tracks, should be written out at its ledger value, and property added should be stated on the books at its original cost. As a consequence of following this rule, since 1916 over 8 billion dollars in values, inflated through price increases, have been added to the property accounts. As previously stated, carriers are denied the right to include these charges in Operating Expenses because of accounting rules made by the Commission which define such expenses as "Additions," although in most cases they are only replacements of existing items, purchased or installed at higher prices. It would seem appropriate to include the quotation referred to above from the carrier's report to its stockholders in the year 1910, which graphically predicted the situation in which the railways now find themselves:

> "The new accounting classifications promulgated by the Interstate Commerce Commission require all expenditures above bare maintenance to be included in

> the cost of road and equipment, and there seems to be a growing tendency among American railroads to forget the lessons learned through a long list of receiverships and reorganizations, and provide out of capital for outlays which should be met through income. If rates could always be uniformly maintained, if the cost of labor, material and taxes were always stable, if business prosperity were continuous, if it were not necessary for a railroad to make any improvements except such as would substantially increase its earning power, then, under such ideal conditions, it might be claimed that all construction expenditures should be capitalized, and the funds provided therefor through the sale of stock or bonds. Your management has always aimed to conduct its operations so as to give an efficient service to the public, adequately maintain the property, provide for depreciation and obsolescence, pay regular dividends to its stockholders, and earn a surplus income for those necessary additions and betterments which in themselves add but little, if any, to earning power. The pursuit of this policy has established and maintained the high credit of your company, and made possible the physical development through which it is able to render the safe and efficient service required by its patrons, and it is the judgment of your management that any enforced departure from this policy is unwise."

In Ex Parte 166, 168 and 175 the carriers, through Witness H. T. Bradley, valuation engineer, appearing on behalf of the carriers, objected to the Commission's finding of aggregate value without giving weight to the Bureau of Valuation's estimated cost of reproduction. The constant shifting of the rate base findings so as to always produce the lowest value was portrayed in the carriers' brief dated July 9, 1951, and filed in Ex Parte 175, of which the following is an excerpt:

> "Sheet 6 of Appendix A to this witness's verified statement illustrates the arbitrary consequences of ignoring reproduction elements in a period of rising costs, as the Commission has done since World War II in Ex Parte 166 and 168, and of giving them effect in depression years, as it did in Ex Parte 115 and 123. In this portion of his presentation, Mr. Bradley applied the Bureau's method of determining value in Ex Parte 168 to elements of value reported in prior general revenue proceedings. The original cost approach would have produced an aggregate value of $21,761,000,000 in Ex Parte 115, whereas the method actually used resulted in a value of $19,882,000,000. In Ex Parte 123, the original cost method would have produced a value of $21,889,000,000, but the value actually reported in that case was $19,972,000,000.
>
> "In short, valuation of Petitioners' railroad property was subjected to the depressing burden of reproduction cost elements in the thirties and has been denied the correlative protection provided by such elements in recent years of greatly inflated costs. This violates the very essence of fair play. If any weight is to to be accorded to Bureau of Valuation figures, it is most respectfully submitted that the method of determining value may not properly be altered so as always to produce the lowest value."
>
> * * *
>
> "If the national transportation policy's paramount objective of a system of railroad transportation adequate to meet the needs of commerce and defense is to be maintained, it is unmistakably clear that the railroads must be provided with earnings related to current costs. Appropriate weight, accordingly, must be given to reproduction costs or the rate of return must be correspondingly increased if such an approach is to be used in measuring their revenue requirements. In short, the railroads—like labor, agriculture and industry—cannot live unless the dollars they take in bear a practical and reasonable relationship to the dollars which they must pay out."

Another anomaly in valuation for rate-making purposes may be illustrated by the Commission's treatment of the pipe line valuations. Under a consent decree the current valuation of pipe line property became desirable due to its use as a rate base on which pipe line companies were permitted to make charges to users of their facilities to yield a specified return. In these valuations an analysis of the findings discloses that the Commission arrived at its value by weighting the cost of reproduction less depreciation and original cost less depreciation, to which is added value of lands and working capital. For illustration, in the Ajax Pipe Line valuation, an application of the Commission's original cost formula used for railroads would have produced for that property a value approximately one-half of that actually found. It is difficult to understand the attitude of the Commission, having under its regulations both pipe lines and railroads, in adopting for one group of utilities one method, and by the same token turn about and find another method which they deem appropriate to use in valuing railroad property.

VALUATION COURT CASES

In the conduct of its work under Section 19a, the carriers objected to certain methods or rulings of the Interstate Commerce Commission, and filed suits in Federal courts to restrain or compel the Commission to change its course of action. Some of these cases were successful in the lower courts but the Supreme Court refused certiorari.

The following cases reached the U.S. Supreme Court for final adjudication:

- Kansas City Southern Railway Company vs. Interstate Commerce Commission, March 8, 1920 (252 US 178)
- United States ex rel St. Louis Southwestern Railway Lines vs. Interstate Commerce Commission, et al., February 18, 1924 (264 U.S. 64)
- Delaware and Hudson Company, et al. vs. The United States of America and the Interstate Commerce Commission, January 5, 1925 (266 US 438)
- United States of America et al., Appellants vs. Los Angeles & Salt Lake Railroad Company, February 21, 1927 (273 US 299)
- Interstate Commerce Commission, Petitioner, vs. New York, New Haven & Hartford Railroad Company, et al., November 21, 1932 (287 US 178)

A brief synopsis of the issues involved in these cases and a summary of the courts' findings follows:

Kansas City Southern Railway Company vs. Interstate Commerce Commission, Decided March 8, 1920 (252 US 178)

Section 19a of the Interstate Commerce Act originally required that the Commission should investigate and report as to lands ". . . separately the original and present cost of condemnation and damages or of purchase in excess of such original cost or present value." In its report on the valuation of the Texas Midland Railroad (75 ICC 1), the Commission, while recognizing the existence of such excess land acquisition costs, regarded their measurement as impossible in connection with any ascertainment of the then present value of the carriers' lands and refused to report them. The Commission stated that its views were supported by the decision of the Supreme Court in the Minnesota Rate Cases.

The Kansas City Southern Railway Company objected to the failure of the Commission to report the excess cost of acquisition of its lands and filed a mandamus action to force the Commission to comply with the requirements of the Valuation Act. The case finally reached the Supreme Court and on March 8, 1920, the court rendered its decision, which required the Commission to carry out its functions under the statute. Following this, the Commission then proceeded in a number of cases to include in their tentative valuations an estimate of the excess cost of acquisition of lands. The lands of the carriers were divided into types and estimates made of the cost of acquiring lands of these types, based on a study of many actual land transactions. Being dissatisfied with the requirements called for by the statute, the Commission urged Congress to repeal this requirement from the Valuation Act. By an act of June 7, 1922, the Commission was relieved of this task and thereafter discontinued reporting excess cost of acquisition of lands. In its findings of value, no weight was given to the figure reported for excess cost of acquisition of land. All final valuations under Section 19a omit such a finding, although in a considerable number of tentative valuations, the Commission reported the excess cost of acquisition of carrier land.

U. S. ex rel St. Louis Southwestern Railway Lines vs. Interstate Commerce Commission, et al., Decided February 18, 1924 (264 US 64)

In this case, in order to prepare its protest to the tentative valuation, the carrier requested permission of the Commission to examine and make copies of certain original field notes, cost data, copies of contracts, records of construction costs, opinions, sales, assessments and other data, reports, records and compilations of the Land, Accounting and Engineering Sections of the Bureau of Valuation. The request was denied by the Commission until such records had been offered in evidence in hearings before the Commission upon protests against the tentative valuations of carriers' properties, or before a court of competent jurisdiction, on the ground that it would be detrimental to the public interest, and would make it impossible to secure as reliable and uninfluenced opinions as to land values and price and cost information as it could otherwise secure; would unnecessarily prolong the work, and greatly increase the expense thereof; and would seriously interfere with due performance of the regular duties of the Commission's employees. It therefore sealed the records from any inspection other than the Commission's employees.

Following this action, a writ of mandamus was filed against the Interstate Commerce Commission asking that the court grant an order directing the Commission to permit the carrier to examine all of the data referred to upon which its valuations were based. The lower court granted the motion of the Commission to dismiss the petition, whereupon the carrier appealed the case to the Supreme Court. The Supreme Court overruled the lower court and granted the writ of mandamus, wherein it is stated, among other things:

> "manifest justice requires that the railroads should know the facts that the Commission supposes to be established and we presume that it would desire the grounds of its tentative valuation to be subjected to searching tests. But there are necessary limits. While there can be no public policy or relation of confidence that should prevail against the paramount claim of the roads, the work of the Commission must go on, and can not be stopped as it would be if many of the railroads concerned undertook an examination of all its papers to see what they could find out. * * * Moreover at the hearing there will be limits, at the discretion of the Commission, to the right to delay the sittings by minute inquiries that might protract them indefinitely. * * * But subject to that discretion we think that in such way as may be found practicable the relator should be enabled to examine and meet the preliminary data upon which the conclusions are founded, and to that end should be given further information in advance of the hearing, sufficient to enable it to point out errors if any there be."

As a consequence of the decision, the Commission issued an order under date of May 13, 1924, opening certain data therein described to examination by the carriers, and also specifying the manner in which the application to examine the data must be made.

The Delaware and Hudson Company, et al. vs. The United States of America and The Interstate Commerce Commission, Decided January 5, 1925 (266 US 438)

In this case the carrier petitioned that the court require the Interstate Commerce Commission to annul its tentative valuation of the properties of the carriers. It charged that the Commission failed to investigate and report many facts relative to values, as required by the statute; refused to investigate, ascertain and report concerning properties used by it for purposes of a common carrier; refused to apply to inventories prices existing and current on June 30, 1916; omitted to report analyses of the methods employed for ascertaining values, costs, etc.; and also omitted to investigate and report the amount of working capital actually used for purposes of common carriers. All of these allegations were contained in the protest the carrier filed against the tentative valuation.

The lower court dismissed the petition for want of equity, and a direct appeal was filed with the Supreme Court. The Supreme Court affirmed the decision of the lower court and stated:

> "The 'tentative valuation' of the statute is no more than an *ex parte* appraisement without probative effect. By the authorized 'protest' the carrier may offer objections to anything done or omitted in respect thereof and secure the Commission's rulings before the valuation becomes final. Prior to the present proceeding protests, raising the very issues now tendered, had been made and were awaiting action. There is nothing to indicate that the Commission wilfully disregarded the law as honestly interpreted or failed to proceed in an orderly manner, or that it will not consider and pass upon all the matters set up in the protest and repeated here. Pending further action by it the tentative valuation will not become final and no proceedings thereon can be taken. Under the circumstances disclosed appellants must pursue the remedy provided by the statute and give the Commission opportunity to take final action before they can properly ask interposition by the courts."

United State of America et al., Appellants vs. Los Angeles & Salt Lake Railroad Company, Decided February 21, 1927 (273 US 299)

The carrier brought suit in the federal court for southern California to enjoin and annul an order of the Interstate Commerce Commission purporting to determine the final value of its property under Section 19a. The carrier asserted that the order fixing the final valuation was invalid, because it was in excess of the powers conferred upon the Commission and was contrary to the provisions of the Valuation Act, and violated the Fifth Amendment. It also asserted that irreparable injury was threatened.

The carrier charged that the Commission adopted rules for the valuation which were unsound and unwarranted in law, and that in the determination of values it ignored facts and factors of major importance; it refused to report an analysis of the methods employed by it; and that it refused to comply with the requirement that all values and elements of value be separately reported. It also charged that the valuation was made as of June 30, 1914, whereas it should have been made as of June 7, 1923. The value found was that for rate-making purposes, whereas the finding should have been a general one of value for all purposes; that properties enumerated were erroneously excluded from the valuation, and in making the finding of value the Commission erroneously failed to consider nine specified elements of value; that in making the finding of investment in road and equipment it ignored 6 items; that in making the finding of cost of reproduction new it ignored 11 items; that in making the finding of cost of reproduction new less depreciation, it made 13 errors; in valuing the lands 11 errors were made; and that in making the finding as to working capital, a large sum was arbitrarily deducted. It alleged that for these and other reasons the findings made were incomplete, erroneous in law, and misleading in point of fact.

The lower court overruled the demurrer and motion to dismiss, and ordered that a copy of all evidence introduced, which was not submitted to the Interstate Commerce Commission, be certified to it for its consideration and action within six months. The Commission, after reviewing the evidence, returned to the court a report to the effect that it could find no reason to make any change in the determination of the value of the carrier's property. After reviewing the record and the evidence, the court thereupon stated:

> "We, therefore, see no escape from the conclusion and judgment to which we have come, which is, that the orders of the commission fixing the valuations complained of by the petitioner be and they are hereby annulled, and the said Interstate Commerce Commission is hereby enjoined from in any wise enforcing them."

The Supreme Court, without passing on the allegations made, was of the opinion that the District Court should have sustained the motion to dismiss the bill. It stated that a final report on value, like the tentative report, is called an order, but there are many orders of the Commission which are not judicially reviewable. It found the order here complained of was one which did not command the carrier to do or to refrain from doing anything; it did not grant or withhold any authority, privilege or license; and that the so-called order was merely the formal record of conclusions reached after a study of data collected in the course of an extensive research conducted by the commission through its employees. It was the exercise solely of the function of investigation.

The Supreme Court, in addition, found that in Section 19a Congress had provided adequate remedies for the correction of errors in the final valuation and the classification thereof, and that when the final report was introduced in evidence, the opportunity to contest the correctness of the findings therein made were fully preserved to the carrier and any error made therein may be corrected at the trial. It also found that there was no basis for relief under the general equity powers. The investigation was undertaken in aid of the legislative purpose of regulation, and the conclusions, if erroneous in law, may be disregarded; but neither its utterances, nor its processes of reasoning, as distinguished from its acts, are a subject for injunction.

Interstate Commerce Commission, Petitioner, vs. New York, New Haven & Hartford Railroad Company, et al., Decided November 21, 1932 (287 US 178)

In this and other cases the Commission's valuations omit the value or cost of reproduction of contracts, rights, interests and privileges owned or used by the carriers; such as contracts and leases for the use of stations, terminals, elevators and warehouses, telegraph and telephone lines, wharves and wharfage rights, trackage, and operating rights over the lines of other carriers, contracts for the use of rolling stock, and various other rights of occupation, use and ownership. As to this latter objection, the Commission ruled that when a carrier gives another carrier a qualified use in common with itself, such as the right to use its tracks, the facts will be described in the inventory of both the owner and the user, but the value of the property will be reported in the inventory of the owner solely. (75 ICC 1, 24) This conclusion of the Commission not to report the value of trackage rights was challenged by the respondent in a mandamus action brought against the Commission. When the case reached the Supreme Court, the writ of mandamus was denied, the court holding:

> "We do not go beyond the necessities of the case before us in shaping our decision. Whether an inventory such as this one, omitting a specific valuation of important rights and interests, gives full or adequate effect to the intention of the lawmakers, we are not required to determine. In later or collateral controversies that question may be pertinent. For the purpose of this case, it is enough to hold, as we do, that the duty of specific valuation, if it exists, has been imposed upon the Commission too vaguely and obscurely to be enforced by a mandamus. * * * Public policy forbids that the work of the Commission in the fulfillment of the stupendous task of valuation shall be hampered by writs of mandamus except where the departure from the statute is clear beyond debate. The report is not a stage in a judicial proceeding affecting this carrier or others. 'It is the exercise solely of the function of investigation.' (*U.S. v. L.A. R.R. Co. supra,* p. 310.) * * * In any work so vast and intricate, what is to be looked for is not absolute accuracy, but an accuracy that will mark an advance upon previous uncertainty. If every doubt as to the extent and form of valuation is to be dispelled by mandamus, the achievement of the ends of Congress, already long deferred, will be put off till the Greek Kalends." (287 U.S. 178)

CURRENT USE OF VALUATION INVENTORIES AND RECORDS

Prior to 1906, when the Interstate Commerce Commission was given authority over the substance as well as the form of carriers' accounts, the usual practice in accounting for property changes was to follow replacement accounting, i.e., charge all replacements to operating expenses and add to the investment account only those items of additional property. As a consequence of following this practice over a long period, most railroads had no continuous property records, although many of them had a record of what certain individual structures originally cost.

During the years 1870–1900 many railroads went through reorganization, and when the new company took over the old property, it wrote into the property investment account an amount equivalent to the par value of securities issued in the reorganization. Likewise, many railroads expanded their systems by the purchase or merger of other railroads. Here again, an amount equivalent to the value of securities issued to acquire the new property entered into the accounting and this figure was written into the investment account on the carriers' books. The doctrine of "original cost when first dedicated to public service," had not yet come into being, and even if it had, the original cost of the property in many cases was unknown.

The Valuation Act of 1913 and its detailed inventory of all railroad property classified by the primary investment accounts supplied the carriers with information they previously lacked. Not only did the valuation inventories classify the property by primary investment accounts, but by ownership, use, and by states as the valuation sections did not cross state lines. As a consequence of the valuation, the carrier not only had an inventory as of the original valuation date, but the Commission's orders required it to report subsequent changes in the same detail as the original valuation. The Valuation Act very wisely called for the reporting of units of property as well as their cost, thus fluctuations in the purchasing power of the dollar were not controlling, and it was possible to add units of property in the original valuation to those subsequently acquired, irrespective of their cost, and by applying new prices to the aggregate quantities, thus arriving at an up-to-date inventory priced with current dollars. As the ICC instructions were followed by all carriers, uniformity in practices was secured, and as the returns were subject to field and office check by the ICC, public authorities accepted without qualification the returns made by the carriers showing additions and betterments to their property.

With all of this detail, both the carriers and the commission were able to produce in a short time revised inventories which would serve many corporate purposes, as well as being a source of information for regulatory bodies dealing with taxes, issuance of securities in purchases, mergers and reorganizations, depreciation schedules, retirement entries, and many others.

For the sake of brevity, there follows a statement prepared by the director of the Bureau of Valuation, dated June 16, 1949, which enumerates many of the uses made by the carriers and regulatory bodies in dealing with the property records of the railroads. It can be said that while the valuation and its perpetuation cost a large sum of money, the uses of the information in modern engineering and accounting practice more than justify the large expense and, indeed, if it were not for the continuous inventory and records provided for by the Valuation Act, many tax savings and other benefits would have been lost to the railroads.

INTERSTATE COMMERCE COMMISSION

Bureau of Valuation

STATEMENT SHOWING THE PRINCIPAL CLASSES OF RAILROAD AND PIPELINE VALUATION DATA ON FILE WITH THE BUREAU OF VALUATION, THE PRINCIPAL USES MADE BY THE COMMISSION OF SUCH DATA, AND THE MANY USES MADE OF VALUATION RECORDS BY THE CARRIERS AND OTHERS

Principal classes of valuation data in the records of the Bureau of Valuation are:

1. Basic or primary "elements of value," including inventories and other data relating to original cost, cost of reproduction new and less depreciation, present value of lands and working capital, these inventories and other data fully reflecting conditions of ownership and use, and character of the property.
2. Data, as of varying dates, of the accumulated quantities of the principal items of carrier property, priced at the same basic price level from which a cost of reproduction estimate can be brought to currency through the use of our Railroad Construction Indices.
3. Supporting data collected from records covering the entire lives of the carriers and predecessors, where records were available, comprising financial and corporate histories, results of corporate operations, syndicating and banking, investments, development of mileage owned by construction periods, and information relating to aids, gifts, grants, and donations.
4. Audited statements of property changes and their costs, since primary valuation date, separated between additions, betterments and retirements (the last further divided between original property and subsequent additions). These are further classified as to ownership and use and are worked into inventories broken down by elements of value and by States.
5. Service life data on principal items of railroad property, such as, ties, rail, bridges, buildings, equipment, etc.
6. Current cost data, together with construction indices and guide prices, compiled annually for railroads and pipe lines, joint equipment agreements, depre-

ciation, deferred maintenance and time and use studies, land values and other data necessary to determinations of present-day "elements of value."

7. Data as to the non-use of facilities due to over-expansion of plant, loss of traffic and other causes. (Out-of-service property).
8. Inventory of noncarrier property, including land and structures.
9. Physical characteristics of all railroads, such as, maximum and ruling grades and curvatures, location of bridges, buildings, and other structures.

Principal uses of the valuation data by the Commission are:

1. Aid in passing upon proposed reorganization plans, particularly as to the amount and classes of the securities proposed to be issued.
2. Aid in passing upon application for loans to, and issues of securities by, railroads from time to time.
3. For consideration by mortgage divisions in the proposed mergers, consolidations, reorganizations, and refinancing, the units of property and reproduction estimates being necessary in allocating the property to the different mortgages.
4. In Ex Parte decisions and in cases involving division of rates, the relationship of the values of the properties involved being important.
5. Supplying special studies for Commissioners, such as, for amortization, normal maintenance, car supply problems, rail requirements, and the per diem case.
6. Aid in fixing and checking the reasonableness of the compensation to be paid by carriers for use of joint facilities, terminal companies, etc., as, for example, the Bureau furnished the elements of value put in the record of *Missouri, Kansas & Texas* v. *Kansas City Terminal Railway,* 198 I.C.C. 4.
7. For use in cost of service studies and reports of the Bureau of Accounts and Cost Finding, reproduction cost relationship being a necessity in these studies as well as time and use percentages.
8. To make pioneer studies for the Bureau of Accounts and Cost Finding showing effect of certain accounting revisions on operating expenses.
9. For compilation of rates of depreciation and original cost to be used by railroads in accounting for depreciation in accordance with the Commission's requirements.
10. For determination of past accrued depreciation on reorganized or consolidated railroads.
11. For compilation of original cost to be used by railroads in setting up new investment accounts after reorganizations, consolidations, mergers, etc.
12. For consideration in connection with the determination of proper switching charges.

Principal uses of valuation data by the railroads are:

1. For protecting the company's interests in connection with tax assessments made by the various taxing bodies and the preparation of income tax returns, the railroad construction indices being particularly valuable for this purpose.
2. For arriving at proper insurance schedules covering properties that are insured from year to year.
3. For protecting the company's interest in rate cases and in cases involving division of rates.
4. For arriving at proper rentals to be paid in connection with leasing property to others, or leasing property from others.

5. For arriving at a proper basis covering the use of joint facilities with other railroad companies, including the use of important terminal stations.
6. For acquisition of properties from other railroads, individuals and corporations other than common carriers.
7. For making estimates as to the cost of trackage rights.
8. For supplying ledger values provided for under the accounting classification of the Commission to be used in the abandonment of properties, sale of properties, and retirements which are made in connection with other property changes.
9. For development of data to comply with the requirements of the depreciation order of the Commission to check data supplied by it for depreciation accounting purposes. Our engineers supply initial rates of depreciation on fixed property and act as consultants on equipment, pipe lines and water carrier property, to the Bureau of Accounts and Cost Finding, in connection with the above.
10. For protecting the company's interests in meeting the demands of public authorities for elimination of grade crossings.
11. For preparing data to be used in complying with requirements of State Commissions.
12. For preparing estimates to be used as a basis on which to secure the approval of new construction projects from time to time by the management.
13. For working up data to be used in formulating plans of reorganization, mergers, consolidations, etc.
14. For the establishment of original cost of owned properties to be used as a check of the original cost supplied by the Commission for opening the books of new companies after reorganization.
15. For preparing data to be used in making application for loans from the government. This involves the development by our engineers of salvage values on entire railroads.
16. For determining the proper accounting of expenditures in connection with property changes as between investment and maintenance.
17. For use in settling damage claims on equipment as set out in their rules book referring to joint equipment agreement, which agreement was compiled by our Engineering Section and the Railroad Equipment Committee.
18. The valuation records are the only records available which show the railroad management what physical property the company actually owns from time to time, divided between the various kinds of property, such as, equipment, structures, tracks, lands, etc.
19. Indices and guide prices prepared annually by the Engineering Section of the Bureau are used by the railroads as a basis for estimating cost of new work. See volume 48, page 408, American Railway Engineering Association.
20. Many State tax commissions now inform themselves on property changes reported and valuations reported by the Interstate Commerce Commission and these values are reflected in the taxable value placed on railroad property. See volume 48, page 407, American Railway Engineering Association.

Principal uses of valuation data by other Government agencies, States, municipalities and the general public are:

1. Supplying current reproduction valuations to States for taxing purposes and complying with many hundreds of requests for maps, field notes, indices, special studies from cities, colleges, libraries, financial institutions and other corporations.

2. Bureau of Internal Revenue
   a. Depreciation Studies
   b. Deferred Maintenance Studies
   c. Determination of the normalcy of the 1935–1939 level of business in the railroad manufacturing industry.
3. War Department Engineers
   a. Making estimates of the value of bridges to be removed in connection with flood control programs.
   b. Preliminary estimate for cost of constructing relocated railroads in connection with flood control work.
   c. Estimate of the value of bridges removed in connection with the operation of the Truman–Hobbs Act.
   d. Supplying cost data to assist in budget estimates both as to maintenance and construction.
   e. Estimating costs of railroad construction in foreign countries under varying geographical conditions.
4. Department of Commerce
   Supplying information and requests to numerous calls relating to our Railroad Construction Indices.
5. International Export and Import Bank
   Estimate of railroad construction work under varying conditions in South American countries.
6. War Assets Corporation
   Estimate of salvage value of many items of railroad property, such as, rail, track material, tank cars, etc.
7. Terminal Unification
   Supplying reproduction estimates of railroads involved in terminal unification, such as, at Chicago, Illinois, and New Orleans, Louisiana.
8. Acting as advisor and furnishing information to both railroads and Post Office representatives in the Post Office Railway Mail Pay case.

BIBLIOGRAPHY

ICC Annual Reports to Congress

ICC Valuation Reports

Beginning with (Old Series) Vol. 75 ICC
Through 149 (not consecutive), and New Series
Vol. 22 Through 50 (consecutive)

Interstate Commerce Acts Annotated

Engineering Board Memorandums

U. S. Supreme Court Cases as Indicated by Citations

Circulars of Advice and Statements of Developments

Issued by the Secretary, Presidents' Conference Committee, 1913–1934.

Monograph entitled "Federal Valuation of Railroads"

By Edwin F. Wendt, Consulting Engineer, Pittsburgh, Pa. AREA Proceedings, Vol. 41, 1940, page 907–964.

APPENDIX A

SUMMARY OF ICC ELEMENTS OF VALUE AND AGGREGATE VALUES IN EX PARTE VALUATIONS

●

ABSTRACTS FROM ICC DECISIONS IN FREIGHT RATE CASES COVERING VALUATION OR RATE BASE PORTION

Sheet 1 of 3.

Interstate Commerce Commission

Aggregate Valuation Figures for All Class I Railroads

Total "Used" "Common-Carrier" Property

	Basic Valuations	*Ex Parte 74 (58-ICC-220) 7-29-20*	*Ex Parte 103 (178-ICC-539) 10-16-31*	*Doc. 26000 (195-ICC-5) 7-31-33*
Quantities as of	Avg. Dec. 1916	12-31-19	12-31-29	12-31-32
"Period" prices as of	Normal 1914		1930	1933
Multiplier	100		155	
Cost of Reproduction New, Excl. Land	$15,576,693,346		$26,864,303,934	$22,948,252,110
Cost of Reproduction Less Depr.	12,368,945,391		21,298,024,016	17,007,605,975
Per Cent of Cost New	79%		79%	74%
Original Cost, Excl. Land			21,164,643,979	21,865,799,274
Original Cost Depreciated			16,782,601,590	
Value of Land and Rights	2,593,638,539		3,409,135,849	2,731,009,060
Working Capital	408,412,368		476,700,000	319,005,000
"Final Value" or "Approximate Aggregate Value"	16,043,879,764	$18,900,000,000* 18,000,000,000 (a)		
Investment in R&E (Accts. 701-702)	18,307,293,336	20,040,572,611* 19,000,000,000 (a)	24,884,674,485	25,528,102,616
Accrued Depreciation and Amortization Book Accts. 702½ C-D-E-F-779	670,780,282		2,117,378,000	2,578,382,619
Cash on Hand (Acct. 708)	403,945,726		530,103,000	316,953,120
Material and Supplies (Acct. 716)	428,140,023		470,227,000	316,620,176

*All carriers
(a) Class I—Estimated

Sheet 2 of 3.

INTERSTATE COMMERCE COMMISSION

AGGREGATE VALUATION FIGURES FOR ALL CLASS I RAILROADS

TOTAL "USED" "COMMON-CARRIER" PROPERTY

	Ex Parte 123 (226-ICC-41) *3-8-38*	*Ex Parte 115* (229-ICC-435) *11-21-38*	*Ex Parte 148* (248-ICC-545) *3-2-42*	*Ex Parte 162* (264-ICC-695) *6-20-46*
Quantities as of	12-31-36	12-31-37	12-31-39	12-31-44
"Period" prices as of	139	139	1939	
Multiplier				
Cost of Reproduction New, Excl. Land	$25,078,852,674	$25,016,457,455	$25,501,983,634	
Cost of Reproduction Less Depr.	18,058,276,718	18,000,642,670	16,278,164,511	
Per Cent of Cost New	72%	72%	64%	
Original Cost, Excl. Land	21,965,701,130	21,965,701,130	22,105,434,223	
Original Cost Depreciated		15,817,379,948		
Value of Land and Rights	2,346,077,930	2,346,077,930	2,255,899,718	
Working Capital	289,596,774	289,596,774	296,584,724	
"Final Value" or " Aproximate Aggregate Value"	19,972,000,000	19,882,000,000		$19,571,000,000
Investment in R&E (Accts. 701-702)	24,974,084,351	25,164,248,252	25,115,576,588	26,255,388,106
Accrued Depreciation and Amortization Book Accts. 702½ C-D-E-F-779	2,758,803,799	2,899,623,452	3,051,609,273	4,540,717,276
Cash on Hand (Acct. 708)	538,975,144	361,600,963	538,409,000	943,017,507
Material and Supplies (Acct. 716)	307,245,322	385,273,899	327,396,000	603,932,463

Sheet 3 of 3.

INTERSTATE COMMERCE COMMISSION

AGGREGATE VALUATION FIGURES FOR ALL CLASS I RAILROADS

TOTAL "USED" "COMMON-CARRIER" PROPERTY

	Ex Parte 166 (269–ICC–33) 10–6–47	*Ex Parte 168* (276–ICC–9) 8–11–49	*Ex Parte 175* (281–ICC–557) 8–2–51	*Ex Parte 175* (284–ICC–589) 4–11–52
Quantities as of	12–31–46	12–31–47	12–31–49	12–31–50
"Period" prices as of	12–31–46	12–31–47	12–31–49	12–31–50
Multiplier	178	200	215	220
Cost of Reproduction New, Excl. Land	$32,613,665,594	$36,391,377,380	$38,203,486,924	$41,803,528,860
Cost of Reproduction Less Depr.	20,653,629,888	23,108,194,185	24,659,309,683	27,089,501,613
Per Cent of Cost New	63%	63%	65%	64.80%
Original Cost, Excl. Land	24,035,180,653	24,564,552,260	26,157,866,052	26,835,186,360
Original Cost Depreciated	*16,183,000,000	*16,581,000,000	*17,931,217,143	*18,462,608,216
	* 67%	* 67%	* 69%	* 68.80%
Value of Land and Rights	1,935,063,167	1,930,745,196	1,952,374,483	1,949,220,416
Working Capital	610,712,400	703,212,600	658,039,200	716,864,200
"Final Value" or "Approximate Aggregate Value"	20,622,713,588	20,978,646,326	22,138,013,014	22,677,972,933
Investment in R&E (Accts. 701–702)	26,897,681,404	27,306,377,944	29,134,975,488	29,786,968,447
Accrued Depreciation and Amortization Book Accts. 702½ C-D-E-F-779	†5,970,811,534	†6,219,863,730	†6,630,266,721	†6,823,298,043
Cash on Hand (Acct. 708)	873,480,736	942,551,350	826,928,243	955,497,603
Material and Supplies (Acct. 716)	653,152,991	765,752,277	725,491,106	725,845,543

	*Estimated	*Estimated	*Estimated	*Estimated
	†Depr. $4,692,000,000	†$4,929,621,838	†$5,313,170,194	†$5,493,605,935
	Amort. 1,278,000,000	1,290,241,892	1,317,096,527	1,329,692,108

ABSTRACTS FROM ICC DECISIONS IN FREIGHT RATE CASES COVERING VALUATION OR RATE BASE PORTION

ICC REPORT NO. 3400

IN RE INVESTIGATION OF ADVANCES IN RATES BY CARRIERS IN OFFICIAL CLASSIFICATION TERRITORY

Decided February 22, 1911

(20 ICC 243)

Pages 256–263

The question, then, is, To what net earnings are these carriers properly entitled? The courts have often said that a public-service corporation is entitled to a fair return upon the value of its property being devoted to the public service. While this language has been used in connection with proceedings to determine the point below which the revenues of public-service corporations may not be forced by legislative action, it states a rule of general application. Both the value of the property and what is a fair return upon that value must be considered.

Some states have authorized and even instructed their railway commissions to put a value upon the property of railways operating within their borders. In some instances the elements to be considered in determining that value have been prescribed by statute, and the effect of the valuation when made is indicated. This Commission has no such authority. We can not in this case fix in terms the value of any one of these railroads, nor would that value, if determined in this case, be binding in subsequent proceedings; but, manifestly, in order to decide the issue presented we must have a general notion of the value of the properties of these defendants and must form an idea of the elements which should properly enter into the determination of that value.

Here we have the benefit of the judgment of the Supreme Court of the United States. In *Smyth v. Ames,* 169 U.S., 466, that court had before it a statute of the state of Nebraska fixing certain maximum freight rates to be observed within the limits of that state, the question being whether those rates were so low as to be in violation of the fourteenth amendment. In disposing of the case the court elaborately considered, both generally and as applied to the facts of that particular record, the relation of value to a reasonable rate, announcing its conclusion in a paragraph found on page 545. The law as there stated has never been qualified, and the paragraph, while often quoted, may be repeated here:

> We hold, however, that the basis of all calculations as to the reasonableness of rates to be charged by a corporation maintaining a highway under legislative sanction must be the fair value of the property being used by it for the convenience of the public. And, in order to ascertain that value, the original cost of construction, the amount expended in permanent improvements, the amount and market value of its bonds and stocks, the present as compared with the original cost of construction, the probable earning capacity of the property under particular rates prescribed by statute, and the sum required to meet operating expenses are all matters for consideration, and are to be given such weight as may be just and right in each case. We do not say that there may not be other matters to be regarded in estimating the value of the property.

While the court enumerates the factors which should be considered in the determining of the value of the property no attempt is made to assign any definite value to these different factors, and counsel who have argued this case both for and against the advances are hopelessly divided upon this point. It is earnestly insisted by some that the only test or value is the cost of reproduction and that all other elements should, as a practical matter, be disregarded. Other counsel urge, with equal earnestness, that the money actually invested in the property affords the only just basis upon which to compute the reasonableness of the return, while still others argue that this Commission should prescribe reasonable rates and that the various railroads should be allowed to earn what they can under those rates. It would not be profitable to here attempt any discussion of the questions raised, but we may point out the extent to which the present record contains information upon each of the various elements of value embraced in the above enumeration by the court.

The first two elements—original cost of construction and permanent improvements—may be considered together.

Carriers are now required to state in their statistical returns to the Commission the cost of their properties. If this account were correctly kept it would show the money expended from the first in building and equipping the railroad.

In point of fact, this item is not reliable. The present railroad systems in Official Classification territory have usually been formed by the combination of a large number of smaller railroads, which were built as independent properties. The Baltimore & Ohio system, for example, embraces more than 100 such properties. The only information which the present system has of the original cost of construction is that derived from the books of the various companies which have been absorbed. These books were seldom accurately kept and often represent as money what was, in fact, something else. The beginnings of this account, therefore, are very imperfect and unreliable.

Since 1888 carriers have been required to make statistical returns to this Commission, showing, among other things, the amounts invested from year to year in their properties and since that date it is possible to determine with substantial accuracy the cost of the improvements made.

It is also generally possible to determine by an analysis of the reports to what extent these improvements have been made from the earnings of the road and to what extent the money which has gone into them has come from new capital, either stock or bonds. It was, however, the custom of many companies previous to 1907 to charge as a part of their operating expenses improvements to the roadway and equipment, and this introduces an element of uncertainty into the above item, even in recent years.

It is sometimes possible, by reference to other financial publications and to their own reports to stockholders, to trace the history of these properties for many years previous to the enactment of the act to regulate commerce. On the whole, it may be said that we know something of the actual cost of building and equipping the railroads in Official Classification territory, the extent of that information varying largely with different railroads.

If from the item "cost of construction" could be subtracted the amount entering into that item which has come from the operation of the property itself, we should have the investment in the property; that is, the amount of money which has been actually contributed to the building and maintaining of the railroad, and we were strongly urged by certain counsel representing the shippers to adopt this as the most reliable and practically the sole test in determining the amount upon which a return was to be allowed.

Were it possible to determine the exact amount of money which has been put into these properties, the amount of return which has been paid up to the present time, the degree of prudence with which the property has been constructed and operated, certainly the investment would furnish a very satisfactory basis for arriving at an equitable return. But these facts never can be determined with accuracy. We can not know even the actual amount of money which has gone into these enterprises from outside sources, nor the return which has been paid upon it, nor whether reasonable diligence was exercised in the investment or in subsequent management. Disaster may have come upon it, for which the public ought not to stand accountable. This factor must be more or less controlling, according to the circumstances of each individual case.

The third factor named by the Supreme Court is the amount and market value of the stocks and bonds. This information can be obtained with great accuracy, covering both the present and a considerable number of years, but no counsel in argument has attached any importance to the information when obtained. In this feeling we do not altogether share. It seems to us that the price at which these stocks and bonds sell may be a matter of some significance in determining the amount which the railroad should be allowed to earn.

We are not fixing the value of a collection of ties and rock and steel rails, but of a railroad equipped and doing business. What is that railroad worth as a railroad for the transaction of a railroad business?

Most of the great systems in Official Classification territory have existed in substantially their present form for the past 25 years. While there is to-day no competition worth the name in the railway rate, and while there never will again be such competition, this has not been true of the past. Originally there was the most active competition in the rate of transportation by rail, and these tariffs, especially in Official Classification territory, are largely the product of that competition. There is a strong presumption that rates so arrived at are reasonable rates. Now, the market value of the stocks and bonds of each of these carriers represents the sum which that property will bring in the open market. That is the value which has been worked out in the actual operations of recent years in competition with its rivals, and is at least a strong index of the value of that property in comparison with other properties in this territory. It is the only way in which the value of these properties can be determined by the test of bargain and sale.

The market value depends largely upon the rate which has been charged, and to assume that the market value is a fair index of value for rate-making purposes is to assume that the rates charged have been, in the main, reasonable. In a degree this presumption does arise with respect to these rates under consideration. This is not the case of a gas plant or a water plant, which has no competitor in the service of its particular community, and whose rates have not in fact been established by legislative action. Actual competition has played an important part in working out these transportation charges in Official Classification territory, although in many instances the effect of such competition has been overcome.

There is another aspect in which this stock and bond factor is important. The Government has invited private capital to invest in the construction and operation of these public utilities. While it might have established the rate, it has left that to competitive forces. The public has for many years known the results of the operations of these defendants, and their securities have thereby acquired certain values upon the market. At these values enormous private investments have been made. We were told upon the hearing of the extent to which savings banks and insurance companies held the securities, especially the bonds, of these railways. We know that private investors have bought, not for speculative purposes, but as a legitimate and permanent investment, large amounts of the stocks of many of these companies.

Now, this Government having permitted this to be done can not close its eyes to the fact that it has been done. We can not be oblivious to the effect of our action upon the value of these investments, which have been made in good faith. In this view the market value of these stocks and bonds for the last 10 years certainly, and the effect which our action may have upon their market value for the future, must be considered. We can not, of course, allow such rates as will in all cases guarantee or perpetuate the prices at which these stocks have been bought, but in viewing the entire situation we should have that price in mind.

The next item named by the Supreme Court is the present cost of reproduction. This is undoubtedly a factor of great importance in determining the value of the railroads of this country, upon which earnings may be legitimately demanded. The courts have repeatedly recognized this in their decisions touching the rates of public-service corporations. Many states have authorized a physical valuation of their railroads in this view. This Commission has several times urged Congress to take steps looking to such a valuation, but up to the present time this has not been done.

It was insisted upon the argument that this was the only test of value entitled to serious consideration, and we were urged to postpone our determination of these questions until such valuation could be made. In view of the fact that the Supreme Court has not yet apparently held that the present cost of reproduction furnishes the only measure of value, and especially in view of the refusal of Congress to act upon the suggestion of this Commission by taking steps to procure such valuation, it would seem to be our duty to proceed with the disposition of this case as best we can upon the present record. While there is, with respect to a few of these properties, some suggestion in testimony as to reproduction cost, there is no evidence upon that point in No. 3400 which merits serious consideration, and since we are entirely without such information it is useless to discuss the many delicate and important questions which might be presented if a reliable physical valuation were before us.

The last item is "the probable earning capacity of the property under particular rates prescribed by statute and the sum required to meet operating expenses," which means, information necessary to determine the net revenues which will accrue from the application of particular rates.

This information the Commission has. The statistical returns required from carriers under the act show in great detail the gross income of these carriers, both from operation and from other sources, together with their expenses of operation and their various fixed charges. From an analysis of these reports it is possible to determine with substantial accuracy the amounts which these defendants have received in recent years and what has been done with those amounts. While it is not possible to compare the present with former years in case of some of these systems since additional lines have been taken on, and the figures do not therefore cover the same mileage, still it is possible to determine with considerable certainty the history of operating expenses and of net results to these carriers under the rates which have existed in the past, and to form an opinion, although not an exact one, with respect to results for the future under the rates in effect and under the proposed advanced rates.

The foregoing are the factors which, in the opinion of the Supreme Court, are to be weighed in determining the value of these properties for rate-making purposes. When it is remembered that information upon one and perhaps the most important of these heads is entirely lacking, that the Supreme Court itself has not attempted to assign a particular value to any one of the above factors, which must be combined to produce the result, that counsel after the most careful consideration, both of the law and of the economic and social problems which underlie this subject, are hopelessly divided as to the relative importance of these respective items, it will be seen that anything like a mathematical conclusion, or one for which a definite reason can be assigned, is impossible. Further reflection confirms what this Commission, having under advisement a similar question, said *In re Proposed Advances in Freight Rates, 9 I.C.C. Rep., 382, 404:*

> It is plain that until there be fixed, either by legislative enactment or judicial interpretation, some definite basis for the valuation of railroad property and some limit up to which that property shall be allowed to earn upon that valuation, there can be no exact determination of these questions. In the absence of such a standard the tribunal, whether court or commission, which is called upon to consider this matter, can only rely upon the exercise of its best judgment.

We must take the history of these properties and, from a consideration of all the facts before us, arrive at some rough notion of their value for railroad purposes. As a part of that same inquiry we must form some idea of the rate of return to which the property of these carriers is entitled.

Here, again, it should be observed that this Commission has no jurisdiction to deal with that question as such. We have no authority to say that a railroad ought to earn, either as a matter of right or as a matter of public policy, any given per cent upon its value; but in discharging our duty, to say whether these particular rates which the carriers propose to establish are just and reasonable, we must determine in a general way what a fair return would be, and that matter will be next considered.

It now is and long has been the settled doctrine of our courts that the railway is a public highway. The fair inference from those decisions is that the Government may, through the states or the Nation, if the Federal Constitution be broad enough, construct and operate these public utilities, or it may delegate that duty to private individuals. In case the railroad is operated by private capital, the Government may prescribe the rules under which the public service shall be discharged and the rates which shall be charged for that service, subject to the constitutional limitation that the private property shall not be deprived of a due return.

Outside the United States a majority of railroad mileage is to-day owned and operated by the different governments. It has been our policy from the first to delegate this duty to private individuals, and in this way a vast amount of private capital has been induced to invest in railroad construction and operation.

Now, the ordinary considerations of justice require that the money so invested by invitation of the Government should be allowed a fair return. This does not mean that we should permit rates which will guarantee all railroad investment, nor which will guarantee any railroad investment at all times, but we should allow rates which will yield to this capital as large a return as it could have obtained from other investment of the same grade. If rates formerly in effect have become insufficient, then higher rates should be permitted.

Our railroads must be maintained in a state of high efficiency. This the public interest demands. Commerce and industry can not afford to wait on transportation facilities. Our rates should be such as to render possible a high-class, not an extravagant, service.

It was said during the course of these hearings that our present railroad facilities were not sufficient to handle the business now offered, and that in the interest of economy, even though business did not increase, considerable expenditures should be made. However that may be, it is reasonably certain that business will increase. For the 14 years, 1896–1909, the tonnage handled by our railroads increased 106½ per cent. It is hardly probable that the next 14 years will witness a corresponding progress, but unless our national development has stopped, the business of our railroads must continue to grow. This will require additional facilities of all kinds. It is generally conceded that within the next few years, if our means of transportation by rail are to keep pace with the calls upon them, very large sums must be expended in the way of new construction and new equipment. While some small portion of this may come from current earnings, the great bulk must be new capital, and this capital must be obtained from the investing public. If, therefore, we are to rely in the future, as we have in the past, upon private enterprise and private capital for our railway transportation, the return must be such as will induce the investment. It is therefore not only a matter of justice, but in the truest public interest that an adequate return should be allowed upon railway capital.

ICC EX PARTE NO. 74

IN THE MATTER OF THE APPLICATIONS OF CARRIERS IN OFFICIAL, SOUTHERN, AND WESTERN CLASSIFICATION TERRITORIES FOR AUTHORITY TO INCREASE RATES

Decided July 29, 1920
(58 ICC 220)

Pages 223–229

In this proceeding the carriers by railroad subject to our jurisdiction seek authority, pursuant to the provisions of section 15a of the interstate commerce act, to increase their freight revenues to a basis that will enable them to earn an aggregate annual net railway operating income equal, as nearly as may be, to 6 per cent upon the aggregate value of the railway property of such carriers held for and used in the service of transportation. The applications, which were filed in the latter part of April and the early part of May, 1920, were made at our suggestion to assist us in complying with the provisions of that section. * * *

Section 15a of the interstate commerce act provides that in exercising our powers under that section we shall "initiate, modify, establish, or adjust" rates for the carriers as a whole, "or as a whole in each of such rate groups or territories as the Commission may from time to time designate." We accordingly assigned for oral argument on March 22, 1920, the question, among others, "whether for the purposes of said section 15a the rate adjustment shall be made for the carriers as a whole, or by rate groups or territories to be designated by the Commission, and if the latter, what rate groups or territories shall be so designated." The preponderance of opinion was that the boundaries of official, southern, and western classification territories should be observed, and that three groups should be designated accordingly. In making their proposals in this proceeding the carriers have observed generally those three groups, but the carriers in New England and in the southwest have brought to our attention the peculiar financial needs of the railroads in those territories. The New England carriers do not propose a change in the grouping suggested by the carriers generally, but certain of the southwestern lines ask that we carve out of the western territory a separate southwestern group. This separate application of the southwestern lines is opposed by many shippers served by these carriers and by other carriers in the western group.

* * *

Paragraph (3) of section 15a is as follows:

> The Commission shall from time to time determine and make public what percentage of such aggregate property value constitutes a fair return thereon, and such percentage shall be uniform for all rate groups or territories which may be designated by the Commission. In making such determination it shall give due consideration, among other things, to the transportation needs of the country and the necessity (under honest, efficient, and economical management of existing transportation facilities) of enlarging such facilities in order to provide the people of the United States with adequate transportation: *Provided,* That during the two years beginning March 1, 1920, the Commission shall take as such fair return a sum equal to 5½ per centum of such aggregate value, but may, in its discretion, add thereto a sum not exceeding one-half of one per centum of such aggregate value to make provision in whole or in part for improvements, betterments or equipment, which, according to the accounting system prescribed by the Commission, are chargeable to capital account.

In establishing rates for the two-year period we have no discretion as to the amount of the fair return except that we may add to the 5½ per centum provided by law "a sum not exceeding one-half of 1 per centum of such aggregate value to make provision in whole or in part for improvements, betterments, or equipment, which, according to the accounting system prescribed by the Commission, are chargeable to capital account." Having determined the per cent, we are called upon to perform the administrative task of establishing rates that will yield in the aggregate as nearly as may be that per cent until March 1, 1922.

Evidence has been submitted tending to show that we should accord to the carriers the maximum per cent authorized by the Congress. The high rates of interest now prevailing are cited by the petitioners, and our attention is called to prominent instances where large railroads with recognized financial standing have been obliged within recent months to pay interest rates well in excess of 6 per cent on new capital. The evidence shows that the New York Central Railroad Company recently sold $36,000,000 of 15-year equipment notes, carrying an interest rate of 7 per cent, and that notes carrying the same rate of interest were sold by other carriers, as follows: Pennsylvania Railroad Company, $50,000,000 of 10-year collateral notes; Northern Pacific Railroad, $4,500,000 of 10-year equipment notes; Atlantic Coast Line Railroad, $6,000,000 of 10-year collateral notes; Louisville & Nashville Railroad, $7,500,000 of 10-year collateral notes. Discounts and commissions raised the total cost of the capital to these carriers to 7½ per cent per annum.

* * *

Property Investment

The calculations of the carriers as to the increases in revenue needed by them are predicated upon the assumption that the Commission should permit a return of 6 per cent on the book figures for investment in road and equipment, improvements on leased railway property, materials, and supplies and government allocated equipment, hereinafter referred to as book cost. Their contention is that the aggregate value of the property of the carriers in each group, held for and used in the service of transportation, is substantially in excess of the aggregate of the amounts shown as their respective book costs.

The carriers recognize the infirmities inherent in the investment accounts as carried upon the books of the carriers, as a measure of the value of the respective properties taken separately; but they contend that it is appropriate for us to use the aggregate of such figures as the basis of our calculations, tested in the light of the work of our bureau of valuation as thus far progressed, the tendencies thereby shown, and the conclusions to be drawn therefrom by those familiar with the work so far done, and also by consideration of such matters of common knowledge or within the knowledge of the Commission as bear upon the subject.

The aggregate amount carried as book cost of road and equipment by all classes of carriers reporting to us, as of December 31, 1919, is set out below according to the territorial groups defined in the applications of the carriers:

* * *

Total, all groups $20,040,572,611

In the administration of section 15a of the interstate commerce act it becomes necessary for us to determine, as nearly as may be, the aggregate value of the railway property of the carriers defined in that section, held for and used in the service of transportation. In making this determination, we are authorized to utilize the results of our investigation under section 19a of the act, in so far as we deem such results available; and we are required to give due consideration to all the elements of value recognized by the law of the land for rate-making purposes, and are required to give to the property investment account of the carriers only that consideration, which, under such law, it is entitled to in establishing values for rate-making purposes.

Considerable evidence of a general character as to the various elements of value has been produced herein, which we have carefully scrutinized.

While the valuation of the railroads under section 19a of the interstate commerce act is still incomplete, the work has progressed so far that the results are of value and informative in reaching the determination we are now required to make. So far as the work has produced results, either as to particular roads, or as showing general tendencies and principles, we have given consideration thereto. As will appear from examination of our various valuation reports, and from section 19a itself, our investigations under that section are designed to give information as to the original cost of the property, the cost of reproduction new, the accrued depreciation, the amount of the investment, the corporate histories of the properties, the values of the lands, and other values and elements of value, if any.

We have also before us the investment accounts of the carriers. Since 1907 there have been mandatory regulations by us as to the manner in which the investment accounts should be kept. In the administration of section 20 of the interstate commerce act we have had frequent occasion to investigate, and in many cases to correct, errors apparent in the investment accounts; other errors have been discovered and brought to our attention in the progress of the work of valuation under section 19a.

The probable earning capacity of the properties under particular rates prescribed by law and the sums required to meet operating expenses, separately and collectively, are indicated in the record.

There is also evidence which tends to show the amount and market value of the bonds and stocks of the carriers.

In properly appraising all these elements of value we are mindful of the fact that the carriers are operating units and going concerns. This fact has been given due consideration in the light of the financial history of the transportation system of the United States, as developed by the record and as known to us. The needs for working capital, and materials and supplies on hand have been considered and allowance therefor has been made.

From a consideration of all of the facts and matters of record, and those which, under section 15a of the interstate commerce act, we are both required and authorized to consider, we find that the value of the steam-railway property of the carriers subject to the act held for and used in the service of transportation is, for the purposes of this particular case, to be taken as approximating the following:

* * *

Total $18,900,000,000

ICC NO. 13293. REDUCED RATES, 1922

IN THE MATTER OF RATES, FARES, AND CHARGES OF CARRIERS BY RAILROAD SUBJECT TO THE INTERSTATE COMMERCE ACT

Decided May 16, 1922
(68 ICC 676)

Pages 678–685

Report of the Commission

This proceeding was instituted upon our own motion for the purpose of determining whether, and to what extent, if any, further general reductions in rates, fares, and charges of carriers by railroad applicable in interstate or foreign commerce may lawfully be required under section 1 or other provisions of the interstate commerce act upon any commodities or descriptions of traffic; and also to determine what will constitute a fair return on and after March 1, 1922, under section 15a (3) of the interstate commerce act.

The important questions for determination are whether present rates, fares, and charges, in the aggregate, as a whole or in the several rate groups defined in *Increased Rates, 1920,* 58 I.C.C., 220, 489, *Authority to Increase Rates,* ibid., 302, or upon specified commodities or descriptions of traffic, are or will be unreasonable under section 1 or other provisions of the act; whether such rates, fares, and charges are those which will most nearly produce a fair return, as provided in section 15a; and what the fair return shall be on and after March 1, 1922. When this proceeding was instituted there were pending before us several petitions filed by carriers and by various organizations of shippers in which we were asked to enter upon general investigations into the reasonableness of existing rates and charges. * * *

Fair Return

Section 15a (3) of the interstate commerce act provides:

> The Commission shall from time to time determine and make public what percentage of such aggregate property value constitutes a fair return thereon, and such percentage shall be uniform for all rate groups or territories which may be designated by the Commission. In making such determination it shall give due consideration, among other things, to the transportation needs of the country and the necessity (under honest, efficient and economical management of existing transportation facilities) of enlarging such facilities in order to provide the people of the United States with adequate transportation: *Provided,* That during the two years beginning March 1, 1920, the Commission shall take as such fair return a sum equal to 5½ per centum of such aggregate value, but may, in its discretion, add thereto a sum not exceeding one-half of one per centum of such aggregate value to make provision in whole or in part for improvements, betterments or equipment, which, according to the accounting system prescribed by the Commission, are chargeable to capital account.

In *Increased Rates, 1920, supra,* we exercised the discretion conferred upon us and to the 5½ per cent return added the one-half of 1 per cent during the two-year period to make provision for improvements, betterments, or equipment.

Since August, 1920, the carriers as a whole, or as a whole in their respective rate groups, have failed by a considerable margin to earn the authorized return. It is urged by some that under existing conditions the question of a fair return for the future is academic and that it is not necessary for us to determine a percentage of return at this time. We do not take this view. The operation of economic forces which have prevented, or which may hereafter prevent, carriers from earning a fair return under the adjustment of rates then prevailing does not constitute a bar to determination of what a fair return should be. By the qualifying words "as nearly as may be," Congress recognized that conditions during certain periods might prevent such realization under any adjustment of rates.

The provisions of section 15a in this respect have been framed in recognition of constitutional guaranties of fair return upon property devoted to public use. They also declare the policy of Congress—

> in its control of its interstate commerce system * * * to make the system adequate to the needs of the country by securing for it a reasonable compensatory return for all of the work it does. *Railroad Commission of Wisconsin et al.* v. *C.B.&Q. R.R. Co.,* 66 L. ed. (U.S. Sup. Ct.) 236, 42 Sup. Ct. Rep. 232, decided February 27, 1922.

The determination of what will constitute a fair return under paragraph (3) of section 15a is, in our judgment, a function distinct from that of initiating and adjusting rates under paragraph (2) of that section. Section 15a, reasonably construed, contemplates the determination of a return which the carriers, collectively or in rate groups, may attain over a period of time under rates adjusted from time to time with that object in view. The phrase "from time to time" does not mean that we should adjust and readjust rates to meet business fluctuations. Whether carriers may be able to earn an aggregate net railway operating income equal to a fair return must depend to a large extent upon business conditions. In the *Wisconsin case, supra,* the court said:

> The new measure imposed an affirmative duty on the Interstate Commerce Commission to fix rates and to take other important steps to maintain an adequate railway service for the people of the United States. This is expressly declared in section 15a to be one of the purposes of the bill.

We have before us a practical problem. The record emphasizes the need of a constant influx of capital to meet the country's growing transportation needs. In the 10-year period ending June 30, 1916, a period of relatively low costs of materials, supplies, and labor as compared with present costs, there was a net addition to capital account for new lines and extensions, additions, betterments, and general expenditures properly chargeable to that account which aggregated about 5¾ billion dollars, or an average of 574 millions per annum. According to an exhibit of the carriers, expenditures for such purposes in the 12 months ended September 30, 1921, aggregated about 365 millions, an average of 1 million a day. This omits certain roads not reporting. The carriers estimated that, based on the volume of traffic which they were then handling, capital expenditures in the year 1922 should approximate 458 millions, and that if transportation facilities are to be expanded in 1922 as they should be to provide for a materially increased volume of business, the expenditure this year should be approximately 858 millions, or an average of 2⅓ million dollars a day. Others estimate lesser amounts. Some authorities on transportation and economic conditions place the requirements for the next few years at even higher amounts, to come in part out of earnings, and predict that, unless there is immediate resumption of new construction, a return of anything like normal business will result in "strangulation for lack of transportation." Others are of opinion that the existing transportation machine, if properly maintained, with necessary additions in the way of terminals and trackage facilities, is adequate to handle the business which may reasonably be expected in the immediate future.

It is obvious that large additions to capital must continually be made. Most of the capital will have to be acquired through the issuance of securities which must be sold in the markets of the world in competition with other classes of securities. Within the next few years the Government must provide for the refunding of some 6 billions of its indebtedness. The carriers must attract money by rates of return and stability of investment. While return must not exceed a reasonable charge against the public served, it must be such as to obtain the needed new capital. It is necessary to determine and make public, as required by section 15a, a percentage of fair return. Determination of the percentage implies, or carries with it, no guaranty. Read in connection with the provision for recapture of one-half of the excess above 6 per cent it is, instead, a limitation.

Because the yield on some railroad bonds has declined to something over 5 per cent it does not follow that a fair return should approximate that percentage. We do not deal alone with interest rates on mortgage obligations, or with the more favorably located and prosperous carriers whose credit conditions may enable them to obtain money at relatively advantageous rates. In the recapture provisions Congress recognized that uniform rates on competitive traffic which would adequately sustain all the carriers would produce substantially and unreasonably more than a fair return for some carriers. We should not take the few, and the highest type of their securities, as the basis for determining what shall be a fair return for all. It can hardly be disputed that the carriers of this country should not continue to provide for all needed capital by successive bond issues. Issuance of bonds in a disproportionate degree unduly increases fixed charges and tends to weaken the credit of the carriers. In such a process eventually a point must be reached where no new capital can be raised, except for short terms at high rates. No substantial proportion of the new capital has been raised by issuance of stock since 1907.

Notwithstanding the failure of the carriers to earn the 6 per cent allowed in the first two years of operation under section 15a, there is an upward trend in railroad securities, which share in the improved conditions that have prevailed generally in the money market. This is urged upon us as an argument for reduction in the percentage to be determined. Other elements, however, are to be considered. The intent of Congress was to create a steady and reliable flow of money "for enlarging such facilities in order to provide the people of the United States with adequate transportation." A substantial reduction in the percentage of return might be unsettling in its effect, particularly in light of the fact that the return allowed in 1920 was not realized. The fact that a utility may reach financial success only in time or not at all is a reason for allowing a liberal return on the money invested in the enterprise. *Galveston Electric Co.* v. *City of Galveston.* 42 Sup. Ct. Rep., 351, decided April 10, 1922.

In numerous cases cited, courts and regulating authorities of States have recognized that public utilities and railroads may be permitted individually to earn under reasonable rates at least 6 per cent upon fair value. In some instances higher rates of return have been approved. But we are here considering return upon "the aggregate value of the railway property."

The interstate commerce act in many provisions other than those quoted indicates that 6 per cent may be regarded as a fair return. Paragraph (6) of section 15a provides for the disposition of net railway operating income in excess of 6 per cent of the value of the property held for and used in the service of transportation. One-half of the excess goes into a reserve fund, which may be drawn upon for certain purposes, in accordance with paragraph (7), when net railway operating income for any year is less than a sum equal to 6 per cent upon the value. Under paragraph (12) we may make loans from the general railroad contingent fund, such loans to bear interest at the rate of 6 per cent per annum. Under paragraph (14) we may lease equipment or facilities purchased from the general railroad contingent fund the rental charges to be at least sufficient to pay a return of 6 per cent per annum plus allowance for depreciation. That Congress by direct legislation fixed the fair return for the period of two years beginning March 1, 1920, at the rate of 5½ per cent, to which, in our discretion, we might add not exceeding one-half of 1 per cent, is a matter which may fairly be considered in the determination of the rate for the period immediately ensuing. But, taken in connection with the other provisions of section 15 (a), it does not constrain us to consider 5½ per cent as maximum in determining a fair return for the ensuing period.

Under our system of accounts all charges to the account "railway tax accruals" are deducted from railway operating revenues before arriving at railway operating income, and all State and Federal taxes, income or other, relating to carriers' railway property, operations, and privileges, are charged to that account. This method of accounting was recently sanctioned by the Supreme Court of the United States in *Galveston Electric Co.* v. *City of Galveston, supra.* As indicated by the Court, the net income under this accounting procedure is to the stockholder a tax-exempt income, and this fact should be considered in determining what return shall be deemed fair.

The railway operating income, increased or diminished, as the case may be, by the credit or debit balances in the accounts known as equipment rents and joint-facility rents, becomes net railway operating income, the amount of which is less than it otherwise would be by the amount of income tax accrued or paid. The term "net railway operating income" is defined in paragraph (1) of section 15a. Under paragraph (3), above quoted, rates are to be so adjusted that carriers as a whole or in designated rate groups will earn an aggregate annual net railway operating income equal, as nearly as may be, to a fair return. If this were realized in any instance the carrier would receive that return over and above all taxes including the Federal tax on income, and if the fair return as determined and made public by us was 6 per cent the carrier would hold that return "tax free" in the sense that after payment of its income tax it would still have left the 6 per cent.

Railway corporations, like all others, are subject to income taxes which, since January 1, 1922, amount to 12.5 per cent on their net income less deductions computed as provided in the income tax law, 42 Stat. L., 277. In our view railway corporations should, like other corporations, pay their Federal income taxes out of the income, rather than collect it, in effect, from the public in the form of transportation charges adjusted to enable it to retain the designated fair return over and above the tax. We may observe that a fair return of 5.75 per cent, representing an aggregate annual net railway operating income arrived at after deducting, among other things, the Federal income tax on a return of 6 per cent, would be approximately the equivalent of a fair return of 6 per cent, out of which the Federal income tax was payable.

Railway Property Value

In *Increased Rates, 1920, supra,* one of the material facts to be determined was the aggregate value of the properties of the carriers held for and used in the service of transportation. As was pointed out, the territorial grouping designated by us differs somewhat from that proposed by the carriers; but, inasmuch as the record dealt principally with the three major groups as defined by the carriers, the evidence was considered, in respect to grouping, as presented by the carriers and others then before us.

Upon consideration of all of the facts and matters then of record, and those which, under section 15a, we were either required or authorized to consider, we found—

> that the value of the steam-railway property of the carriers subject to the act held for and used in the service of transportation is, for the purposes of this particular case, to be taken as approximating the following:
>
> * * *
>
> Total $18,900,000,000

For reasons there stated no apportionment of the aggregate value of the properties in the western group, as defined by the carriers, was made to show the value of the properties in the western and mountain-Pacific groups, as we defined them. Nor was there any estimation of the aggregate value of the properties of electric railways other than those operated by steam roads, or of the boat lines.

In the instant proceeding there is little of record which goes directly to the subject of value. There has been a general acceptance by carriers and shippers of the value taken in our former determination as an appropriate basis for the purposes of the present proceeding. The respondent carriers have not attempted to show that that value should be increased, other than by appropriate consideration of the subsequent increments to the transportation plant. We have before us deductions made by certain of the State commissions and shippers, based upon the results of the valuation work under section 19a of the interstate commerce act so far as announced, and also computations based upon the market value of outstanding stocks and bonds.

More than 20 months have passed since our former determination, and in that period the valuation of the railroads under section 19a has gone forward. The work is still incomplete, but has progressed to such an extent that we may accept the results with fuller assurance, both as to particular roads and as showing general trends and principles. In our administration of various sections of the act, and in our certification of standard return for the purposes of the Federal control act, we have had occasion to make further investigation and corrections of investment accounts of the carriers.

The various other values and elements of value, as set forth in *Increased Rates, 1920, supra,* pages 228–229, have been reexamined in the light of the present record and the requirements of section 15a. We find no present reason to disturb the value taken by us in that proceeding as approximating the sums there stated, except to the extent that subsequent additions to or withdrawals from the property in service, including materials and supplies and working capital, and further depreciation, make adjustment necessary. Whether the value taken by us in 1920 should stand without consideration of these later items or not, the difference would be reflected only in fractions of per cents of the returns hereinafter indicated as the results of operation.

FIFTEEN PER CENT CASE, 1931

ICC EX PARTE NO. 103

IN THE MATTER OF INCREASES IN FREIGHT RATES AND CHARGES

Decided October 16, 1931
(178 ICC 539)

Pages 556–557

THE SUPPORTING EVIDENCE

Applicants' Evidence.—* * * In 1930, the net railway operating income of class I carriers amounted to $868,878,792, or 3.54 per cent of the value of the property, ascertained by adding to the aggregate value found by us in *Increased Rates, 1920,* 58 IC.C. 220, the net cost of additions and betterments made subsequent to that date. Using as a basis the relation of revenues and expenses for the first six months of 1931 to those of 1930, the net railway operating income for 1931, it is estimated, will amount to $553,000,000, or 2.25 per cent upon value as above ascertained. Compared with 1930, in the first six months of 1931 freight revenues decreased 18 per cent, passenger revenues 23.3 per cent, mail 5.4 per cent, express 24.2 per cent, and miscellaneous 18.8 per cent. Operating expenses decreased 17.2 per cent, and to effect this decrease it was necessary to limit maintenance. Using as a basis freight revenues for 1931, so estimated, the 15 per cent increase in rates and charges sought would, if there were no consequent falling-off in traffic, yield an additional $502,000 000 of revenue, which. allowing for income tax and other deductions, would bring net operating income to $985,000,000, or 4.01 per cent on the assumed property value.

* * *

The carriers are not seeking the full fair return on value to which they assert that they are entitled by law. They are willing to share with other industries the burden of the general depression. They ask to be relieved of a part of their present burden on the grounds that public regulation prohibits them from sharing to the same extent as private industries in the profits of prosperity, that their present low earnings imperil their credit and hence the stability of an industry on which all others are dependent, and that the increase desired will restore confidence, stimulate buying, and lead the way to a return of prosperity. They further assert that on any conceivable basis of valuation they are falling so far short in their earnings as to make it unnecessary to determine in this proceeding the actual aggregate value of their properties devoted to carrier use. For similar reasons they deem it unnecessary to inquire whether the 5.75 per cent, heretofore fixed by us, is a fair return under present conditions.

GENERAL RATE LEVEL INVESTIGATION, 1933

ICC REPORT NO. 26000

IN THE MATTER OF RATES AND CHARGES OF CARRIERS BY RAILROAD SUBJECT TO THE INTERSTATE COMMERCE ACT, 1933

Decided July 31, 1933
(195 ICC 5)

Pages 49–51

In the 1920 rate advance case we found the value of the steam-railway property of the carriers subject to the act held for and used in the service of transportation, for the purposes of that case, to be approximately $18,900,000,000. No change was made in this value in *Reduced Rates, 1922,* other than allowing for subsequent additions to or withdrawals from the property. Since that time large additions to the property have been made and valuation of railway property under section 19 (a) of the act has progressed much further. According to figures computed by our Bureau of Valuation and made of record, the cost of reproduction new less depreciation of the property other than land of class I, II, and III carriers, including switching and terminal companies, as of December 31, 1932, at prices as of June 1, 1933, plus the value of land as of June 1, 1933, was $20,632,000,000. If working capital, materials, and supplies as of December 31, 1932, are added the total on this basis is approximately $20,971,000,000. As computed by our Bureau of Valuation the original cost of all steam railways in the United States as they existed on December 31, 1932, other than land, plus land as of the same date but priced as of June 1, 1933, and plus allowances for working capital, was $26,232,000,000. The property investment or so-called carriers' book value of class I, II, and III carriers, but not including switching and terminal companies and not including working capital, for the country as a whole as of December 31, 1932, was approximately $26,091,000,000, before deducting depreciation.

Testimony was introduced by a representative of certain farm organizations purporting to show the market value of the stocks and bonds of all railroads outstanding in the hands of the public at the first of certain years. These values, expressed in millions of dollars, are: 1922, 13,040; 1928, 21,070; 1929, 22,149; 1930, 22,164; 1931, 19,086; 1932, 10,534; 1933, 8,949. * * * In view of the methods used, it is doubtful that the values of stocks and bonds thus derived accurately reflect fair average market values of the railroad properties for the years indicated, but doubtless they give a rough indication of the fluctuation in such values. Market value of outstanding securities is one factor to be considered in determining whether or not carriers are earning a fair return, but may not be considered as controlling.

Respondents, in computing rates of return, used mainly their investment in road and equipment, often referred to as book value, without deducting accrued depreciation, with the addition of the amount of cash and materials and supplies on hand. They also used the Ex parte 74 value, but in bringing it down to date did not deduct the depreciation accrued since 1920, although they presented tables prepared by others which show what the effect of such deduction would be.

The rates of return for class I steam railways, including switching and terminal companies, for the country as a whole for the past 12 years, based on property investment and on the value used by us in Ex parte 74, readjusted for class I railways and brought down to date, are as follows:

Period	*Rate of Return on Property Investment*	*Rate, Excluding Depreciation* [1]	*Rate of Return, Ex Parte 74*	*Rate, Excluding Depreciation* [1]
	Percent	*Percent*	*Percent*	*Percent*
Year 1921	2.81	3.09	3.13	3.18
Year 1922	3.54	3.87	3.92	3.98
Year 1923	4.30	4.68	4.76	4.81
Year 1924	4.20	4.54	4.63	4.66
Year 1925	4.71	5.12	5.19	5.26
Year 1926	4.96	5.42	5.45	5.56
Year 1927	4.27	4.68	4.67	4.81
Year 1928	4.61	5.08	5.02	5.21
Year 1929	4.81	5.31	5.22	5.44
Year 1930	3.27	3.64	3.54	3.73
Year 1931	1.99	2.23	2.13	2.29
Year 1932 [2]	1.24	1.39	1.33	1.42

[1] Depreciation since 1920 excluded in computing figures.
[2] Computed on 1931 value.

If based on reproduction new less depreciation, or on original cost as above defined, the rates of return in recent years would be somewhat greater than those shown in the foregoing table. But even if so low a value as the approximately 15 billion dollars urged by a representative of farm organizations be used, the average rate of return in the three years ended with 1932 would be 3.8 percent, and for the single year 1932, 2.2 percent.

EMERGENCY FREIGHT CHARGES, 1935

ICC EX PARTE NO. 115

IN THE MATTER OF INCREASES IN FREIGHT RATES AND CHARGES, 1935

Decided June 9, 1936
(215 ICC 439)

Page 443

Report of the Commission on Further Hearing

By the Commission:

* * * It is averred in the petition that in the first 11 months of 1935 the total net railway operating income of the class I railroads represented a return of 1.85 percent on their aggregate book investment and a return of 1.98 percent, on the so-called Ex Parte No. 74 value brought down to date.[1]

[1] The approximate aggregate value as found by us in *Increased Rates, 1920,* 58 I.C.C. 220 adjusted with reference to subsequent additions or retirements but without further consideration of depreciation. The showing of values ignores those found by us under section 19a of the act.

GENERAL COMMODITY RATE INCREASES, 1937

ICC EX PARTE NO. 115

IN THE MATTER OF INCREASES IN FREIGHT RATES AND CHARGES, 1937

Decided October 19, 1937
(223 ICC 657)

Pages 665–666

Financial Condition of the Railroads

* * *

Despite the improvement in net railway operating income since 1932, such income continues to fall far short of an adequate return on the fair value of the aggregate railway property investment. For this reason it is not necessary, for the purposes of this proceeding, that we specifically find the fair value of applicants' property devoted to public use, either as a whole or by groups. The evidence on that subject herein is of a general character only. It may be noted that if the aggregate value should be taken as 26 billions the return for the year ended April 30, 1937, was 2.75 percent, on 20 billions 3.58 percent, and on 18 billions 3.98 percent. Deducting the $80,000,000 derived from the emergency charges, these percentages become 2.44, 3.18, and 3.53, respectively.

Page 728

General Discussion

Financial needs of the railroads.—* * * We have not undertaken in this proceeding to determine specifically the fair value of railway carrier property for rate-making purposes, because no one has contended that the railroads were earning a reasonable return on fair value. Assuming, however, that the fair value for the class I railroads is no more than $18,000,000,000, the return earned for the year ended April 30, 1937, was only 3.98 percent, and allowing for the emergency charges it was only 3.53 percent. Even if the fair-value figure were cut to $15,000,000,000, the corresponding percentages would be, respectively, no more than 4.77 and 4.24. How conservative these fair-value assumptions are is indicated by the fact that in *Increased Rates, 1920,* 58 I.C.C. 220, we estimated the fair value of all railroad carrier property at $18,900,000,000, and in *General Rate Level Investigation, 1933, supra,* our Bureau of Valuation found the cost of reproduction new, less depreciation, of property other than land, as of December 31, 1932, at prices as of June 1, 1933, plus the value of land as of the same date, and plus working capital, materials and supplies, to be $20,971,000,000. The assumptions above are for class I railroads only, whereas the findings in 1920 and 1933 applied to all railroads, but the class I railroads account for more than 95 percent of the property, and it is to be borne in mind that the 1932 estimates were based on the low unit prices prevailing at the depth of the depression. Furthermore, the percentages given above are averages for all of the class I railroads, including the Pocahontas lines and a few other and smaller roads with exceptional earnings.

The record amply justifies the conclusion that in the aggregate the railroads are earning very materially less than a reasonable return on the fair value of their carrier properties. Let us, then, consider the significance of that conclusion. It means, of course, that the great majority of the individual railroads are not earning the return which the Supreme Court has held that under the Constitution they must be given an opportunity to earn. But it has a practical significance to the country quite apart from any question of the constitutional rights of the property owners. The public service which our railroads perform has been committed to private enterprise sustained by private capital. There are conditions necessary to the successful operation of that system of providing a public service, and those conditions must be respected, if results satisfactory to the country are to be had. In other words, the game must be played according to the rules. One of these essential conditions, or rules, we stated in *St. Louis & O'Fallon Ry. Co. Excess Income,* 124 I.C.C. 3, 30, as follows:

> The end in view, as we have stated, is the maintenance of an adequate national railway transportation system. Such a system, so long as it is privately owned, obviously can not be provided and maintained without a continuous inflow of capital. Obviously, also, such an inflow of capital can only be assured by treatment of capital already invested which will invite and encourage further investment.

FIFTEEN PER CENT CASE, 1937–1938

ICC EX PARTE NO. 123

IN THE MATTER OF INCREASES IN RATES, FARES, AND CHARGES

Decided March 8, 1938
(226 ICC 41)

Pages 60–62

Value of the carrier property employed.—Consideration of the need of the applicants for sufficient revenues to enable them to provide such transportation service as is contemplated in section 15a of the act necessarily requires that the fair value of their property be taken into account. Even though the applicants are not here asserting a constitutional right to a fair return of any definite amount, it is necessary for us to inquire into the question of the value of the property employed in performing the service, both because of its bearing upon the economic cost of performing the service, and because of the duty we are under to avoid putting rates upon a basis which would compel the use of the property without just compensation, although the Constitution does not protect against all business hazards, *Montana Public Service Com. v. Great Northern Utilities Co.*, 289 U. S. 130.

There have been submitted and received in evidence, without objection, data prepared by our Bureau of Valuation as to the usually recognized elements of value of railway property, under the usual processes employed. These data have not been questioned by anyone in this proceeding. The estimates covered the original cost of the properties, other than lands and rights; the costs of reproduction new and less depreciation, lands and rights also excepted; and a statement which was referred to as "original cost less depreciation—except lands and rights" and represented the application to original cost of the ratio of cost of reproduction less depreciation to cost of reproduction new. In addition were shown the present value of lands and rights, and an estimate of the working capital, including materials and supplies, used in common-carrier service of the railways. The following statement summarizes the data so submitted as to elements of value of property used in common-carrier service (all carriers) to January 1, 1937:

* * *

In addition to the elements of value shown in the exhibits submitted by the bureau, and summarized above and in the appendix, we have in the record information as to the trend of material and construction prices, past and present; the volume of earnings, past and present, under the rates prescribed by law; and the sums estimated as necessary to meet operating expenses, both past and for the relatively near future. The record shows the amount of the stocks and bonds, and we have commented upon the market value thereof, and the trend of their prices in the market. Certain other of these matters are discussed elsewhere in this report. We are mindful of the fact that the carriers whose properties are embraced in this proceeding are operating units and going concerns.

The showing before us covers the elements enumerated in *Smyth v. Ames*, 169 U.S. 466, and numerous subsequent decisions of the Supreme Court of the United States, as applied by us in *Richmond, F. & P.R. Co. Excess Income*, 170 I.C.C. 451, and other cases, and follows the methods employed in administering the amended section 19a of the act, *Texas Midland R.*, 75 I.C.C. 1, 80, and numerous other cases. A precise determination of the value of each unit of railway property employed would be an unnecessary refinement in this proceeding, but it is feasible to make approximations which are sufficiently definite, treating the roads by classes, and by regions and districts. For the purpose of this particular proceeding, the values of the railway property subject to the act, used in common-carrier service, may be taken as approximating the following sums:

* * *

	Approximate aggregate value
Total, all districts	$21,060,000,000

GENERAL COMMODITY RATE INCREASES, 1937

ICC EX PARTE NO. 115

IN THE MATTER OF INCREASE IN FREIGHT RATES AND CHARGES, 1937

Decided November 21, 1938
(229 ICC 435)

Pages 449–451

Values of properties.—In our report in Ex Parte No. 123, 226 I.C.C. 60–64, and appendix, pages 160–162, we detailed the elements of value of the applicants' common-carrier property, as of January 1, 1937. The same underlying data have been made part of this record.

A recheck has disclosed a latent duplication in the costs of reproduction new and less depreciation of certain subsidiaries of the Chesapeake & Ohio Railway, amounting to $62,395,219 and $57,634,048 respectively, which was carried into the total cost of reproduction new and less depreciation for the Pocahontas region, for the southern district, and for the United States. Other elements of value were not affected. We have called the attention of all parties to this error. The approximate values of the railway properties as reported by us would be decreased by approximately $40,000,000 as to the Pocahontas region, the southern district, and in the United States, by giving consideration to all the figures before us, with the corrections in the two costs stated.

For the purpose of testing the later returns of the applicants from their common-carrier operations, the January 1, 1937, final-value figures stated by us should be adjusted for subsequent changes in property and in the other factors usually considered in determining value. The property changes during the year 1937 were slight—in fact, considering accrued depreciation, a relatively small decrease appears in reported net investment—so that the estimate of value as of January 1, 1937, may well be brought down to January 1, 1938, for present comparative purposes, merely by making the correction above indicated and then by adjusting for changes during the year 1937 in net investment and in materials and supplies and cash. So treated, the table set forth in our report 226 I.C.C. 61, if confined to class I carriers only, would become as follows:

* * *

These data in the light of other considerations referred to in the report cited, indicate that as of January 1, 1938, the values of class I common-carrier railway property may be taken for the purposes of the present rate-making proceeding as approximately as follows:

* * *

	Approximate Aggregate value
Total, all districts	$19,882,000,000

The approximate aggregate values for rate-making purposes of the common-carrier properties of railway carriers other than those in class I, similarly brought down to the beginning of 1938 by allowing for changes in investment and depreciation accounts, are as follows:

Class II	$ 319,500,000
Class III	60,500,000
Switching and terminal	726,000,000
Total	$1,106,000,000

For our present inquiry the indicated total value of the common-carrier property of all railway carriers may be taken as approximately $20,988,000,000, as of January 1, 1938. These calculations are based upon consideration of the elements of value specified in section 19a of the act, and enjoined upon us by judicial interpretation, and are for the limited purposes specified.

ICC EX PARTE NO. 148

INCREASED RAILWAY RATES, FARES, AND CHARGES, 1942

Decided March 2, 1942

(248 ICC 545)

Page 555

VALUE OF COMMON-CARRIER RAILWAY PROPERTY

The petitioners do not regard any issue as to the fair value of the property as necessarily involved.

We have received in evidence data prepared by our Bureau of Valuation as to the elements of value, as defined in section 19a of the act, of the property used in common-carrier service by the railways of the United States, as of January 1, 1940, the latest available date for such a study.

From our study of the record, it does not seem necessary for our determination to enter into a discussion of the value of the common-carrier property of the petitioners. The proceeding has not taken on the aspects of a "fair return" case. As stated by counsel for the Class I petitioners at the opening of the hearing, this is a revenue case, not a rate case.

ICC EX PARTE NO. 162

INCREASED RAILWAY RATES, FARES, AND CHARGES, 1946

ICC EX PARTE NO. 148

INCREASED RAILWAY RATES, FARES, AND CHARGES, 1942

Decided June 20, 1946

(264 ICC 695)

Page 723

PETITIONERS' CLAIMS AS TO THEIR REVENUE NEEDS AND RATES OF RETURN

* * *

2. The use, as a basis for stating the percentage of return, of "investment in railway property used in transportation service" "after accrued depreciation as shown by the carriers' books" is to be questioned.

a. The use of the total amounts shown in accounts 701 and 702, Cost of Road and Equipment, reflects the very large charges made to corresponding accounts during the long period prior to 1907, when the Commission was first given power to control such matters. As we said in *St. Paul and Puget Sound Accounts*, 29 I.C.C. 508, 509—

> all students of railroad economics are well aware of the fact that, prior to 1907, when the Commission was given real power to control such matters, the accounts of carriers in many cases were influenced more by other considerations than by a desire to reflect the actual facts.

And in our annual report to Congress for 1908, we referred to—

> the well-known facts that no court, no commission, or accountant, or financial writer would for a moment consider that the present balance sheet statement purporting to give the "cost of property" suggests, even in a remote degree, a reliable measure either of the money invested or of present value.

Since adoption and use of the prescribed uniform system of accounts the force of these criticisms has been lessened, particularly as to property acquired or constructed after 1907, but as to the older portions of the railroad properties, the criticism remains valid to a considerable degree.

3. The figures appearing in the table submitted by the petitioners include the net amounts appearing in accounts 716, Materials and Supplies, and 708 Cash. These amounts are larger than are necessary for normal operation of properties of this character, as we know very well from our valuation work in carrying out our duties under section 19a of the act, and from the repeated examinations made in investigations of this character where value on a Nation-wide basis was found. In the predecessor proceedings to Ex Parte No. 148, *Fifteen Percent Case, 1937–1938,* 226 I.C.C. 41, 61 and *General Commodity Rate Increases, 1937,* 229 I.C.C. 435, 450, as of January 1, 1937, we found working capital, including materials and supplies, as $289,596,774, which, on inspection, proves to be 9.28 percent of the total operating expenses for that year. Application of that percentage to the operating expenses of the Class I railroads for 1945 would produce a figure of $654,409,565, to be contrasted with $968,456,129 in account 708, Cash, and $595,759,037, in account 716, Materials and Supplies, or a total of $1,564,215,166 which enters into the total investment shown in the petitioners' statement as above set forth. But this computation would be as of the end of the year; applied to the middle of the year the comparable figure would be $593,914,190, contrasted with approximately $1,530,000,000, made up of $925,000,000 for cash and $604,000,000 for materials and supplies then carried on the carriers' books.

The exhibit submitted by our Bureau of Valuation in Ex Parte No. 148, which is part of this record, gives for working capital, including materials and supplies, for all class I railroads, $296,584,724, as of January 1, 1940. The books of the same carriers (line-haul railways and lessors of class I) as of the preceding day, December 31, 1939, showed cash, $538,409,000, and materials and supplies, $327,396,000, and these amounts, rather than the lesser sum found by us, appear in the total investment figure for the year 1940 above set forth.

These continuing (and normal) differences have been considered and explained in many of our valuation proceedings. Materials and supplies are accumulated in advance, for reconstruction and construction which is to be charged to capital account; cash is accumulated, particularly as sinking fund, interest, or dividend dates approach, which is ear-marked or devoted to uses other than transportation service. This latter feature is emphasized by petitioners in this proceeding in response to suggestions by protestants that the cash position of the petitioners is so favorable that they need no emergency relief as sought.

4. To give effect to the depreciation which has taken place as to fixed property and investment, the petitioners in the foregoing table have deducted depreciation as it has been accrued on the carriers' books, and only to that extent. But as shown by their exhibit, "Accrued depreciation for Class I carriers and their non-operating subsidiaries (was) not reported prior to January 1, 1917." But even if taken into account at the time, though not reported, the total representing depreciation as recorded in the carriers' books is not to be taken as reflecting the total depreciation, for prior

to 1943 depreciation accounting on roadway property was not mandatory, and any voluntary charges therefor were extremely rare. In other words, the whole amount of depreciation found by us on inspection under the provisions of the valuation act, section 19a, does not appear on the carriers' books, and is reflected only partially in the carriers' exhibit from which the preceding table was compiled. The unrecorded depreciation is large in amount and substantially affects the use of recorded investment less recorded depreciation as a safe guide to ascertainment of the actual rate of return.

5. The net effect of these suggestions may be judged by comparison of the first item shown in the table above, Investment, after depreciation shown on books, with our valuations in previous rate cases.

In *Increased Rates, 1920,* 58 I.C.C. 220, 228, we found the approximately aggregate value for rate making purposes of all the railroads (whatever the type), including working capital, as $18,900,000,000. The figure shown in the petitioners' exhibit submitted in this case for the year 1921 is $20,167,926,242. The 1920 investment is not stated in the exhibit.

In *Reduced Rates, 1922*, 68 I.C.C. 676, 684–5, although our former figures were generally accepted by carriers and shippers, we reexamined our calculations made in 1920, and found no present reason to disturb the sums stated, except to the extent that subsequent additions or withdrawals of property in service, including materials and supplies and working capital, and further depreciation might make adjustments necessary. The character of the case did not require further precision, as the increase in investment during the year 1922, as shown by the petitioners here, including materials and supplies and cash with road and equipment, was only approximately $262,000,000 before and $145,000,000 after depreciation.

The value found by us for class I railroads as of January 1, 1937, in *Fifteen Percent Case, 1937–1938, supra,* at pages 60–63, was an approximate total of $19,972,000,000. In this proceeding the corresponding figure for roads of the same class, shown by petitioners as appears in the table referred to above, is $23,151,216,272 as of the end of 1937, and $23,229,985,905 as of the beginning of that year. Our finding of approximate value was reexamined in *General Commodity Rate Increases, 1937, supra,* where we corrected a clerical error (immaterial to present discussions), and found the approximate value of class I railways as of January 1, 1938, as being $19,882,000,000, and of all railway carriers as $20,988,000,000. The amounts shown in the petitioners' statement in this proceeding for class I carriers for the year 1938 are $23,151,216,272 at the beginning of the year and $23,062,465,309 at its close. The valuation as of January 1, 1938, $19,882,000,000, is the latest we have made of the class I carriers as a whole. If it be adjusted by making allowance for the lessened amount of total investment shown on the books from December 31, 1939, to 1945, after deduction of recorded depreciation computed from the petitioners' statement as $469,550,529, the value figure found by us for the class I roads as of January 1, 1945, would become approximately $19,412,449,471, as contrasted with $22,600,000,000 shown by the petitioners as their depreciated base.

The carriers' depreciated base, $22,600,000,000 (which is partially estimated), may be tested by another computation, based upon figures in the record. Beginning with the original cost of road and equipment, plus the present value of lands and rights, plus an allowance for working capital and materials and supplies, estimated by our Bureau of Valuation as of January 1, 1940, and deducting (only) the recorded depreciation accrued on road and equipment as of the preceding day (December 31, 1939), lessor companies included, an aggregate figure is deduced of $21,606,309,392. This may be compared with the figures for either 1939 or 1940 shown in the table above, or more precisely, as shown in the carriers' statement, $23,069,550,529 for 1939 and $23,302,841,754 for 1940. However, as explained in the paragraph numbered 4 above under this general hearing, the recorded depreciation by no means approaches the total amount which has taken place, as observed by us and found in our numerous valuation proceedings under section 19a of the act. It is to be understood that as original cost as such is practically unattainable on various properties, the Bureau's figure therefor is in part an estimate, but an estimate which we believe approximates the fact.

* * *

VALUE OF PROPERTY OF CLASS I RAILROADS, AND RATES OF RETURN

We can ascertain and state from data in the record the approximate total value for rate-making purposes of the properties of the class I railroads, petitioners before us. We do not include class II and III and switching and terminal companies, but lessor companies are included. We have used as a basis the values for January 1, 1938, found by us as heretofore recited, and have allowed for the net amount of subsequent increases and retirements, changes in recorded depreciation, amortization, and the normal amount necessary for working capital, in which we include necessary materials and supplies and cash. The calculations are made as of the end of the calendar year 1944 or beginning of the year 1945—which we take as synonymous, adequate data for 1946 not being available. Greater refinement would be possible with more time and staff available, but the following approximations of rate-making value are sufficiently accurate for present purposes, and they are found by us to be the approximate values of the properties of the class I railroads in public transportation service, as of the beginning of the year 1945, namely:

* * *

	Approximate aggregate value Jan. 1, 1945
Total, all districts	$19,571,000,000

ICC EX PARTE NO. 166

INCREASED FREIGHT RATES, 1947

Decided October 6, 1947

(269 ICC 33)

Pages 47–48

VALUATION OF RAILROAD PROPERTIES

Certain interested parties suggested that we place in the record data concerning the value of the property in common-carrier service by railroad, and our Bureau of Valuation prepared exhibits concerning the elements of the value of the property of the class I line-haul railroads, stating the "three costs" and other factors stated in section 19a of the act, as of the beginning of the present calendar year. The Bureau's exhibits were received in evidence without objection. For all districts the following figures were stated:

Cost of reproduction new, lands and rights not included	$32,613,665,594
Cost of reproduction less depreciation, lands and rights not included	20,653,629,888
Original cost, except lands and rights	24,035,180,653
Present value of lands and rights	1,935,063,167
Working capital, including materials and supplies	610,712,400

By the petitioners' statement, the amount of depreciation and amortization accrued by the class I railroads as of December 31, 1946, was $5,958,242,632. Deducting this amount from the original cost item above shown, and adding the present value of lands and rights and allowance for working capital, including materials and supplies, gives $20,622,713,588 as a resulting estimate which follows methods often employed.

The "Investment in railway property used in common carrier service, after accrued depreciation" claimed by the petitioners as of the same date is $22,548,967,331. Part of the difference is due to the amounts included for cash and materials and supplies, and in part to the fact the Bureau's figures as to original cost are partly actual costs and partly estimates, and the land figures are estimates of present value, while the petitioners state the amounts carried on their books. The figure used by the State commissions is $19,591,000,000, derived by adjusting a former estimate of the Commission for subsequent changes in property.

These figures are all much closer together than is usually the case when the aggregate value of railway property is involved, and for present purposes we do not think it necessary to analyze them further, or to divide them by districts and regions.

ICC EX PARTE NO. 168

INCREASED FREIGHT RATES, 1948

Decided August 11, 1949
(276 ICC 9)

Page 17 II.

Valuation data.—This is primarily a revenue case. In previous reports in this series of petitions for rate-increase authorizations we have considered the question of the aggregate value for rate-making purposes of the property of the class I railway carriers devoted to common-carrier service. The latest discussion is found in *Increased Freight Rates, 1947,* 269 I.C.C. 33, at pages 48–49. We have brought these figures to the latest possible date, upon the best basis available from the record.

According to this record, the value of the property in the common carrier service of the class I railways is estimated at $20,978,646,326 as of January 1, 1948. This is based upon the original cost, except land and rights, plus the present value of land and rights, and an estimated normal amount of working capital, including materials and supplies, less the recorded accrued depreciation. The detail of these figures for the country as a whole and for the districts and regions is shown in the table below.

In 1948 the gross capital expenditures of the railways were very large, aggregating $1,266,000,000 in round figures. Valuation data showing the additional net investment during 1948 are not available. However, in view of the high prices of labor and materials, it seems safe to assume that the values on January 1, 1949, were appreciably higher than those on January 1, 1948, which are shown in the table.

* * *

	Values
Total United States	$20,978,646,326

ICC EX PARTE NO. 175

INCREASED FREIGHT RATES, 1951

Decided August 2, 1951
(281 ICC 557)

Pages 563–565

TRAFFIC, REVENUES, EXPENSES, AND FINANCIAL CONDITION OF THE RAILROADS

Since our interim report in this proceeding the rail carriers have revised somewhat their initial estimates in the light of subsequent developments and more recent information. As stated in our interim report, the net railway operating income of class I railways for the four war years 1942–1945 averaged $1,200.7 million per year. This was equivalent to a rate of return on net investment as computed by the carriers of 5.16 percent. In the five postwar years 1946–1950, net railway operating income has averaged $825.8 million, including back mail pay, or a return of 3.51 percent. (Exhibit 42, p. 1) For the year 1950 net railway operating income, including back mail pay, represented a rate of return on net investment as of December 31, 1950 of 4.22 percent, and. excluding back mail pay was 3.95 percent. As computed by the railroads, net investment includes book investment in road and equipment less accrued depreciation, plus materials, supplies, and cash. Net investment as of December 31, 1949, was $24,028,408,760, and as of December 31, 1950 was $24,631,245,000. The net investment as of December 31, 1949 is $1,890,395,746 higher than the total value determined by the elements of the value of property devoted to common-carrier service of the class I railways shown in the table below, as of January 1, 1950.

Using the total value shown in the table below as a rate base, the net railway operating income of class I railroads for the year 1950 of $1,039,834,971 (which includes back mail pay) represented a rate of return of 4.70 percent. For comparison the net railway operating income in 1950, including back mail pay, was 4.22 percent, and not including back mail pay, 3.95 percent on net investment, as computed by the railroads as of December 31, 1950.

ELEMENTS OF VALUE OF PROPERTY IN COMMON-CARRIER SERVICE
CLASS I LINE-HAUL RAILWAYS, JANUARY 1, 1950

* * *

	Total United States
Original cost except land and rights	$26,157,866.052
Present value of land and rights	1,952,374,483
Working capital, including materials and supplies	658,039,200
Total	$28,768,279,735
Less: Recorded depreciation and amortization	6,630,266,721
Values	$22,138,013,014

As the elements of value referred to are not available for a date later than January 1, 1950, this base and rate of return predicated thereon take no account of capital expenditures during the year 1950, which are included in the rail figure as of December 31, 1950. Gross capital expenditures in 1950 aggregated $1,066,000,000 and were estimated by the railroads for 1951 at $1,376,000,000. If this latter estimated figure is realized it would represent the highest gross capital expenditure in any year in railroad history.

ICC EX PARTE NO. 175
INCREASED FREIGHT RATES, 1951

Decided April 11, 1952
(284 ICC 589)

Pages 606–613

* * *

I. Financial Situation of the Railroads

* * *

Rate of return.—Considerable evidence was adduced by the petitioners, and countervailing evidence by protestants with reference to rates of return on the property of public utilities that had been recognized as proper by the courts, by this Commission, and by other regulatory authorities, State and Federal, as to various types of public service agencies. In presenting this character of evidence the petitioners made it clear that their purpose was not to endeavor to build up a conventional case of attack on a body of rates as being confiscatory, but rather that the evidence was persuasive as to the rate basis which they should be permitted to impose. They adduced a carefully prepared and documented showing to give an over-all estimate as to the "cost of capital" to them in the shape of returns which investors would successfully demand as the price of supplying the necessary capital to carry on the enterprise. As to each line of attack on the present rate basis, the deduction from their showing was that the rate of return for the carriers generally was insufficient to meet either test.

It is not, we think, necessary to go into a detailed or elaborate discussion of the questions presented. Rates of return for individual carriers, relevant when considering either the adequacy of their particular rates or the confiscatory character of schedules prescribed for them, cast little light on what would be a fair rate of return when great groups—in fact all—of the carriers are aggregated, and the proposal is for equal treatment of them. On the other hand, we cannot accept the contention that with the repeal of the recapture provisions of the Transportation Act of 1920, our long-exercised right and duty to consider the return being earned by the carriers by groups, upon an average basis, was taken away from us. It is an economic necessity that we do so, if we are to make rate adjustments which will conform to the standards of the Interstate Commerce Act and will move the traffic of the Nation, as well as keep the components of the transportation system in as good a state of health as other conditions permit. It is inevitable that with a rate structure which the country needs, adjusted so that over-all rates are reasonable and just, some carriers will earn more, and others less, than the average which is a fair return for the roads as a whole or in groups. That the particular remedy for this obvious condition, which Congress undertook to apply by the recapture provisions of the act of 1920, failed because of inherent imperfections, in no wise alters the necessity for continuing to view the situation of the segments of the industry as a whole or in groups, in order to carry out the objects of the national transportation policy and to conform to the requirements of the act that rates shall be just and reasonable.

Using both the Department of Commerce and the railroad net railway operating income, the rates of return for 1952, in terms of the amount of net investment estimated and claimed by the railroads, compare as follows:

	Rate of return	
	At current rates	At proposed rates
	Percent	Percent
Department of Commerce estimate	3.71	4.79
Class I railroads' estimate	3.53	4.59

These rates would be somewhat higher on the basis of the "elements of value" method stated in our report on further hearing, 281 I.C.C. 563, *supra,* namely, for the Department of Commerce, 4 and 5.16 percent, and for the railroads, 3.81 and 4.95 percent, under the current and proposed rate bases, respectively.

Valuation.—In consideration of the question of the adequacy of the returns of the petitioners, the value of their properties devoted to common carrier service is a necessary factor to be examined. Our report on further hearing, 281 I.C.C. 563, *et seq.,* stated our estimates of the values of the class I railroad properties, as of January 1, 1950, which, for the purposes of this proceeding, we considered should be based upon our estimates of original cost (except lands and rights), the present value of lands and rights, with an allowance for working capital and materials and supplies computed in the manner in which we estimated such accounts in proceedings under section 19a of the act, less recorded amounts for depreciation and amortization. This method probably somewhat understates the actual depreciation which has occurred. In the recent further hearings, the data used were supplemented by the submission in evidence by the petitioners of similar data as of January 1, 1951, and by estimates of the net increment in investment to be made during the year 1952.

Our deduction of value in the former report on further hearing, $22,138,013,014, as of January 1, 1950, is criticised by petitioners in testimony and upon argument, as not consistent with methods of estimation employed by us in former cases, and as not giving sufficient weight to the present day high costs of reproduction. It is not considered necessary now to analyze the claims in detail. Inflationary processes are and have been so strong that it is clear that estimates of cost of present day reproduction, while useful in measuring inflationary forces, need not be given controlling considerat'on in estimating value of public service property for rate-making purposes. No prudent man would consider reproducing the properties on the basis of the extremely high reproduction costs estimated. Intention to make such use of the cost of reproduction estimate was disclaimed on the argument. In fairness, to bring about the end result of a reasonable return and reasonable rates which it would be possible to charge, the manner of estimation of value shown in our former report on further hearing should be employed again as the measure of value for the purposes of this proceeding at this stage. The figures so deduced are not far from the amount shown in the investment accounts of the petitioners, and are not far from the total capitalization as of December 31, 1950.

Following that method, the aggregate value as of January 1, 1951, of the properties of the class I railways is taken as being $22,677,972,933. This figure may be compared with the carriers' present estimate as of the previous day, December 31, 1950, slightly reduced from the former showing, of $24,591,861,642 and with a "grand total debt, stock, and surplus" as of the same day for the class I line-haul operating companies of $23,028,005,562. Their estimate as of December 31, 1951, was $25,463,300,000, and of the end of the present calendar year (assuming continuance of current rates) $26,225,100,000.

The valuation estimates of the Department of Commerce as of the end of the calendar years 1951 and 1952 are $23,549,600,000 and (assuming current rates)

$24,311,400,000, respectively. The difference between these two figures represents the petitioners' estimate of the increment to investment, undepreciated, during the calendar year 1952.[6]

Rates of return by districts and regions.—Applying the method of estimation of rate-making value adopted in our earlier report in this proceeding, already described, the following table shows, for the United States and for the several districts and regions, the aggregate values so deduced, as of January 1, 1951, the aggregate net railway operating income for 1951 and the rate of return in percent which the latter sum bears to the value stated. The table is but slightly out of balance with a similar table submitted by the petitioners, in part calculated by them along the same lines. Comparison of the two estimates indicates that the difference chiefly, and possibly wholly, is due to the fact that the table below bases the percentage of return on our estimate of value as of the beginning of the calendar year, while the petitioners based their estimate on computations of value as of the end of the year; in other words, by adding to the amounts appearing in the table subjoined the (estimated) net amount of increment in investment during the year. The railroads' method was also employed by the Department of Commerce in its estimates of return. A proper computation would probably more reasonably be based upon the mid-point in the year. But as that figure has not been shown, and as the railroads' computations are based solely upon estimates incapable of verification in our records, as to the net amount of investment during the year, and the differences are but slight, no further reconciliation is considered necessary.

The rates of return shown below may be considered as somewhat, but in the main inconsiderably, overstated for the reasons indicated, and also because of some differences in the readjustment of certain items of retroactive mail pay and tax refunds as between affected years.

Districts and regions	*Values after depreciation and amortization Jan. 1, 1951*	*Net railway operating income 1951*	*Rate of return*
			Percent
United States	$22,677,972,933	$942,696,259	4.2
Eastern district	9,099,554,546	290,490,127	3.2
New England region	914,348,164	16,254,710	1.8
Great Lakes region	3,730,648,074	140,813,989	3.8
Central eastern region	4,454,558,308	133,421,428	3.0
Southern district	4,386,917,593	248,940,802	5.7
Pocahontas region	1,233,959,750	91,804,203	7.4
Southern region	3,152,957,843	157,136,599	5.0
Western district	9,191,500,794	403,265,330	4.4
Northwestern region	3,045,911,780	83,744,996	2.7
Central western region	4,320,543,729	225,880,366	5.2
Southwestern region	1,825,045,285	93,639,968	5.1

Inclusion of the Pocahontas region with the roads in the eastern district would result in an aggregate return for the combination of regions commonly called "official territory" (from the title of the governing freight classification) of 3.7 percent.

Rates of return, individual lines.—Scrutiny of the underlying data for the foregoing table as to the individual class I roads shows that there is now a much less wide band

[6] The estimates of rates of return yielded in this report may readily be translated by simple proportion to any of the other valuation estimates stated.

of varying rates of return than has formerly been exhibited. The principal railroads, considered with respect to the relative amounts of traffic they carry, and also as to the proportion of the total investment they represent, do not show a great amount of variation in the rates of return as between high and low levels, as will be shown.

The 3 Canadian lines in New England, aggregated, show a deficit; so also the Rutland Railroad Company; New York, Ontario and Western Railway Company; The Long Island Rail Road Company; The Pennsylvania–Reading Seashore Lines; and The Staten Island Rapid Transit Railway Company—all in the eastern district. The deficit of The Central Railroad Company of New Jersey is counterbalanced by the return of the Central Railroad Company of Pennsylvania, 13.2 percent. No class I line in the southern district (including the Pocahontas region) had a deficit for 1951; in the western district, the Chicago, St. Paul, Minneapolis and Omaha Railway Company, in the northwestern region, the Utah Railway Company in the central western region, and the San Antonio, Uvalde & Gulf Railroad Company in the southwestern region, are deficit lines for that year.

In contrast with the showing as to deficit lines, 20 class I roads that enter into the computation of the foregoing table had returns above 8 percent for the year 1951, and of those 3 probably would be excluded if values were taken as of the middle instead of the first of the year. The roads are shown in a footnote.[7]

None of the deficit lines indicated, and none (other than certain conspicuous industry-affiliated lines) with earnings exceeding an 8-percent rate, are or have been important factors in controlling the general region- or country-wide basis of freight rates. We have long recognized—as did Congress in the Transportation Act of 1920, sec. 422—that even with a reasonable general basis of rates there must be some railroads that would have high, and some low, rates of return or none at all, and that in the interest of the commerce of the country neither the success of the most prosperous nor the unfortunate plight of the least favorably circumstanced lines could control in our determination of a wide basis of reasonable rates for application on lines of high, low, and average earning capacity. These roads perforce all must compete with each other for a large portion of the common body of available traffic, which must be carried at a common rate basis if the lines compete effectually. The great body of traffic is carried neither by the high earning nor low earning or deficit roads.

The following table shows the respective rates of return for all class I railroads having values exceeding $190,000,000 as computed by us. These roads represented 81.8 percent of the total value of the class I roads shown in the preceding table, and their net railway operating income was 80.2 of the total. The importance of these major lines in the economy of the industry is obvious. But three of them—the New York, Chicago, and St. Louis Railroad Company (8.8 percent), and the two largest lines in the Pocahontas region, The Chesapeake and Ohio Railway Company (7.9 percent) and the Norfolk and Western Railway Company (7 percent) showed earnings of as much as 7 percent. It is no longer true, as was the case in years past, that the earnings of the Pocahontas lines "shocked the conscience."

---

[7] The figures given represent percent of aggregate value:
Great Lakes region: Cambria and Indiana, 18.1; Detroit & Toledo Shore Line, 10.3; Lehigh & New England, 11.6; New York, Chicago & St. Louis, 8.8; Pittsburgh & Lake Erie, 8.1; Central eastern region: Bessemer & Lake Erie, 9.0; Central R. Co. of Pennsylvania, 13.2; Elgin, Joliet & Eastern, 8.1; Southern region: Atlanta & St. Andrews Bay, 15.5; Clinchfield, 16.2; New Orleans & Northeastern, 9.4; Northwestern region: Lake Superior & Ishpeming, 9.4; Central western region: Colorado & Wyoming, 8.5; Toledo, Peoria & Western, 9.2; Southwestern region: Beaumont, Sour Lake & Western, 25.2; Kansas City Southern, 8.3; Kansas, Oklahoma & Gulf, 9.8; New Orleans, Texas & Mexico, 13.3; St. Louis Southwestern and Subsidiarles, 9.6; Texas & Northern, 52.1.

Railroads With Estimated Values Each Exceeding $190 Millions, and Net Railway Operating Income, and Rates of Return Earned, Respectively, 1951

	Estimated value, Jan. 1, 1951	Net railway operating income 1951	Rate of return on value
	(thousands)	(thousands)	Percent
New England region:			
Boston & Maine	$ 268,997	$ 4,907	1.8
New York, N.H. & H.	421,658	7,897	1.9
Subtotal	690,655	12,804	1.85
Great Lakes region:			
Delaware, L. & W.	287,756	8,490	3.0
Erie	371,974	19,763	5.3
Lehigh Valley	221,037	10,392	4.7
New York Central	1,801,512	40,050	2.2
New York, Chicago & St. L.	255,350	22,394	8.8
Wabash	208,701	10,064	4.8
Subtotal	3,146,330	111,153	3.5
Central Eastern region:			
Baltimore & O.	949,206	36,833	3.9
Pennsylvania	2,371,851	59,520	2.5
Reading	324,045	13,319	4.1
Subtotal	3,645,102	109,672	3.0
Pocahontas region:			
Chesapeake & O.	628,845	49,442	7.9
Norfolk & W.	430,634	29,956	7.0
Subtotal	1,059,479	79,398	7.5
Southern region:			
Atlantic Coast Line	335,566	10,037	3.0
Gulf M. & O.	191,678	9,559	5.0
Illinois Central	633,689	30,659	4.8
Louisville & N.	507,342	24,340	4.8
Seaboard Air Line	286,873	19,185	6.7
Southern	550,571	27,947	5.1
Subtotal	2,505,719	121,727	4.9
Northwestern region:			
Chicago & N.W.	575,699	7,224	1.3
Chicago, M.St.P.& P.	699,442	15,326	2.2
Great Northern	567,799	23,214	4.1
Northern Pacific	541,480	16,331	3.0
Subtotal	2,384,420	62,095	2.6
Central western region:			
Atchison, T. & S.F.	1,038,707	71,613	6.9
Chicago, Burlington & Q.	648,107	30,117	4.6
Denver & Rio Grande W.	196,543	11,712	6.0
Chicago, R.I. & P.	459,291	17,256	3.8
Southern Pac. (Pac. Lines)	895,348	45,382	5.1
Union Pacific	815,912	35,651	4.4
Subtotal	4,053,908	211,731	5.2
Southwestern region:			
Missouri Pac.	493,719	23,962	4.9
St. Louis—S.F.	298,701	12,643	4.2
Texas & N.O.	277,143	11,179	4.0
Subtotal	1,069,563	47,784	4.5
Total, selected large roads	$18,555,176	$756,364	4.1

By regions, the rates of return earned by these large carriers are as follows:

Region	*Percent of return*
New England	1.85
Great Lakes	3.54
Central Eastern	3.00
Pocahontas	7.49
Southern	4.86
Northwestern	2.60
Central Western	5.22
Southwestern	4.47

For the districts, the Eastern, including the Pocahontas region, rate of return was 3.66; the Southern region, 4.86; and the Western, 4.28 percent.

The districts and regions shown are those commonly employed in accounting and statistical studies, and grew out of the needs of the United States Railroad Administration during the First World War. While the names given them are generally fairly descriptive, important lines classified in different regions in fact interlace and compete for common traffic to a considerable extent, so that it is not practical to use the regional basis of grouping for the purposes of rate adjustments, especially such character of adjustments as we have been called upon to make in the series of general rate increase cases since the beginning of the Second World War.

Judged by any standard shown of record, the rates of return earned or prospectively to be earned by the railroads by the districts and region specified in our former reports in this case, are substandard. Some important roads are earning little enough that a continuance of the earnings situation will imperil their solvency, while some are in comfortable condition. Neither the strongest nor the weakest lines can control the rate adjustment; and as has been shown, the great body of the rail carriers are in the middle class, with aggregate earnings that for the immediate future must be considered as substandard, and inadequate.

Consideration of these rates of return for their bearing on this proceeding, which relates to the rate level for the future, requires that allowance be made, necessarily in general terms, for the effect of the following factors already referred to. On the revenue side, the interim increase allowed and the additional increases were in effect but portions of the calendar year 1951, and some rates, particularly intrastate rates, have lagged somewhat further behind. On the expense side, important changes in the wage scales became effective during the present calendar year; some moderate increases have occurred in material prices; and as to the operating revenues shown, hereafter (and now in effect) will be marked increase in corporate Federal income taxes, which must be deducted to ascertain net railway operating income. Beyond these factors, which are all ponderable items, is the inevitable uncertainty which must exist as to the amount and nature of future traffic, and the course of wage and price trends in the future. Informed opinions stated in the record tend to narrow the uncertainty as to the probable volume and character of traffic available during the present year, at least; but forecasting the future trend of wages and material prices is a highly speculative process.

APPENDIX B

EXCERPTS FROM THE INTERSTATE COMMERCE ACT, REVISED TO NOVEMBER 1, 1951

●

SECTION 19a. VALUATION OF PROPERTY OF CARRIERS

●

PREAMBLE. NATIONAL TRANSPORTATION POLICY

●

SECTION 15a. RULE OF RATE MAKING

EXCERPTS FROM

THE INTERSTATE COMMERCE ACT, REVISED TO NOVEMBER 1, 1951

PUBLISHED AS SENATE DOCUMENT NO. 72, 82d CONGRESS, 1st SESSION

Section 19a. Valuation of Property of Carriers

Pages 74–80

VALUATION OF PROPERTY OF CARRIERS

SEC. 19a. *(March 1, 1913, amended February 28, 1920, June 7, 1922, June 16, 1933, August 9, 1935.) (49 U.S.C., Sec. 19a.)* (a) That the Commission shall, as hereinafter provided, investigate, ascertain, and report the value of all the property owned or used by every common carrier subject to the provisions of this part, except any street, suburban, or interurban electric railway which is not operated as a part of a general steam railroad system of transportation; but the commission may in its discretion investigate, ascertain, and report the value of the property owned or used by any such electric railway subject to the provisions of this part whenever in its judgment such action is desirable in the public interest. To enable the Commission to make such investigation and report, it is authorized to employ such experts and other assistants as may be necessary. The commission may appoint examiners who shall have power to administer oaths, examine witnesses, and take testimony. The Commission shall, subject to the exception hereinbefore provided for in the case of electric railways, make an inventory which shall list the property of every common carrier subject to the provisions of this part in detail, and show the value thereof as hereinafter provided, and shall classify the physical property, as nearly as practicable, in conformity with the classification of expenditures for road and equipment, as prescribed by the Interstate Commerce Commission.

(b) First. In such investigation said Commission shall ascertain and report in detail as to each piece of property, other than land, owned or used by said common carrier for its purposes as a common carrier, the original cost to date, the cost of reproduction new, the cost of reproduction less depreciation, and an analysis of the methods by which these several costs are obtained, and the reason for their differences, if any. The Commission shall in like manner ascertain and report separately other values, and elements of value, if any, of the property of such common carrier, and an analysis of the methods of valuation employed, and of the reasons for any differences between any such value and each of the foregoing cost values.

Second. Such investigation and report shall state in detail and separately from improvements the original cost of all lands, rights of way, and terminals owned or used for the purposes of a common carrier, and ascertained as of the time of dedication to public use, and the present value of the same.

Third. Such investigation and report shall show separately the property held for purposes other than those of a common carrier, and the original cost and present value of the same, together with an analysis of the methods of valuation employed.

Fourth. In ascertaining the original cost to date of the property of such common carrier the Commission, in addition to such other elements as it may deem necessary, shall investigate and report upon the history and organization of the present and of any previous corporation operating such property; upon any increases or decreases of stocks, bonds, or other securities, in any reorganization; upon moneys received by any such corporation by reason of any issues of stocks, bonds, or other securities; upon the syndicating, banking, and other financial arrangements under which such issues were made and the expense thereof; and upon the net and gross earnings of such corporations; and shall also ascertain and report in such detail as may be determined by the Commission upon the expenditure of all moneys and the purposes for which the same were expended.

Fifth. The Commission shall ascertain and report the amount and value of any aid, gift, grant of right of way, or donation, made to any such common carrier, or to any previous corporation operating such property, by the Government of the United States or by any State, county, or municipal government, or by individuals, associations, or corporations; and it shall also ascertain and report the grants of land to any such common carrier, or any previous corporation operating such property, by the Government of the United States, or by any State, county, or municipal government, and the amount of money derived from the sale of any portion of such grants and the value of the unsold portion thereof at the time acquired and at the present time, also, the amount and value of any concession and allowance made by such common carrier to the Government of the United States, or to any State, county, or municipal government in consideration of such aid, gift, grant, or donation.

(c) Except as herein otherwise provided, the Commission shall have power to prescribe the method of procedure to be followed in the conduct of the investigation, the form in which the results of the valuation shall be submitted, and the classification of the elements that constitute the ascertained value, and such investigation shall show the value of the property of every common carrier as a whole and separately the value of its property in each of the several States and Territories and the District of Columbia, classified and in detail as herein required.

(d) Such investigation shall be commenced within sixty days after approval of this part and shall be prosecuted with diligence and thoroughness, and the result thereof reported to Congress at the beginning of each regular session thereafter until completed.

(e) Every common carrier subject to the provisions of this part shall furnish to the Commission or its agents from time to time and as the Commission may require maps, profiles, contracts, reports of engineers, and any other documents, records, and papers, or copies of any or all of the same, in aid of such investigation and determination of the value of the property of said common carrier, and shall grant to all agents of the Commission free access to its right of way, its property, and its accounts, records, and memoranda whenever and wherever requested by any such duly authorized agent, and every common carrier is hereby directed and required to cooperate with and aid the Commission in the work of the valuation of its property in such further particulars and to such extent as the Commission may require and direct, and all rules and regulations made by the Commission for the purpose of administering the provisions of this section and section twenty of this part shall have the full force and effect of law. Unless otherwise ordered by the Commission, with the reasons therefor, the records and data of the Commission shall be open to the inspection and examination of the public.

(f) Upon completion of the original valuations herein provided for, the Commission shall thereafter keep itself informed of all new construction, extensions, improvements, retirements, or other changes in the condition, quantity, use, and classification of the property of all common carriers as to which original valuations have been made, and of the cost of all additions and betterments thereto and of all changes in the investment therein, and may keep itself informed of current changes in costs and values of railroad properties, in order that it may have available at all times the information deemed by it to be necessary to enable it to revise and correct its previous inventories, classifications, and values of the properties; and when deemed necessary, may revise, correct and supplement any of its inventories and valuations.

(g) To enable the Commission to carry out the provisions of the preceding paragraph, every common carrier subject to the provisions of this part shall make such reports and furnish such information as the Commission may require.

(h) Whenever the Commission shall have completed the tentative valuation of the property of any common carrier, as herein directed, and before such valuation shall become final, the Commission shall give notice by registered letter to the said carrier, the Attorney General of the United States, the governor of any State in which the property so valued is located, and to such additional parties as the Commission may prescribe, stating the valuation placed upon the several classes of property of said carrier, and shall allow thirty days in which to file a protest of the same with the Commission. If no protest is filed within thirty days, said valuation shall become final as of the date thereof.

(i) If notice of protest is filed the Commission shall fix a time for hearing the same, and shall proceed as promptly as may be to hear and consider any matter relative and material thereto which may be presented in support of any such protest so filed as aforesaid. If after hearing any protest of such tentative valuation under the provisions of this part the Commission shall be of the opinion that its valuation should not become final, it shall make such changes as may be necessary, and shall issue an order making such corrected tentative valuation final as of the date thereof. All final valuations by the Commission and the classification thereof shall be published and shall be prima facie evidence of the value of the property in all proceedings under the Act to regulate commerce as of the date of the fixing thereof, and in all judicial proceedings for the enforcement of the Act approved February fourth, eighteen hundred eighty-seven, commonly known as "the Act to regulate commerce," and the various Acts amendatory thereof, and in all judicial proceedings brought to enjoin, set aside, annul, or suspend, in whole or in part, any order of the Interstate Commerce Commission.

(j) If upon the trial of any action involving a final value fixed by the Commission, evidence shall be introduced regarding such value which is found by the court to be different from that offered upon the hearing before the Commission, or additional thereto and substantially affecting said value, the court, before proceeding to render judgment shall transmit a copy of such evidence to the Commission, and shall stay further proceedings in said action for such time as the court shall determine from the date of such transmission. Upon the receipt of such evidence the Commission shall consider the same and may fix a final value different from the one fixed in the first instance, and may alter, modify, amend or rescind any order which it has made involving said final value, and shall report its action thereon to said court within the time fixed by the court. If the Commission shall alter, modify, or amend its order, such altered, modified, or amended order shall take the place of the original order complained of and judgment shall be rendered thereon as though made by the Commission in the first instance. If the original order shall not be rescinded or changed by the Commission, judgment shall be rendered upon such original order.

(k) The provisions of this section shall apply to receivers of carriers and operating trustees. In case of failure or refusal on the part of any carrier, receiver, or trustee to comply with all the requirements of this section and in the manner prescribed by the Commission such carrier, receiver, or trustee shall forfeit to the United States the sum of five hundred dollars for each such offense, and for each and every day of the continuance of such offense, such forfeitures to be recoverable in the same manner as other forfeitures provided for in section sixteen of the Act to regulate commerce.

(l) That the district courts of the United States shall have jurisdiction, upon the application of the Attorney General of the United States at the request of the Commission, alleging a failure to comply with or a violation of any of the provisions of this section by any common carrier to issue a writ or writs of mandamus commanding such common carrier to comply with the provisions of this section.

* * *

Pages 1-2

National Transportation Policy

(September 18, 1940.) (49 U. S. C., preceding Sections 1, 301, 901, and 1001.) It is hereby declared to be the national transportation policy of the Congress to provide for fair and impartial regulation of all modes of transportation subject to the provisions of this Act, so administered as to recognize and preserve the inherent advantages of each; to promote safe, adequate, economical, and efficient service and foster sound economic conditions in transportation and among the several carriers; to encourage the establishment and maintenance of reasonable charges for transportation services; without unjust discriminations, undue preferences or advantages or unfair or destructive competitive practices; to cooperate with the several States and the duly authorized officials thereof; and to encourage fair wages and equitable working conditions;—all to the end of developing, coordinating, and preserving a national transportation system by water, highway, and rail, as well as other means, adequate to meet the needs of the commerce of the United States, of the Postal Service, and of the national defense. All of the provisions of this Act shall be administered and enforced with a view to carrying out the above declaration of policy.

---

* * *

Pages 61–62

Rule of Rate Making

SEC. 15a. *(February 28, 1920; amended, June 16, 1933, September 18, 1940.) (49 U. S. C., Sec. 15a.)* (1) When used in this section the term "rates" means rates, fares, and charges, and all classifications, regulations, and practices relating thereto.

(2) In the exercise of its power to prescribe just and reasonable rates the Commission shall give due consideration, among other factors, to the effect of rates on the movement of traffic by the carrier or carriers for which the rates are prescribed; to the need, in the public interest, of adequate and efficient railway transportation service to the lowest cost consistent with the furnishing of such service; and to the need of revenues sufficient to enable the carriers, under honest, economical, and efficient management to provide such service.

* * *

Report of Committee 16—Economics of Railway Location and Operation

J. W. Barriger, *Chairman*	C. W. Sooby, *Secretary*	H. B. Christianson, Jr., *Vice Chairman*
H. A. Aalberg	W. S. Kerr	A. L. Sams
E. G. Allen	H. A. Lind	P. J. Schmitz
Herbert Ashton	A. E. MacMillan	H. F. Schryver
J. W. Barriger IV	F. H. McGuigan, Jr.	H. M. Shepard
F. C. Berghaus	R. L. Milner	L. K. Sillcox
C. H. Blackman.	H. P. Morgan	R. F. Spars
I. C. Brewer	F. N. Nye	A. E. Street
D. E. Brunn	F. B. Peter	J. E. Teal
P. J. Claffey	C. W. Pitts	G. H. Tilson
J. J. Corcoran	E. C. Poole	D. K. Van Ingen
Miss O. W. Dennis	W. E. Quinn	H. D. Walker
J. T. Fitzgerald	J. P. Ray	H. P. Weidman
J. M. Fox	W. T. Rice	H. L. Woldridge
C. C. Gatewood	C. P. Richardson	J. A. Wood
C. E. Gipe	C. P. Richmond	W. H. Wood
H. C. Hutson	M. D. Robb	J. S. Worley
W. M. Jaekle	E. H. Roth	
D. B. Jenks		

Committee

To the American Railway Engineering Association:

Your committee reports on the following subjects:

1. Revision of Manual.

   Progress report, including recommended revisions .... page 416

Special—Revision of Manual.

   Manual chapter on Complete Roadway and Track Structure, collaborating with Committees 1, 3, 4 and 5.

   The recommendations of the committee are incorporated in the report on Assignment 1 .... page 419

2. Methods for increasing the use of existing railway facilities, collaborating with Signal Section, AAR.

   Final report, submitted as information .... page 419

3. Methods and formulas for the solution of special problems relating to economics of railway operation.

   Final report, submitted as information .... page 421

4. Effect of higher speed on railway revenues, operating expenses, and charges to capital account.

   No report.

5. Comparison of running time with total time between loading and unloading points of freight cars, and methods of reducing total time, collaborating with Car Service Division, AAR, and American Association of Railroad Superintendents.

   No report.

Committee on Economics of Railway Location and Operation,
J. W. Barriger, *Chairman*.

AREA Bulletin 504, November 1952.

Report on Assignment 1

Revision of Manual

A. L. Sams (chairman, subcommittee), H. A. Aalberg, E. G. Allen, J. W. Barriger, C. H. Blackman, C. E. Gipe, A. E. MacMillan, H. P. Morgan, F. B. Peter, J. P. Ray, J. E. Teal.

Your committee has completely reviewed Chapter 16 of the Manual, and offers the following recommendations in connection therewith:

Pages 16–1 to 16–10, incl.

I ECONOMICS OF RAILWAY LOCATION

1951

Submitted for reapproval with the following changes:

Page 16–1, Par. 2. Economic Plant.

Change the last sentence to read "It is considered good practice to take into account the future, within reasonable limits, provided the necessary funds are available."

Page 16–5, second paragraph, last word in first line and first word in second line.

Substitute "curvature" for "central angle".

Page 16–5, fourth paragraph.

Delete: ", requiring the maximum elevation of the outer rail," and also delete ", requiring less elevation".

Pages 16–11 to 16–44, incl.

II POWER

1940

Submitted for reapproval without change.

Pages 16–45 to 16–49, incl.

OPERATING DATA REQUIRED FOR A STUDY OF THE ECONOMIC JUSTIFICATION OF LINE AND GRADE REVISIONS

1951

Submitted for reapproval with the following change:

Page 16–47, second line of first paragraph under 4. Transportation Costs.

Insert the words "in Statement A—Annual Cost of Present Operations Compared with Estimated Cost After Improvements Are Made", between "(d)" and "is".

Page 16–51

GRADES AND ALINEMENT THROUGH TUNNELS

1950

Submitted for reapproval with the following change:

Delete the parenthetical expression ", if possible," in Par. 4.

Pages 16–53 to 16–60, incl.

METHOD FOR PLOTTING A VELOCITY PROFILE

1943

Submitted for reapproval without change.

Page 16–71

FEASIBILITY AND ECONOMY OF THROUGH ROUTING OF SOLID TRAINS AND THE EFFECT THEREOF UPON THE CAPACITY OF TERMINALS

1924

Submitted for reapproval with the following change:

Delete the last sentence of Par. 4 and substitute "This should include such arrangements for car inspection and repair as will minimize the necessity for special handling of bad order cars enroute".

Page 16–71

OPERATION OF OPPOSING AND FOLLOWING MOVEMENT OF TRAINS BY BLOCK SIGNALS ON MULTIPLE TRACK

1950

Submitted for reapproval without change.

Page 16–72

THE COST OF STOPPING AND STARTING STEAM OPERATED TRAINS

1950

Delete all the references under this heading and substitute the following:

For detailed discussion, tables, charts and examples, see the following:

AREA Proceedings, Vol. 28, 1927, pages 473, 1318.
AREA Proceedings, Vol. 37, 1936, pages 541, 974.
AAR Signal Section Proceedings, 1936, Vol. XXXIV, page 6.
AAR Signal Section Proceedings, 1937, Vol. XXXV, page 6.
AAR Signal Section Proceedings, 1937, Vol. XXXVI, page 6.
AAR Signal Section Proceedings, 1939, Vol. XXXVII, page 6.
AAR Signal Section Proceedings, 1941–42, Vols. XXXIX–XL, page 6.
AAR Signal Section Proceedings, 1943–44, Vols. XLI–XLII, page 7 A.
AAR Signal Section Proceedings, 1945–46, Vols. XLIII–XLIV, page 7 A.
AAR Signal Section Proceedings, 1949, Vol. XLVII, pages 6, 317.
AAR Signal Section Proceedings, 1950, Vol. XLVIII, pages 7, 388.

Page 16–72

FORMULA FOR DETERMINING COMPARATIVE ECONOMIES OF FLAT AND HUMP YARD SWITCHING

1950

Submitted for reapproval without change.

Page 16–77

COMPARATIVE FREIGHT TRAIN PERFORMANCE CHARTS

1932

Submitted for reapproval without change.

Page 16–78

FORMULA FOR SIDING LENGTH FOR FREIGHT TRAINS

1947

Submitted for reapproval without change.

Pages 16–79 to 16–84, incl.

METHOD FOR THE DETERMINATION OF PROPER ALLOWANCE FOR MAINTENANCE OF WAY EXPENSE DUE TO INCREASED USE AND INCREASED INVESTMENT

(This method has become popularly known as the "Yager" formula)

1936

Submitted for reapproval without change.

Page 16–84

ANALYSES TO DETERMINE WHEN A RAILWAY OR BRANCH LINE SHOULD BE RETIRED

Submitted for reapproval without change.

Pages 16–85 to 16–90, incl.

METHODS FOR DETERMINING THE MOST ECONOMICAL TRAIN LENGTH, CONSIDERING ALL FACTORS ENTERING INTO TRANSPORTATION COSTS

1940

Submitted for reapproval without change.

Pages CRTS-1 and CRTS-2

MANUAL CHAPTER ON COMPLETE ROADWAY AND TRACK STRUCTURE

On March 10, 1952 the Board Committee on Outline of Work, with the approval of the Board of Direction, asked Committee 16 to undertake the review of all of the material in the present Manual chapter on Complete Railway and Track Structure, collaborating with Committees 1, 3, 4 and 5, looking to bringing this material up to date, as might be necessary, for inclusion in Chapter 16 in the Manual as to be reprinted in 1953.

Your committee has reviewed the Manual chapter in question, in collaboration with the committees named, and offers the following recommendations:

Page CRTS-1

TRAFFIC CLASSIFICATION OF RAILWAY MAIN TRACKS

1940

Reapprove without change and incorporate in Chapter 16.

Page CRTS-2

SCHEDULE OF CLASSES OF COMPLETE ROADWAY AND TRACK STRUCTURE—1939

This document makes reference to a schedule, presented in detail in the Proceedings, Vol. 41, 1940, pages 640–645—a schedule which, with respect to the items and page numbers given, will become entirely out of date with the reprinting of the revised Manual in 1953. In view of this fact, and the further fact that it is impossible to revise the schedule until after the Manual has been completely reprinted, with its new page numbers, it is recommended that this document be withdrawn from the Manual, looking to its restoration at a later date, when the schedule in question can be brought up to date and submitted to the Association.

Report on Assignment 2

Methods For Increasing the Use of Existing Railway Facilities—Train Communication

D. E. Brunn (chairman, subcommittee), J. J. Corcoran, H. C. Hutson, H. A. Lind, A. E. MacMillan, F. B. Peter, C. P. Richardson, C. P. Richmond, E. H. Roth, P. J. Schmitz, C. W. Sooby, H. D. Walker, J. A. Wood.

Your committee submits this as a final report, for information.

The change in operating conditions due to CTC, longer sidings, and reduction in curves and grades, along with the practice of most railroads of changing from steam to diesel power to expedite the movement of traffic, make it most difficult to measure the time saved by the use of two-way radio or induction phone, since the use of such equipment in most cases is combined with the other improvements to obtain maximum operating efficiency.

It has been reported that on one railroad an estimated time of about 30 min was saved for each long freight train and about 15 min for each local train entering major terminals through the use of radio in the locomotives and cabooses, together with the use of two-way wired communication systems in the yards.

It has also been reported that on another road, through the use of radio telephone, an estimated saving of 4 hr and 20 min on a 49-hr trip covering 1034 miles, is made, and that the productivity of a diesel-electric switching locomotive and crew is increased.

The use of radio or induction phone becomes a very important part in the safe operation of trains as radio enables caboose and locomotive crews to communicate immediately regarding any irregularities noted, such as "hot boxes", shifted loads, etc. The engineer can make a normal speed reduction, or stop action to be taken can be discussed and determined. Without radio the crew in the caboose is usually unable to get a signal to the engineer for various reasons, and to avoid more serious damage the air valve is opened by the crew in the caboose, causing a sudden application of the brakes. This frequently results in broken drawbars, damaged knuckles, damaged equipment or lading, and possible derailment, with track damage and possible personal injury. In the absence of train communication, a crew member must walk the entire length of the train, in fair or foul weather, to discuss and determine the plan of action with the engineer.

With train communication, train crews have also advised their dispatcher of crossing accidents or of crew injuries, and prompt arrangements have expedited the arrival of ambulance, medical or other assistance.

Unusual track and bridge conditions have been reported to dispatchers, enabling prompt action in warning other trains and in correcting the defects.

Flood or storm conditions and rock slides are reported promptly by train crews, providing an expeditious source of important over-all information.

In cases of extraordinary diesel locomotive trouble, connections have been made from trains through a base station to the dispatcher, who called the mechanical department to furnish additional equipment or to advise the necessary material to get out for repairs.

As a matter of information, the following data have been taken from reports of the Communications Section, AAR.

Proceedings—Communications Section—November 1946

On pages 604 and 605 there is an Appendix I, showing main line and yard and terminal installations of radio and/or inductive communication systems. No specific train hour savings are shown. General terms, such as Train Movements Expedited, Improved Switching, etc., are used.

Proceedings—Communications Section—October 1947

Pages 492 to 496, incl. A list here, shown as Appendix I, is the same as appearing in the November 1946 Proceedings, except that it is more extensive. In several cases train hour savings are specifically mentioned, viz:

CB&Q—McCook, Neb.—Denver, Colo.; saves ½ to 4 hr on a 255-mile run.

NYC—Indianapolis, Ind.—Springfield, Ohio; saves 50–70 min on a round trip.

While undoubtedly many of these installations result in train hour savings, the detailed train hour savings have not been worked out.

Proceedings—Communications Section—September 1948

Pages 398, 399 and 400. This is mostly discussion.

Reports—Communications Section—September 1949

Pages 348 and 349. This appears to be the most complete information available for train hour savings and is an analysis of the extensive Pennsylvania Railroad installation of radio phone.

Reports—Communications Section—October 1950

Pages 326 to 328, incl. This is a supplementary report of the Pennsylvania radio phone installation and reflects the train savings.

A communications bibliography prepared by Committee 3—Communication Transmission, as shown on page 31 of the AAR booklet "Applications of Electricity to Railways—1951", refers to the subject of radio very thoroughly. Information as to type of equipment, specifications, allocation of frequency, and operation of stations, should be obtained through the Communications Section.

It is a known fact that the operation of radio equipment will increase the efficiency of railroad operation and expedite the movement of trains to the extent that it will more than justify the cost of the radio equipment.

This is a final report, submitted as information, on the premise that full economic data will be made available through the Communications Section, AAR.

Report on Assignment 3

Methods and Formulas for the Solution of Special Problems Relating to Economics of Railway Operation

R. L. Milner (chairman, subcommittee), H. B. Christianson, Jr., P. J. Claffey, J. J. Corcoran, C. W. Pitts, E. C. Poole, C. P. Richardson, C. P. Richmond, H. M. Shepard, R. F. Spars, J. E. Teal, G. H. Tilson, D. K. Van Ingen, H. P. Weidman, H. L. Woldridge, C. W. Sooby.

This is a final report, submitted as information, on the current assignment—

Train Hour Cost and Cost of Stopping and Starting Trains, Collaborating with AAR Signal Section

This assignment covers two related but distinct subjects. These subjects have been treated as separate assignments by Signal Section Committee I—Economics of Railway Signaling, which has collaborated in the study.

TRAIN HOUR COST

The first part of the report refers specifically to train hour cost, which herein embraces the following accounts:

Wages of train and enginemen	Acct. 392 and 401
Fuel and water for locomotives	" 394 and 397
Lubricants and other supplies for locomotives	" 398 and 399
Enginehouse expenses	" 400
Train supplies and expenses	" 402
Locomotive repairs	" 308

Locomotive depreciation and retirements	Acct. 331 and 330
Interest on locomotive investment	" 756½
Car repairs, depreciation, retirements, interest on car investment	" 314, 330, 331 and 756½
Equipment rental—per diem	" 503 and 536
Maintenance of way and structures	" 201 and 279

There are many units for measuring railroad operating expense or unit cost. The unit is generally a ratio or combination of volume, distance, time or vehicle; or more specifically the ton-mile, car day, miles per hour, gross train mile, dispatchment, and among a large number of others, the train hour. Selection of the appropriate unit for measuring changes in gross, or unit cost that are estimated to be effected by proposed improvements, will depend upon their type.

More than one unit may be required in some cases. It is, therefore, evident that the use of a single measuring unit will require that the effect of the proposed improvements upon the various accounts of operating expense, in terms of that unit, be properly measured at every step.

Reduced Road or Running Time Per Train

Train hour cost, reduced to dollars, is inflexible and covers specific operations and conditions. Its application may in many cases be limited. Improvements or additions may affect in widely different ways one or more of the following: train tonnage, number of trains, distance, speed, train or crew overtime, helper service, standing delays, power or freight car availability or turnaround time, train stops, besides other operating factors or conditions as noted later.

Cost per train hour before and after such improvements may also be an important factor to take into account.

The immediate problem is an economic one, wherein only the improvements affecting train hours or the cost of operating trains may be considered.

Cost per train hour must be either the average cost per hour for all trains, or of a specific train or group of trains. The cost per train hour is found by dividing total cost by total train hours, or:

Cost per train hour = total operating cost ÷ total train hours
Which, restated, is:
Total operating cost = train hours X cost per train hour.

Thus, if train hours are reduced, then the total cost would also decrease proportionately. The savings derived in this manner would, however, be inaccurate to the extent that the cost per train hour may be affected by the proposed improvements. Thus, there is a second variable to be considered. The above formula probably comes most nearly to being correct where train hours are eliminated by reduced road time per train. This might be brought about by increased train speeds gained through such projects as curve and grade reduction, heavier rail, speed restriction elimination, improved power, roller-bearing cars, improved signaling, and so on.

In such cases, it is probable that train-hour costs would most often need to include only the overtime portion of train and enginemen wage expense.

Standing Delays

The above simple formula would hold less true where train hours were reduced through elimination of delays involving much standing time. Standing time implies considerably reduced fuel and water expense in the case of steam power, and almost no fuel expense and water expense in diesel operation.

Train-hour losses through idle or standing time are often reduced through:

Improved coaling and watering facilities
Grade reductions to eliminate pusher service or doubling
Improved signaling
Respacing of sidings
Addition of sidings or second tracking
Respacing of locomotive terminals
Improvements eliminating train stops
Use of locomotives with larger capacity tenders.

Such elimination of train hours of idle or standing time has no effect on train miles; consequently, locomotive repairs would not be affected appreciably as these are influenced primarily by train miles.

Reduction in Trains Operated

If the improvements noted result in the elimination of trains through increased train loads, then the train hour cost will include basic as well as overtime wage expense. Typical of such improvements are: improved power, longer sidings and yard tracks, grade reduction, and roller-bearing equipment. In such cases it will be necessary to measure the effect of such improvements upon all the factors making up train hour cost.

General

Obviously, the effect of any proposed changes in operating facilities must be closely analyzed and measured for accurate results. Application of a general or short-cut method based on tabulated data, using basic or overtime wages, or both, as called for, may, in many cases be satisfactory of itself or as a preliminary estimate, where time is inadequate for a detailed solution; or it may serve as reference, or be used as statistical or background data. In other cases such short-cut methods may lead to erroneous estimates of savings and correspondingly erroneous conclusions and recommendations.

This, of course returns us to the point that each problem that is to be measured by the expression "Train Hour Cost" must be analyzed carefully throughout its progress, if accurate results are to be assured.

It would be quite difficult to develop a practical formula which could be applied to the endless variety of problems indicated. A complex formula, even if developed, might take as long to apply as would the detailed solution of the problem.

It seems more desirable to set up a number of general problems or proposed improvements to be justified by estimated savings, with a statement giving the items of cost to be developed therefor.

Total train hour cost varies with trains and average speed (road time) plus terminal time. Improvements which affect the number of trains, or the average speed, will affect train hour unit or gross cost. A representative number of such improvements are indicated in the statement shown on page 424. This statement is arranged to show the items of expense that must be considered in determining the unit cost per train hour, before and, if necessary, after the proposed improvement. Its development took the following considerations into account.

1. Engine crew wages vary with type of power, class of service, weight on drivers, distance if over 100 miles, and terminal overtime.

Statement Showing Items of Expense to be Included in Determining Train Hour Costs
Before and After
Proposed Expenditures for Improvements

ACCOUNTS AND ACCOUNT NUMBERS

IMPROVEMENTS (Selected)	Wages of Trainmen 401 Over-time	Wages of Trainmen 401 Basic	Wages of Enginemen 392 Over-time	Wages of Enginemen 392 Basic	Fuel 394	Water 397	Lubricants 398	Other Supplies 399	Enginehouse Expense 400	Train Supplies and Expenses 402	Loco. Repairs 314	Loco. Depreciation 331	Loco. Retirements 330	Interest on Loco. Investment 756½	Car Repairs, Depreciation, Retirements, Interest on Car Investm. 314-330-331-756½	Equipment Rental Per Diem 503-536	MofW & S Expense 201 to 279
Affecting Speed or Actual Running Time of Trains:																	
Curve reduction to reduce or eliminate restrictions........................	V	-	V	-	-	-	-	-	-	-	-	-	-	-	-	V	V
Grade reduction, resulting in increased speeds.............................	V	-	V	-	-	-	-	-	-	-	-	-	-	-	-	V	V
Heavier rail..........................	V	-	V	-	-	-	-	-	-	-	-	-	-	-	-	V	V
Any improvement reducing effect of speed restriction..................	V	-	V	-	-	-	-	-	-	-	-	-	-	-	-	V	V
Improved power.........................	V	-	V	-	V	V	V	V	V	V	V	V	V	V	-	V	V
Roller bearing equipment - cars........	V	-	V	-	-	-	-	-	-	-	-	-	-	-	V	V	-
Improved signaling to permit higher running speed......................	V	-	V	-	-	-	-	-	-	-	-	-	-	-	-	V	V
Improved braking and sanding equipment.	V	-	V	-	-	-	-	-	-	-	-	-	-	-	V	V	-
Affecting Standing Delays:																	
Improved fueling and water facilities to reduce standing delays............	V	-	V	-	V	V	-	-	-	-	-	-	-	-	-	V	V
Grade reduction, eliminating pusher service delays......................	V	-	V	-	V	V	-	-	-	-	-	-	-	-	-	V	V
Signaling to eliminate standing delays	V	-	V	-	V	V	-	-	-	-	-	-	-	-	-	V	V
Respacing of passing sidings to reduce standing delays.....................	V	-	V	-	V	V	-	-	-	-	-	-	-	-	-	V	V
Addition of passing sidings or 2nd tracking to reduce delays...........	V	-	V	-	V	V	-	-	-	-	-	-	-	-	-	V	V
Respacing of locomotive terminals......	V	-	V	-	V	V	V	V	V	V	-	-	-	-	-	V	V
Improvements eliminating train stops...	V	-	V	-	V	V	-	-	-	-	-	-	-	-	-	V	V
Affecting Number of Trains by Increasing Tonnage per Train:																	
Improved power.........................	V	V	V	V	V	V	V	V	V	V	V	V	V	V	-	-	-
Longer passing sidings or yard tracks.	V	V	V	V	V	V	V	V	V	V	V	V	V	V	-	-	V
Grade reduction........................	V	V	V	V	V	V	V	V	V	V	V	V	V	V	-	-	V
Roller bearing equipment..............	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	-	-

Check V mark indicates expense to be included.

2. Train crew wages vary with class of service, distance if over 100 miles, and terminal overtime.
3. Fuel expense varies with class of power, speed, delays, train stops, slow orders, locomotive miles (principal and helper), and unit cost.
4. Water expense may vary with fuel in steam power operation, and in lesser degree with fuel in diesel power operation.
5. Lubricants expense will vary more with number of dispatchments than with train hours or train miles.
6. Other supplies expense will vary more with number of dispatchments than with train hours or train miles.
7. Train supplies and expenses will vary more with number of dispatchments than with train hours or train miles.
8. Locomotive repairs expense will vary with locomotive mileage, class of power, and type of service.
9. Locomotive depreciation expense will vary with the locomotives involved and the rate.
10. Locomotive retirements may be accurately determined in most cases.
11. Interest on locomotive investment is affected by the locomotive investment involved and the interest rate.
12. Car expenses, including repairs, depreciation, retirements, and interest on investment, will vary with mileage, type, service, depreciation and interest rates.
13. Equipment rental—per diem: If changes in operation involve per diem, the cars involved must be estimated as accurately as possible. The current per diem rate may then be applied.
14. Maintenance of way expenses, (selected) from Accounts 201 through 279, that are involved must be determined on an equated track mile or other suitable basis, depending on the factors involved. If proposed changes involve a change in use, the principles of the Yager formula must be considered.

The selected improvements noted in the statement are basic and indicative of many others which daily confront the railroad engineer. The measure of their value, as indicated by the operating expense accounts noted, is economic, tangible, and can be computed or estimated.

However, the improvements as they affect operation, or as they may speed up service, may result in benefits from a competitive, good-will, or service standpoint, which are more or less intangible and difficult to measure from an economic viewpoint. These are important factors and appropriate consideration must be given them to obtain the final result.

Reference to results of earlier studies relative to train hour cost may be found in:

AREA Proceedings, Vol. 30, 1929, pages 826–892
AAR Signal Section Proceedings, 1949, Vol. XLVII, pages 44 to 52, and 320

COST OF STOPPING AND STARTING TRAINS

The Signal Section, collaborating in the study of the Cost of Stopping and Starting Trains, concluded in 1951 a study dating back more than 15 years. This study covers steam train (coal and oil) and diesel operation and involves the gathering of much basic data on grades, drawbar pull, etc, as well as the making of thousands of calculations to determine the amount of fuel consumed in stopping from and accelerating to various speeds. In going over the Signal Section data, your committee found no fault with the method of procedure or with the end results.

Your committee sees no necessity for duplicating the extensive studies and calculations already made by the collaborating Signal Section committee. It concurs in the report which may be found in:

AAR Signal Section Proceedings, 1950, Vol. XLVIII, pages 7 and 388.

Previous studies may be found in the following references:

AREA Proceedings, Vol. 28, 1927, pages 473, 1318.
AREA Proceedings, Vol. 37, 1936, pages 541, 974.
AAR Signal Section Proceedings, 1936, Vol. XXXIV, page 6.
AAR Signal Section Proceedings, 1937, Vol. XXXV, page 6.
AAR Signal Section Proceedings, 1938, Vol. XXXVI, page 6.
AAR Signal Section Proceedings, 1939, Vol. XXXVII, page 6.
AAR Signal Section Proceedings, 1941–42, Vols. XXXIX–XL, page 6.
AAR Signal Section Proceedings, 1943–44, Vols. XLI–XLII, page 7 A.
AAR Signal Section Proceedings, 1945–46, Vols. XLIII–XLIV, page 7 A.
AAR Signal Section Proceedings, 1949, Vol. XLVII, pages 6, 317.

Report of Committee 13—Water, Oil and Sanitation Services

G. E. Martin, *Chairman,*
W. F. Arksey
G. A. Ausband
R. A. Bardwell
R. C. Bardwell
M. R. Bost
I. C. Brown
R. W. Chorley
George Clark
R. E. Coughlan
B. W. DeGeer
C. E. Fisher
A. K. Frost
R. S Glynn
H. E. Graham
F. E. Gunning
S. H. Hailey
M. A. Hanson
T. L. Hendrix, Jr.
T. W. Hislop, Jr.
H. M. Hoffmeister
A. W. Johnson
C. O. Johnson
J. J. Laudig
W. A. McGee
G. F. Metzdorf
L. R. Morgan
Theodore Morris
J. Y. Neal
A. B. Pierce
J. P. Rodger
E. R. Schlaf
H. M. Schudlich
W. H. Shoemaker
H. L. McMullin, *Vice-Chairman,*
J. M. Short
H. M. Smith
R. M. Stimmel
D. C. Teal
T. A. Tennyson, Jr.
J. E. Tiedt
A. G. Tompkins
J. H. Upham
J. W. Ussher
H. W. Van Hovenberg
R. E. Wachter
C. L. Waterbury
J. E. Wiggins, Jr.
E. L. E. Zahm

Committee

To the American Railway Engineering Association:

Your committee reports on the following subjects:

10. Prevention of corrosion of automatic car washing equipment and facilities.
    Final report, offered as information .... page 460

11. Means of conserving labor and materials, including the adaptation of substitute noncritical materials, and specifications for the reclamation of released materials, tools and equipment, collaborating with Committee 3A, General Reclamation, Purchases and Stores Division, AAR.
    Progress report, offered as information .... page 462

THE COMMITTEE ON WATER, OIL AND SANITATION SERVICES,
G. E. MARTIN, *Chairman.*

AREA Bulletin 504, November 1952.

Report on Assignment 1

Revision of Manual

H. L. McMullin (chairman, subcommittee), R. A. Bardwell, R. C. Bardwell, M. R. Bost, George Clark, B. W. DeGeer, H. E. Graham, T. W. Hislop, Jr., G. F. Metzdorf, J. Y. Neal, A. B. Pierce, W. H. Shoemaker, D. C. Teal, T. A. Tennyson, Jr., H. W. Van Hovenberg, R. E. Wachter, J. E. Wiggins, Jr.

Your committee has reviewed its entire chapter in the Manual and offers the following recommendations with respect thereto:

Page 13–1 to 13–16.1, incl.

GENERAL PRINCIPLES OF WATER SUPPLY SERVICE

Reapprove with the following changes:

B. QUALITY

Add the following sentence to this paragraph, page 13–1:

For cooling diesel locomotive engines, water should be of low hardness and very low chloride content and turbidity.

Pages 13–1 and 13–2

C. SOURCE

Substitute the following for the second, third, fourth, fifth, sixth and seventh paragraphs:

In localities where the supply from stream or well is insufficient and the quality is such that treatment is not feasible, impounding reservoirs may be used provided there is sufficient precipitation to produce the required runoff. Storage of this kind may be provided by constructing dams in streams or valleys where water shed conditions are favorable. Where reservoirs of considerable size are contemplated, a thorough engineering survey of the location should be made. This study should include test hole borings, rainfall and runoff data, as well as a topographical survey of the water shed. The dam should be made of the most suitable materials considering local conditions and should be provided with carefully designed spillways. The survey should also indicate that public and private property rights can be secured, and that the costs are not excessive for the benefits derived from this source of supply. Before constructing an impounding reservoir, very careful consideration should be given to the following particulars—rainfall records, stream gaging records, average temperature and wind velocity, humidity, character of the proposed site (including size, shape and nature of material, which may affect the seepage), extent of drainage area, kind of soil and nature of vegetation on the drainage area which affect the runoff.

In an unproved area, well construction should be preceded by test borings to reveal the strata to be penetrated. The character of the strata largely determines the size of the well and the kind of construction necessary.

Flowing wells, where obtainable, are a satisfactory source; however, their yield is liable to constant decrease and final cessation.

Deep wells that require pumping usually cost more for maintenance and operation than other sources, but their disadvantages are usually offset by the constant quality and security from pollution of the water yielded.

Page 13–2

D. Storage of Water at Water Stations

First paragraph, line 3, omit the word "better."

Second paragraph, line 4, change the word "same" to "it."

Page 13–3

PUMPING PLANTS

Change the sentence beginning with "The automatic starter . . ." line 2, page 13–4, to read as follows:

The automatic starter is easily and conveniently controlled from any remote point by means of hand control stations, float or pressure switches or electrode-type liquid level relays.

Eliminate second paragraph, page 13–4, line 5–9.

Page 13–6

H. Centrifugal Pumps

(b) Disadvantages (page 13–7)

Change the word "must" in first line to "should."

Reword the last sentence, first paragraph, page 13–8, to read as follows:

A check or foot valve is normally required on a suction line.

Page 13–8

J. Pipe Lines

2. Suction Lines

Reword second paragraph, page 13–9, as follows:

In centrifugal pump installations with a suction lift it is necessary to install either a foot valve, a check valve, or a vacuum priming device on the suction line, but with reciprocating pumps, these devices are not usually necessary unless the suction lift is excessive. Where check or foot valves are installed, arrangements should be made for removing any foreign matter which might accumulate in them.

Page 13–9

5. Service Lines

Reword first paragraph, page 13–10, as follows:

(b) Cast iron pipe is used extensively for water mains and is now available in the smaller sizes and its use should be considered for permanent service lines.

Page 13–16

M. Water Meters—Methods for Testing, Reading and Checking Consumption

1. Reading Meters

First paragraph, line 1, change the expression "revolving discs" to "wheels."

Page 13–16.1

SPECIFICATIONS FOR CAST IRON PIPE AND SPECIAL CASTINGS

Reapprove with the following change:

Reword to read as follows:

Cast iron pit-cast pipe shall conform to American Standards Association Specifications A–21.2, last revised (AWWA C 101, last revised) published by the American Water Works Association.

SPECIFICATIONS FOR HYDRANTS AND VALVES

Reapprove with the following change:

Reword to read as follows:

Valves shall conform to American Water Works Association Specifications AWWA C 500, last revised.

Hydrants shall conform to American Water Works Association Specifications AWWA C 502, last revised.

Page 13–17

SPECIFICATIONS FOR LAYING CAST IRON PIPE

Reapprove with the following change:

1. Material

Change specification designation from "A 21.2–1939" to "A 21.2 last revised for (AWWA C 101 last revised)."

Page 13–21

SPECIFICATIONS FOR WOOD WATER TANKS

Reapprove without change.

Pages 13–23 through 13–26

SPECIFICATIONS FOR TANK HOOPS

Reapprove with the following changes:

4. Threads

Change the words "United States Standard" to "National Standard Coarse."

Page 13–27

SPECIFICATIONS FOR STEEL SUBSTRUCTURES FOR WOOD WATER TANKS

Reapprove without change.

Pages 13–29 through 13–35

SPECIFICATIONS FOR TIMBER SUBSTRUCTURES FOR WOOD WATER TANKS

Reapprove without change.

Page 13–37 and 13–38

SPECIFICATIONS FOR RIVETED STEEL WATER AND OIL TANKS

Eliminate these specifications.

Pages 13–38.1 through 13–38.5

SPECIFICATIONS FOR WELDED STEEL TANKS FOR RAILWAY WATER SERVICE

Reapprove with the following changes.

Change title to read:

SPECIFICATIONS FOR WELDED STEEL WATER AND OIL TANKS

Under "101. Scope of Specifications" change "welded steel water storage tanks" to "welded steel water or oil storage tanks."

Insert "103. Drawings" after the second paragraph under "102. Weather."

Eliminate "or a 113 Grade C" line 4, page 13–38.2.

Page 13–38.2

202. Filler Metal

Change to read as follows:

Electrodes shall conform to the AWA–ASTM Specification for Mild Steel Arc-Welding, ASTM Designation A–233, last revised, using any E–60 Classification suitable for the electric current and other conditions of intended use.

302. Design Loads

Change to read as follows:

Dead load shall be the estimated weight of all permanent construction and fittings, using 490 lb and 150 lb per cu ft for steel and concrete, respectively.

Live load shall be the weight of the contents of the tank filled to overflowing with water assumed to weigh 62.5 lb per cu ft.

Wind load or wind pressure, acting in any direction, shall be assumed to be 20 lb per sq ft of vertical projection.

Snow load shall be assumed to be 25 lb per sq ft of the horizontal projection of the tank roof.

The balcony, if any, and the roof, shall be designed to withstand a vertical load of 1000 lb and 500 lb, respectively, applied at any point. Each section of ladder shall be designed to withstand a load of 350 lb.

304. Plate Thickness

Change to read as follows:

Roof	3/16 in min
Shell or downtake tube	¼ in min
Flat bottom	⅜ in min
Suspended bottom	¼ in min
Tubular columns and struts	¼ in min
Lap joints	½ in max
Butt joints	1½ in max

Page 13–38.3

306. Cylindrical Rings

Change to read as follows:

Plates shall be rolled to proper radius in accordance with the following table:

Plate Thickness (Inches)	*Minimum Diameter for Which Plates Need Not Be Rolled (Feet)*
Less than ⅜	40
⅜ to less than ½	60
½ to less than ⅝	120
⅝ and heavier	Must be rolled for all diameters.

Page 13–38.4

501. Testing

Change to read as follows:

Flat bottom tanks shall have the bottom and first side courses tested for leaks by applying air pressure or vacuum to the joints previously coated with soap suds, linseed oil, or by applying other suitable material for the detection of leaks. Upon completion, the entire tank shall be tested by filling with water. All leaks shall be repaired by cutting out weld and rewelding. The tank shall be empty or the water level shall be at least 2 ft below the point being repaired.

Page 13–39

USE OF TREATED WOOD FOR WATER TANKS

Reapprove without change.

Pages 13–39 through 13–41

WATER TREATMENT

Reapprove with following changes and modifications:

Eliminate second and third paragraphs, page 13–40.

Pages 13–43 and 13–44

SPECIFICATIONS FOR SODA ASH TO BE USED IN WATER TREATMENT

Reapprove without change.

Pages 13–45 and 13–46

SPECIFICATIONS FOR HYDRATED LIME TO BE USED IN WATER TREATMENT

Reapprove without change.

Pages 13–47 and 13–48

SPECIFICATIONS FOR QUICKLIME TO BE USED IN WATER TREATMENT

Reapprove without change.

Pages 13–49 and 13–50

SPECIFICATIONS FOR SULPHATE OF ALUMINA TO BE USED IN WATER TREATMENT

Reapprove with following changes:

Change the term "sulphate of alumina" which appears in the title and twelve places in the text to "aluminum sulfate."

Pages 13–51 and 13–52

SPECIFICATIONS FOR SULPHATE OF IRON TO BE USED IN WATER TREATMENT

Reapprove with the following changes:

Change the term "Sulphate of Iron" in the title, to "Ferrous Sulfate."

Change definition, under Article "101. Definition," to read as follows:

101. Definition

The material covered by this specification is ferrous sulfate, the formula of which is $FeSO_4 . 7H_2O$.

Change Article "102. Class" to read as follows:

102. Class

Unless otherwise specified, granular ferrous sulfate will be furnished.

Change Article "202. Chemical Properties" to read as follows:

202. Chemical Properties

The chemical properties of the material shall be determined by standard methods of analysis, and the shipments shall conform to the following minimum requirements:

(a) Ferrous sulfate, anhydrous .... 53 percent minimum
(b) Free sulfuric acid ....0.04 percent maximum
(c) Insoluble impurities .... 2 percent maximum

Change the term "sulphate of iron" to "ferrous sulfate" in Articles 301, 302, 401, 402 and 403.

Page 13–53

ZEOLITE METHOD OF WATER TREATMENT

Reapprove after changing the title to read ZEOLITE METHOD.

Pages 13–55 and 13–56

SPECIFICATIONS FOR SALT TO BE USED IN REGENERATION OF ZEOLITE WATER SOFTENING PLANTS

Reapprove with following changes:

Change Article "202. Chemical Properties" line 5 to read as follows:

Sodium chloride—98.0 percent minimum for evaporated salt, 96.0 percent minimum for rock salt, and shall be free of grease, fats or oil.

Page 13–56

Change "60 mesh screen", lines 3 and 4, Article 302 to "70 mesh screen."

Pages 13–59 through 13–64

STANDARD METHODS OF WATER ANALYSIS AND INTERPRETATION OF RESULTS

Reapprove with following changes:

Change title to: WATER ANALYSIS AND INTERPRETATION OF RESULTS

In line 37, page 13–61, change "($Na_2\ P_4O_7 . 10H_2O$)" to "($Na_2\ B_4O_7 . 10H_2O$)."

Pages 13–57 through 13–58.1

STANDARD METHODS FOR ANALYSIS OF CHEMICALS USED IN WATER TREATMENT

Reapprove with following changes:

Change title to: ANALYSIS OF CHEMICALS USED IN WATER TREATMENT

Change "III ANALYSIS OF SULPHATE OR IRON" to "ANALYSIS OF FERROUS SULFATE."

For "(b) Procedure" under III ANALYSIS OF SULPHATE OF IRON, substitute the following:

(b) *Procedure*

Place 12.25 grams of the sample in a glass stoppered flask. Add 100 ml of the 95-percent ethyl alcohol. Shake with rotary motion for about 10 min. Decant at once into a clean dry beaker and filter the decanted liquid through a Gooch crucible prepared with well washed asbestos. Wash the solid ferrous sulfate in the flask three times with 25 ml of the alcohol. Decant into beaker each time and filter. The filtrate must be clear. Titrate with the 0.01 N sodium hydroxide using phenolphthalein for indicator.

The number of milliliters of 0.01 N sodium hydroxide required times 0.004 gives the percent of free acid.

Change "IV SULPHATE OF ALUMINA" page 13–58 to "ANALYSIS OF ALUMINUM SULFATE."

In line 33, page 13–58, change "sulfate of alumina" to "aluminum sulfate."

Page 13–65

MINIMUM QUANTITY OF SCALING AND CORROSIVE MATTER WHICH WILL JUSTIFY COMPLETE EXTERNAL TREATMENT

Reapprove with the following change:

Change "(Note—Values for "B" . . .)" to read as follows:

(Note—Values for "B" as determined by various investigators, see Vol. 15, 1914, p. 691; Vol. 26, 1925, p. 380; Vol. 27, 1926, p. 197; Vol. 40, 1939, p. 224, and Master Boiler Makers Association Proc. 1946, p. 192, vary from 7 cents per pound for scaling solids removed in 1914, 13 cents in 1925, 21.6 cents in 1938 and 22.75 cents in 1946. The figure of 22.75 cents per pound of scale forming solids removed or rendered nonincrusting, has been accepted as conservative by Committee 13, AREA.)

Page 13–66

QUALITY OF WATER—METHOD OF TREATMENT

Reapprove after changing the title to read SELECTION OF METHODS FOR TREATMENT OF WATER.

Page 13–66

FOAMING AND PRIMING

Reapprove with the following change:

For the third paragraph under this title substitute the following:

The concentration of foaming salts reaches a critical point, depending upon the type and work of the locomotive boiler, the amount and character of the alkali salts, and the amount and type of suspended matter in the water. To prevent foaming the concentration must be kept below this point or properly controlled by the use of a suitable antifoam agent. The best results are obtained by the systematic and frequent blowing off of boilers.

Page 13–67

WASHOUTS, WATER CHANGES AND BLOWDOWN OF LOCOMOTIVE BOILERS AS INFLUENCED BY WATER CONDITIONS

Reapprove with following changes:

Change Par. 1 under this title to read as follows:

1. A schedule for washouts must be governed by local conditions and particularly by the quality of the feedwater. This makes it impractical to outline a program for general application. In districts where all the water is fully treated, 30 days between washouts is usually the practice with water changes between as found desirable.

Change Par. 3 and 4 under this title to read as follows:

3. Water changes are merely exaggerated blowdowns, and necessity for them will depend on the blowing schedule while enroute over the district and on the water quality.

4. Here, as elsewhere, the human factor is of first importance. The man at the throttle can make the best of water carry-over with the steam by careless handling. If he has been well trained, he will carry a reasonable amount of water in the glass, sense the proper time and amount to be blown, and turn the locomotive over to his successor in practically as good condition with respect to water as when it left the enginehouse.

Pages 13–67 and 13–68

WATER FOR DRINKING PURPOSES

Substitute the following for the existing text:

1. Interstate Quarantine Regulations, revised and dated July 23, 1951, issued by Federal Security Agency, provide that the Surgeon General, Public Health Service, shall approve the use of water furnished by railways on cars in interstate traffic if, (1) the water supply at the watering point meets prescribed standards of sanitary quality, and (2) if the methods of, and facilities for delivery of such water to the conveyance and the sanitary conditions surrounding such delivery prevent the introduction, transmission, or spread of communicable diseases. The Surgeon General may base his approval or disapproval of a watering point upon investigations made by representatives of state departments of health or of the health authorities of contiguous foreign nations. Further, if a watering point has not been approved, the Surgeon General may permit its temporary use under such conditions as, in his judgment, are necessary to prevent the introduction, transmission, or spread of communicable diseases.

2. It is preferable that drinking water furnished by railways should be secured from municipal supplies, since they, as a rule, are of prescribed sanitary quality, and subject to supervision from local and state health authorities.

3. When impossible or impractical to secure potable water from municipal sources, precaution should be taken to provide against possible contaminated wells or surface supplies by the use of accepted water treatment facilities and frequent inspection with bacteriological testing.

Pages 13–74 and 13–75

SEWAGE DISPOSAL WHERE SANITARY FACILITIES ARE NOT AVAILABLE

Delete this material from the Manual.

Pages 13–75 to 13–77, incl.

DISINFECTANTS, DEODORANTS, FUMIGANTS AND CLEANING MATERIALS

Delete this material from the Manual.

Pages 13–68 through 13–73

WATER SERVICE RECORDS

Reapprove with the following change:

Change Form 1304, pages 13–73, to the new form shown on page 437.

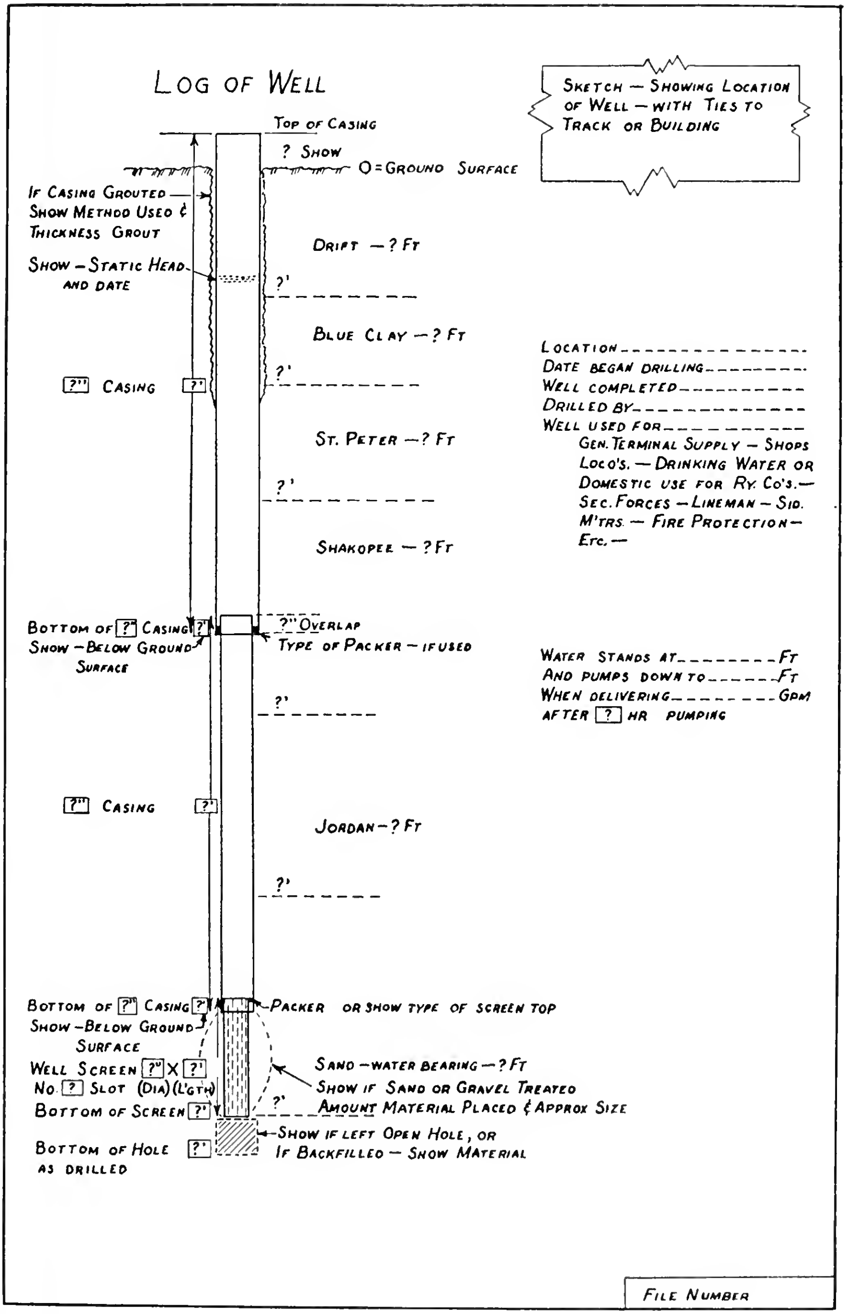
Pages 13–77 and 13–78

WATER SERVICE ORGANIZATION

Reapprove without change.

NEW MATERIAL OFFERED FOR ADOPTION

Your committee also offers the following new material for inclusion in the Manual:



Log of Well
Sketch — Showing Location of Well — with Ties to Track or Building
Top of Casing
? Show
O = Ground Surface
If Casing Grouted — Show Method Used & Thickness Grout
Show — Static Head and Date
Drift — ? Ft
?'
Blue Clay — ? Ft
?'
[?"] Casing [?']
St. Peter — ? Ft
?'
Shakopee — ? Ft
Location
Date began drilling
Well completed
Drilled by
Well used for
Gen. Terminal Supply — Shops Loco's. — Drinking Water or Domestic use for Ry. Co's. — Sec. Forces — Lineman — Sig. M'trs. — Fire Protection — Etc. —
Bottom of [?"] Casing [?'] Show — Below Ground Surface
?" Overlap
Type of Packer — if used
Water stands at ________ Ft
And pumps down to ______ Ft
When delivering ________ Gpm
after [?] hr pumping
?'
[?"] Casing [?']
Jordan — ? Ft
?'
Bottom of [?"] Casing [?'] Show — Below Ground Surface
Packer or show type of screen top
Well Screen [?"] X [?']
No. [?] Slot (Dia) (L'gth)
Sand — water bearing — ? Ft
Show if Sand or Gravel Treated
?'
Bottom of Screen [?']
Amount Material Placed & Approx Size
Show if left Open Hole, or If Backfilled — Show Material
Bottom of Hole [?'] as drilled
File Number

RECOMMENDED MEANS OF CONTROL OF INTERCRYSTALLINE CORROSION

1. Make a complete investigation of boiler feed waters, with special reference to alkaline content and the presence of natural inhibitors.

2. Install embrittlement detectors on boilers operating in suspected water districts.

3. Use properly supervised and controlled chemicals, such as sodium nitrate or lignin, in waters known to have embrittling tendencies.

Report on Assignment 3

Federal and State Regulations Pertaining to Railway Sanitation,

Collaborating with Joint Committee on Railway Sanitation, AAR

H. W. Van Hovenberg (chairman, subcommittee), R. C. Bardwell, B. W. DeGeer, R. S. Glynn, H. E. Graham, S. H. Hailey, A. W. Johnson, G. F. Metzdorf, A. B. Pierce, J. M. Short, D. C. Teal, R. E. Wachter.

This is a report of progress, presented as information.

Your committee summarizes for this year the activities of the Joint Committee on Railway Sanitation, AAR, composed of representatives of the Engineering and Mechanical Divisions; the Medical and Surgical Section, Operating-Transportation Divisions; the U. S. Public Health Service; and the Department of National Health and Welfare of Canada.

The office of Sanitation Research and Development, AAR, the organization which succeeded the Sanitation Research Project, has been revitalized with the employment of R. S. Glynn, formerly assistant engineer of tests, AT&SF, as director, and the new organization is now functioning under the Coordinating Committee on Physical Research, AAR, in order that the several divisional programs may be coordinated from the standpoint of the railroad industry as a whole.

A Special subcommittee, acting for the Joint Committee, has supervised the activities of the office of Sanitation Research and Development and has made recommendations for its maintenance and budget for 1953, and has discussed at length the furtherance of studies on problems with regard to potable waters, sewage disposal, practices in the use of water filling hose, anti-freeze hydrants, processes in washing and cleaning cars, work-train facilities, the handling of food and wastes, etc.

The Joint Committee continues to be a point of contact with the Public Health Service on matters of general sanitation affecting railroads. Your representatives on the Joint Committee are R. C. Bardwell, A. B. Pierce, and H. W. Van Hovenberg.

Report on Assignment 5

New Developments in Water Conditioning for Diesel Locomotive Cooling Systems

M. A. Hanson (chairman, subcommittee), I. C. Brown, B. W. DeGeer, T. W. Hislop, Jr., H. M. Hoffmeister, C. O. Johnson, H. L. McMullin, H. M. Schudlich, R. M. Stimmel, A. G. Tompkins, J. E. Wiggins, Jr., E. L. E. Zahm.

This is a progress report, submitted as information.

Work has been continued in attempting to find an alternate corrosion inhibitor for diesel cooling systems to supplant the commonly used alkaline chromates.

The performance of alkaline chromates is satisfactory, but some users object to the possibility of skin inflammation to persons either handling the compounds or handling engine parts which have been in contact with the treated cooling water.

Some common-sense precautions can minimize this hazard. The use of rubber gloves when handling the compound and the use of protective creams for the personnel regularly handling engine parts is helpful. Reduction of the probability of accidental contact by flushing spilled compound should be practiced. The need for ordinary sanitary practices, such as thorough hand washing after contact with chromates is obvious. A number of railroads, where such precautions have been followed, have had no difficulty with skin inflammations due to the use of chromates for cooling water inhibitors. It would appear, therefore, that this is a relatively mild hazard and that it can be successfully controlled if precautionary measures are followed.[1, 2]

Another reason for attempting to find alternate inhibitors is the possibility of a chromate scarcity in case of a national emergency.

For the past year a test has been conducted in E.M.D. F–3 locomotives using a proprietary compound containing approximately 3 percent sodium nitrite, 10 percent trisodium phosphate, and the remainder sodium tetraborate. This test was started in June 1951 using the compound at the rate of ¾ oz/gal. Treatment was controlled by weekly conductivity tests and the manual addition of chemical as required.

The water supplies used were chiefly city waters, Zeolite softened, and of average good quality. Typical analyses are:

Grains per U. S. Gallon

H	*M*	*P*	*NaCl*	*TDS*	*pH*
0.0	4.5	Trace	1.8	10.0	8.3
0.0	2.1	0.4	1.6	8.0	8.8

One of the units had new heads and liners applied Aug. 1, 1951, and was inspected in Jan. 1952, after 63,000 miles of service. Severe rusting of cylinder heads, liners and water ports had occurred. Some pin-point pitting was present under the rust coat.

The second unit was inspected after 65,000 miles of service and had somewhat less rust present, but otherwise was in substantially the same condition.

The third unit has not yet been inspected.

In both units inspected the corrosion prevention was considered definitely inferior compared to other units using alkaline chromate compounds.

During a portion of these tests the units were losing considerable water, making it necessary to add additional chemicals quite frequently. This may have been partially

[1] Dr. Louis Schwartz, M. D. Conference Meeting on Occupational Dermatitis and Skin Irritations Among Railroad Shop Workers. Oct. 10, 1951.

[2] Schwartz, Tulipan and Peck—Occupational Diseases of the Skin. 1947.

responsible for the conditions found since it is believed the concentration with this type of treatment is considerably more critical than that of the alkaline chromate compounds. Laboratory tests have confirmed this observation. From a practical standpoint this is quite undesirable since it is difficult to maintain full concentration at all times.

Some other models of locomotives may be more difficult to inhibit against corrosion than those tested. At the present time no further tests of this compound are contemplated.

From the data obtained from these tests it appears that this compound provides some degree of protection but not to the same extent as the alkaline chromates.

A rather thorough search of the literature available does not provide much cause for optimism that an alternate inhibitor will be soon found which will inhibit cooling system corrosion as completely as the alkaline chromates.

Report on Assignment 6

Railway Waste Disposal

T. A. Tennyson, Jr. (chairman, subcommittee), W. F. Arksey, M. R. Bost, A. K. Frost, F. E. Gunning, R. S. Glynn, T. L. Hendrix, Jr., J. J. Laudig, W. A. McGee, L. R. Morgan, Theodore Morris, J. Y. Neal, A. B. Pierce, E. R. Schlaf, W. H. Shoemaker, H. M. Smith, J. E. Tiedt, J. W. Ussher, J. E. Wiggins, Jr.

By means of a questionnaire your committee has made a study of the problems of disposal of water which contains sodium chromate drained from diesel engine cooling systems, and the disposal of liquid wastes from passenger car washing operations. Replies indicate that, at present, the picture is as follows.

(1) In the disposal of liquid wastes from diesel engine cooling systems and car washers the elimination or reduction of the oil content of these wastes before disposal is the major problem. Where it is possible to dispose of such wastes through regular shop or terminal waste disposal system the oil traps installed to remove the oil from other waste waters are adequate to take care of these too. In some cases railroads have found it practicable to collect and re-use the water drained from the diesel cooling systems, and in such cases if oil is a problem the use of filtration is indicated.

(2) There have been no complaints against the chemical constituents of these two waste waters where there is adequate dilution, which dilution is now regulated by law in some states.

Continued observation of the development of state pollution control laws and regulations shows that these are progressing along the lines predicted in previous reports.

This is a progress report presented as information.

Report on Assignment 7

Water Facilities for Diesel Locomotives

G. F. Metzdorf (chairman, subcommittee), W. F. Arksey, G. A. Ausband, R. A. Bardwell, I. C. Brown, George Clark, C. E. Fisher, E. R. Schlaf, W. H. Shoemaker, J. M. Short, D. C. Teal, A. G. Tompkins, J. W. Ussher, R. E. Wachter, C. L. Waterbury, E. L. E. Zahm.

Your committee submits the following final report as information.

This report covers water station arrangements and requirements for servicing the diesel locomotive cooling system, steam generators, water closets and lavatories.

Chemically treated water should be used for both the steam generator feed water supply and for the cooling water system, each requiring a different chemical treatment. Untreated water is used for the toilet facilities.

Cooling Water

The cooling water servicing is usually done at engine terminals. When deemed necessary, the diesel engine cooling system is flushed out and refilled with cooling water. Water at temperatures from 110 to 150 deg F is recommended for flushing and refilling the cooling system of warm engines. Between flushing periods water is added to the cooling system as required.

The chemical treatment at most terminals is added to the cooling water manually while refilling the system. Some terminals are provided with a treated cooling water storage supply system, which is most desirable.

The amount of water required to refill a diesel engine cooling system varies from about 40 to 300 gal for yard switchers; 175 to 250 gal for road switchers; 215 to 280 gal for freight locomotives; and 380 to 650 gal for a passenger locomotive.

On runs where it is necessary to add water to the cooling system between engine terminal stops, the cooling system is generally filled with clear, good quality water, and in emergencies, water from the steam generator water supply may be used.

Steam Generator Water

Steam generator water service stations for passenger locomotives are usually required on long runs between engine terminal stops as well as at the engine terminals, except where adequate water storage is provided on the locomotive for the entire run between engine terminal stops.

Steam generator water may be taken from a treated water supply system. Some locomotives are equipped with water treating facilities, in which case, only the regular city water or raw water supply is required.

The steam generator feed water supply storage on a passenger diesel locomotive unit varies from about 1000 to 2800 gal. The average consumption of boiler feed water for heating one passenger car is about 45 gal per hr with outside temperature at 0 deg F. Where steam is used to operate air conditioning and cooling equipment, the demand for water in extreme hot weather may be about 40 gal per car, per hour.

Service Outlets

The number and spacing of water service outlets in a diesel shop and for engine terminal yard or wayside water service stations is governed by the length and number of diesel units to be serviced.

An ideal service outlet spacing arrangement would be to have a water service outlet located opposite the water inlet of each unit of the diesel locomotive at one spotting of the locomotive, to permit servicing each water inlet through a short length of service hose. This arrangement is particularly desirable at wayside or terminal yard water stations where quick service is of prime importance.

The spacing of individual diesel unit service outlets for multiple-unit diesel locomotive water stations varies from about 45 ft to about 75 ft. Where different types of diesel locomotives are serviced at a water station, it may be necessary to provide additional outlets or a longer service hose.

The size of outlet used for cooling water service is generally 1 in or 1¼ in. The rate of flow required for flushing operation is about 50 gpm, and about 25 gpm for adding water to the radiator.

Generator water service outlets vary in size from 2 in to 4 in, dependent upon the size of the service inlet on the diesel unit. The rate of flow of water required for replenishing boiler water reservoir at terminal yard and wayside stations, where the watering time is limited, varies from about 150 to 400 gpm, dependent on the time allotment.

A standard gate or globe valve provided with a hose connection is used for the service outlet inside of heated service shops. Outside stations are generally provided with frostproof water columns or flush-type water boxes. In a severe cold climate it may be necessary to provide heat in the water column pit to prevent freezing. The water column should terminate with a turned-down outlet. The water columns generally used vary in height from about 9 to 12 ft above the top of rail, depending upon the position of the water column with respect to the water inlet on the locomotive.

When sufficient side clearance is available at yard terminal and wayside stations, the water column is most generally used. The water column is more adaptable and convenient for this service and also permits the service hose to remain connected to, and suspended from, the outlet.

A flexible-type hose is used for the service line between the station outlet and the watering inlet on the diesel locomotive. The hose and the service outlet is generally provided with a quick-coupling connection, except when hose is to remain connected to the hydrant. For steam generator service, quick couplings are also generally provided at the diesel inlet connections.

Where practical to leave the hose connected to the water column, the drop-end of the hose should be stayed when not in use, and when the hose is longer than the height of the water column, provision should be made for coiling or draping the service hose at or on the standpipe. Where necessary to store the service hose after each use, a concrete trough with a hinged cover and drain located adjacent to the water service outlet provides a suitable storage space.

Report on Assignment 8

Specifications for Design and Installation of Diesel Fuel Oil Facilities,

Collaborating with Committees 6 and 14

H. M. Schudlich (chairman, subcommittee), W. F. Arksey, R. A. Bardwell, M. R. Bost, I. C. Brown, George Clark, A. K. Frost, F. E. Gunning, S. H. Hailey, M. A. Hanson, A. W. Johnson, C. O. Johnson, J. J. Laudig, W. A. McGee, G. F. Metzdorf, L. R. Morgan, D. C. Teal, J. H. Upham, R. E. Wachter, J. E. Wiggins, Jr.

This is a final report, submitted as information.

The fundamentals covering diesel fueling facilities are covered in the Proceedings, Vol. 53, 1952, page 266. In this report it was suggested that changing conditions would alter slightly the fuel oil specifications in that higher pour point, lower gravity and greater wax content oil could be anticipated. Fuels with these characteristics require special facilities to avoid winter operational difficulties, and in northern section of the country even present fuels require heating. The heating of fuel storage tanks, as well as painting and fire protection, as mentioned in the conclusion of the above reference, will be covered in this report.

Heating

Much has been written covering the merits of tank sizes, design and foundations. This committee will assume that heating facilities will be adapted to existing installations, if necessary, but will also make recommendations with respect to desirable adjuncts to new construction.

In very early fueling designs the heating of the oil was very often glossed over, but experience now dictates that the deposited wax causes operational difficulties with meters and filters, and excessive friction head on the fueling pump. It has contributed to locomotive failure.

Buried fuel tanks placed below the frost line will hold heated oil without too much loss in temperature due to the congealing of the oil and the waxing out at the tank surface. This serves as an insulating layer, protecting the warmer oil.

Fuel tanks above the ground must be insulated to conserve the heat to avoid excessive steam or power consumption, depending on the type of heat being used. Such insulation should be a fiber glass blanket, foam glass block, sheet cork, rock cork, magnesia block, hydrous calcium silicate, felted asbestos, or other approved material held in place with metal straps, bands or wires.

The entire unit should be encased in a metallic jacket or given a thorough water proofing with a bituminous compound so as to avoid moisture absorption and consequent loss of insulating value. The use of a black protective coating aids further in conserving heat due to its property of absorbing radiant heat from direct sunlight.

The equipment for the heating of fuel oil tanks should be simple and inexpensive to install, preferably automatic, economical in operation, and for safety and efficiency should be thermostatically controlled. Steam, electricity and hot water all suggest themselves as being ideal and are all suitable. The choice should be governed by local conditions. Steam may be readily available from a stationary plant, or hot water heat from an adjacent building could be economically piped to the fueling facility. Electricity is always available. A dial thermometer should be installed to read a representative temperature, and pressure or electric-actuated thermometers are also available for remote readings.

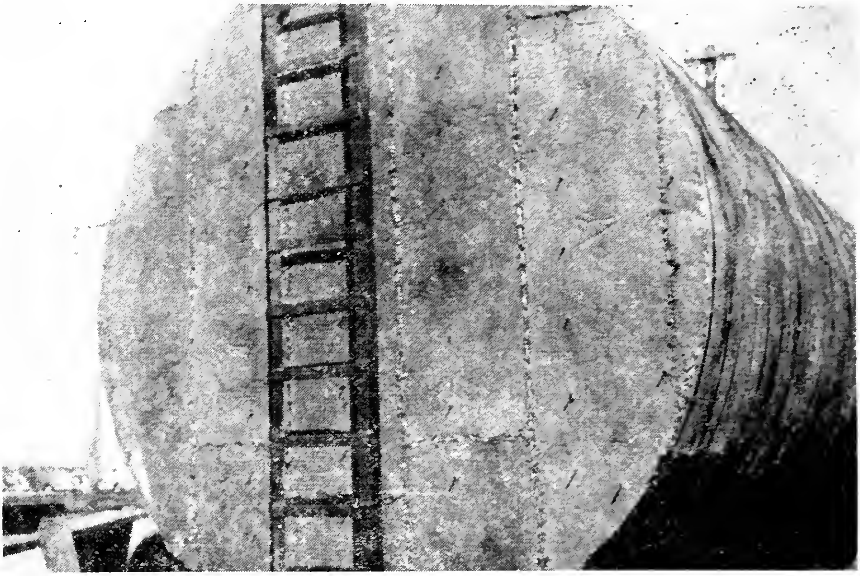


Fig. 1—Fuel tank covered with fiber glass held in place with circumferential bands and studs welded to the head.

When using steam, the heating coil for the tank interior should be of seamless steel tubing located near the pump suction line. This avoids heating the main body of oil. It should be trapped to the sewer to avoid any oil return to the boiler in the event of a leak in the line. The temperature is controlled by means of a thermostat in the tank, operating a motorized or solenoid valve on the steam line, or by means of a thermostatic self-motivated diaphragm valve. Automatic temperature-indicating regulators are also available and provide a very convenient method for temperature regulation. Hand control of fuel temperature is not recommended even though the plant is under constant attendance.

Hot water heating of the oil requires similar seamless steel tubing for circulation of the hot water in the storage tank. The source of the hot water can be either from an existing facility or from an automatic hot water heater, using a standard circulating pump installed directly in the line. Automatic thermostatic controls are also desirable to minimize waste of fuel and prevent overheating of the oil.

Heating of the oil in storage tanks by electricity is usually limited to the immersion-type heater. This should be engineered for definite requirements of heating and controlled by a remote heat-sensitive bulb type thermostat. This type heater should be of low watt density to prevent localized overheating of the oil. It is recommended that the wattage be limited from 5 to 15 w per sq in of heating surface. The element is equipped with standard pipe thread for insertion into a tapped hole near the bottom of the storage tank. The connection box for the heating element and thermostatic control must be Code type, both vapor and water proof. Strip heaters are not recommended for use around fueling facilities. Explosion-proof, fin-type automatically controlled space heaters

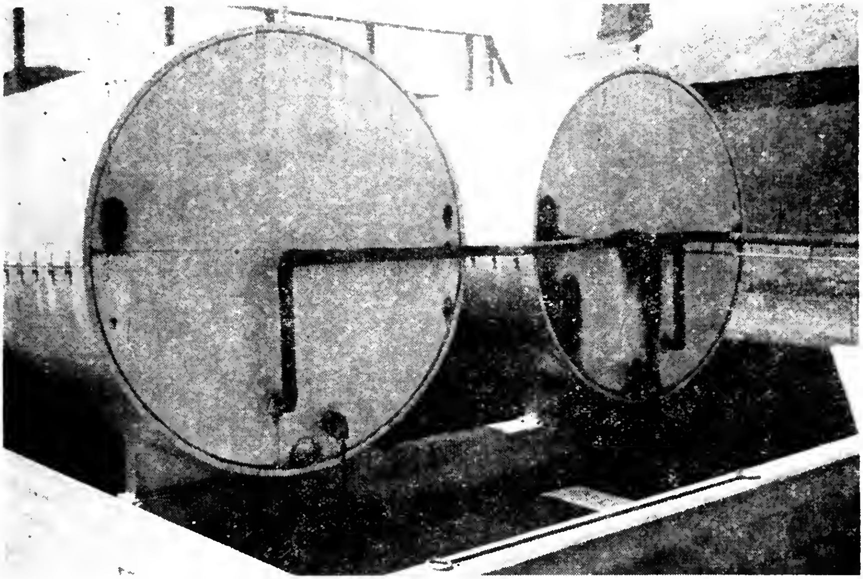


Fig. 2—Jacketed storage tanks with thermostatic control wire in conduit under steam line connected to motorized valve in pump house.

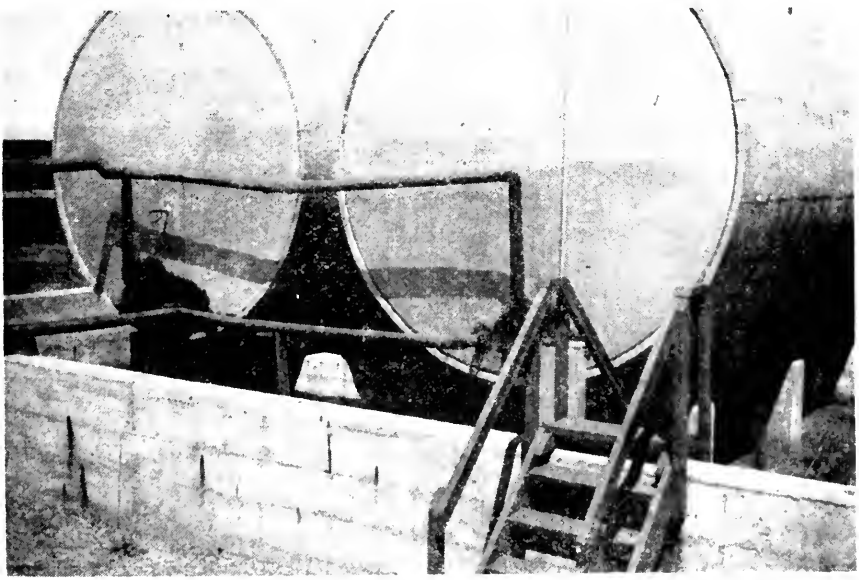


Fig. 3—Self-motivated diaphragm valve located in pump house operated by control bulb in the head of left tank.

up to 20,000 Btu per hr capacity are now available for heating the pump house, so it is now possible to electrify completely a diesel fueling facility.

Heating very large tanks for primary storage is uneconomical because the large heat dissipating surface is costly to insulate and will require an excessive amount of heat. It is essential, therefore, that the heating requirements be limited to consideration of a tank outlet heater. The heater shell extends into the tank and the pump suction is through this unit. It contains the heating coils through which steam is piped, which is discharged to the atmosphere through a freeze-proof trap. The steam supply line enters directly into the head of the unit and the thermostatic control, with a dial thermometer, should be placed in the pump suction at the outlet of the exchanger head.

Where fueling outlets are remote from the pump house, it may be necessary in very cold climates to provide heating for the distribution system. This may be done with steam, by enclosing a small tracer line in the same conduit as the fuel line. or preferably by enclosing both lines in an insulating jacket. This line should discharge into a freeze-proof trap.

Fuel oil lines can be heated electrically with flexible heating cable wrapped around the line, and each unit or section thermostatically controlled to maintain a minimum temperature. These systems are economical to maintain and control, and they provide efficient means of applying heat directly to the line beneath the insulation or in the cover pipe. Whether steam or electricity is used to heat the piping system a relief valve should be placed near the pump discharge to relieve the pressure should the oil overheat and expand from infrequent use. This should discharge to the oil reservoir.

Although heating of fuel oil and its facilities will prevent waxing out and minimize most winter difficulties, it is realized that trouble can be encountered due to the presence of water in the oil and the accumulation of water from condensation caused by atmospheric changes in partially filled tanks. Much has been written covering this subject, but to avoid frozen fuel lines, injector trouble, and general engine inefficiency, small changes in design may be desirable to eliminate water in the fuel.

The installation of a tank trap, which is readily accessible for cleaning, is a worthwhile consideration. There is also available a fuel oil dehydrator, which must be preceded by the conventional filter. An overhead unloading rack which does not remove the last traces of oil from the receiving car allows the settled water to remain in the tank. The use of an outlet suction pipe which has a serrated edge will allow an inch or more of water and debris to remain in the tank car. These all have merit, but notwithstanding, the actual operation of a fueling facility must still be under the control of reliable personnel.

To prevent the freezing of separated water in the locomotive tanks, which may be greater than 0.05 percent, it is necessary to add 0.2 to 0.3 percent methanol or isopropanol to the fuel at times when the temperature is below freezing. This can be done manually by adding the prescribed quantities to the locomotive tank just prior to fueling, or they can be pumped into the fuel line by a proportioning pump operating automatically. Both methanol and isopropanol are effective, although methanol has a limited solubility. Isopropanol, on the other hand, is miscible in all proportions used. Methanol is slightly less expensive.

There are also available on the market fuel oil additives which enhance engine operation, and these to a limited extent absorb the residual water. As certain types of fuel oil depreciate in quality it may be desirable to add combustion accelerators for ease in starting during extremely cold weather periods. These, too, should be added by means of proportioning pumps.

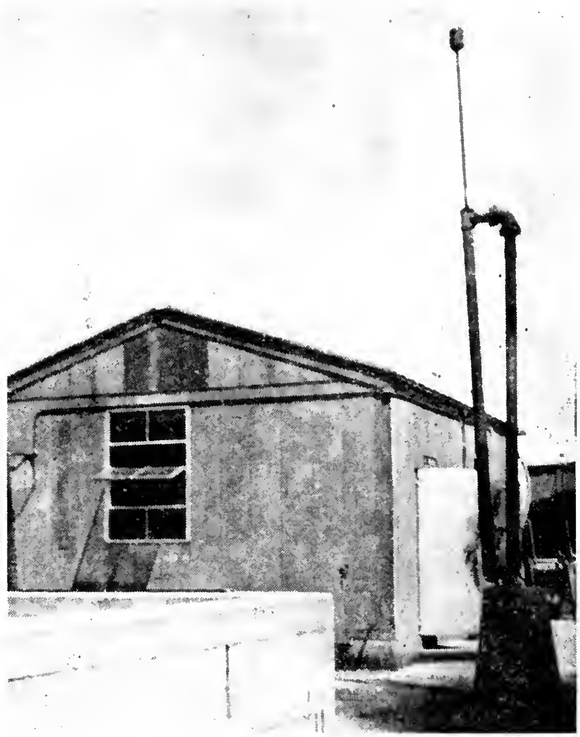


Fig. 4—Counterbalanced overhead unloading pipe.

Fire Protection

Fires around fueling facilities are caused by carelessness; whether due to inadequate design, improper operation, or poor maintenance. It is not the intention of this committee to make recommendations covering the training or drilling of the fire-fighting personnel. This feature is rather complex and general, and is not included in this report. The management at each facility can inaugurate such practices as will best suit local conditions. It is recommended, however, that adequate steps be taken to acquaint the plant firemen with the protection facilities provided, since they can usually extinguish oil fires while still in the incipient stage before they reach dangerous and alarming proportions and become out of control.

Fire prevention is based fundamentally on proper design of all the component parts of the complete unit. It is important to remember that the vapors coming from the fuel oil are responsible for all fires and, therefore, it is desirable to avoid all practices which allow vapors to exist or collect. Since this is almost impossible, all electrical work should be made vapor proof and motors should be totally enclosed with a sealed terminal box. It is preferred to have all pipe welded, however, joints in threaded pipe should be made with oil-resistant compound. Plug cocks are preferable and should be of the lubricated type. The air-relief chamber should be vented to the atmosphere outside of the building and as high as practicable. Pressure-relief valves should be piped back to the storage tank, except that those on the pumps may be piped back into the suction line since they would operate only when the pump is being used.

Fuel pump packing can be a source of operating difficulty and fire hazard. Ordinary packing, even with grease cup seals, is difficult to keep oil tight. When conventional packing is free from oil drip while the pump is idle, it may become hot and expand while the pump is in operation, tightening on the shaft and cutting into the metal. The roughened surface may then be in such condition that it cannot be kept oil tight, more especially with above-ground storage tanks where the pump is under a positive head. It is recommended, therefore, that rotating shafts be equipped with mechanical seals to avoid leakage and the pooling of oil, with resulting fire hazard.

Welding, cutting or any hot repairs require a thorough knowledge of the procedure necessary to insure a safe working condition and to avoid fire and explosion around fueling facilities. It is common practice to blow out all the piping and tanks with air, fill and flush with water, then introduce either carbon dioxide or nitrogen gas to provide the inert atmosphere necessary. It is recommended that the standards of the American Welding Society be referred to before any work is done to acquaint all concerned as to the safest practice.

Many different nozzles and connections have been tried to eliminate the wastage of oil at the locomotive filler connection, but it is now generally recognized that a trigger-operated hose nozzle valve or gate valve at the quick coupling is an absolute necessity to minimize spillage. The development of an automatic shut-off nozzle has not progressed as rapidly as the needs of the railway have required. Its development has been retarded principally on account of the locomotive filler opening being horizontal, the high rate of fueling, and the variations in pressures encountered, due in part to inadequate venting of the locomotive fuel tank. There is available an alarm whistle which can be applied to the locomotive fuel tank, which will assist the attendant in determining the fuel level. Then with reasonable care the waste of fuel will be reduced and the fire hazard diminished.

The waste of fuel and the increase in fire hazard due to overflow and spillage are very common, and the oil saturated premises are becoming quite a concern and problem. Flash fires from employee carelessness can result in serious losses, especially when fire occurs while fueling. Spillage should be discouraged and prevented by having adequate lighting for night fueling, by having the attendant fuel only one unit at a time, and by not trying to fill the tanks to the overflow level. New designs now incorporate lower capacity pumps with smaller hoses and lower pressures. The saturated gravel around the fueling area should be dug out frequently and replaced. It has been considered that a concrete or hard-surfaced apron be designed for the fueling area. This solution is ideal for parts of the country with mild climate, but where winter conditions prevail it is fraught with high maintenance expenditures to keep it free from ice and snow. This type of construction requires sumps and drains, and these should discharge through the terminal oil separator system. At isolated points a sewer system will have to be constructed with a separator, and the capital expenditure is likely to be excessive. Many less elaborate schemes have been developed and are being used, such as timber or concrete troughs at the ends of the ties, with galvanized sheets from the rail base to direct the spillage to them. It is felt, however, that the installation of these facilities encourages carelessness in the fueling process.

When a fueling plant has been properly designed and operated there is a negligible amount of fuel loss and fire hazards are at the minimum, but since we can expect accidents to occur, the design of the plant should include properly engineered fire protection. All fires have a small beginning, and to prevent a major catastrophe portable extinguishers of the proper type for oil fires should be strategically located and readily accessible.

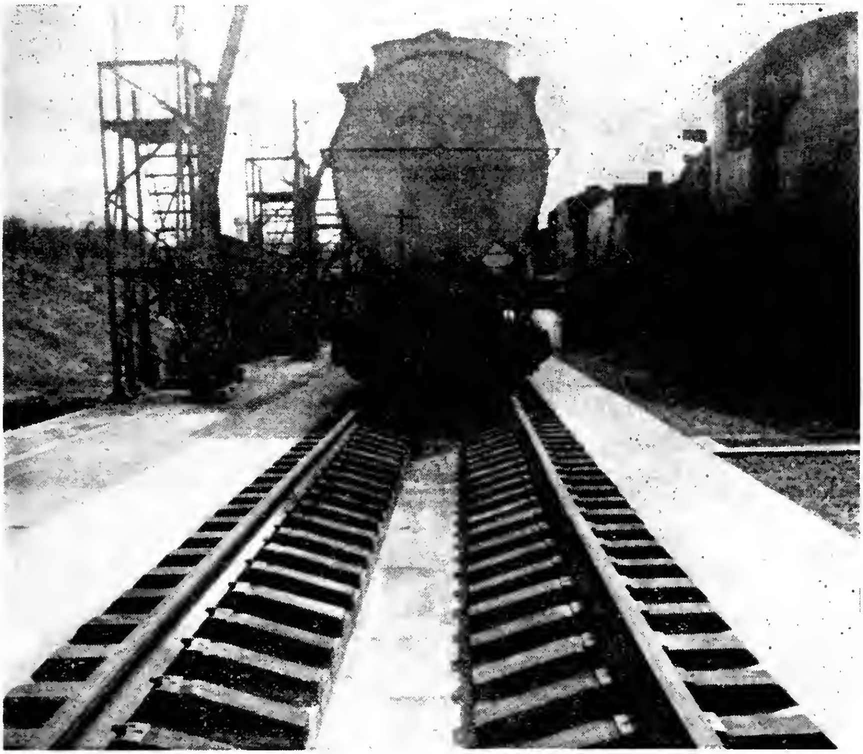


Fig. 5—Concreted roadway with collecting trough sloped to a sump, using stub ties for rail support.

A review of the plant layout will suggest where fires are most apt to start, and portable extinguishers should be placed in convenient protected enclosures. They should be simple and standardized so that it will be unnecessary to instruct each individual employee how to operate them for best results.

A permanent fire-fighting facility should be based on the premise that there are only three methods of controlling a major oil fire, viz, by blanketing it with foam to stop the release of the flammable vapor, by rapid cooling with water fog to stop the heat required for vaporization, or control by agitation with gas.

Fire hydrants should be carefully located so that in case of a major fire they are not in an untenable locality. A single fire hydrant with twin 2½-in standard outlets and sufficient hose with fog nozzles to reach all parts of the fuel plant conveniently is the minimum protection that should be installed. A critical survey will usually dictate that more hydrants are necessary to protect adequately both storage tank and fueling rack premises, especially if they are over 200 ft apart. Standard straight stream or deluge nozzles are not recommended for oil fires because the large water volume tends to spread the burning oil and the concentrated stream does not have the cooling effect necessary for reducing vaporization of the fuel. Portable foam nozzles with pickup piping can be quickly substituted for the fog nozzles if it should become necessary to lay a foam blanket on a stubborn ground fire.

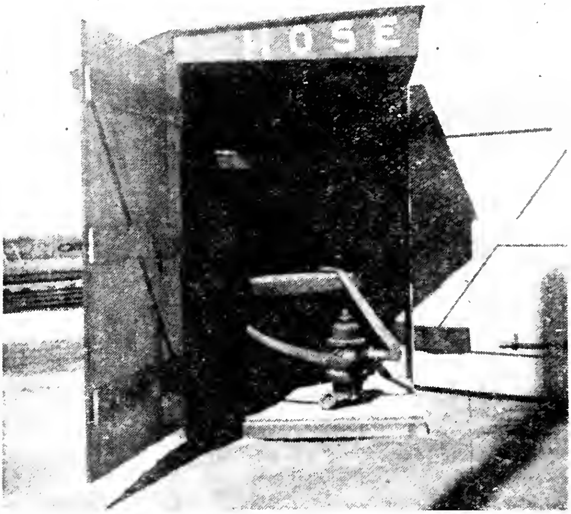


Fig. 6—A single hydrant protected against snow, with racks for hose and fog nozzles.

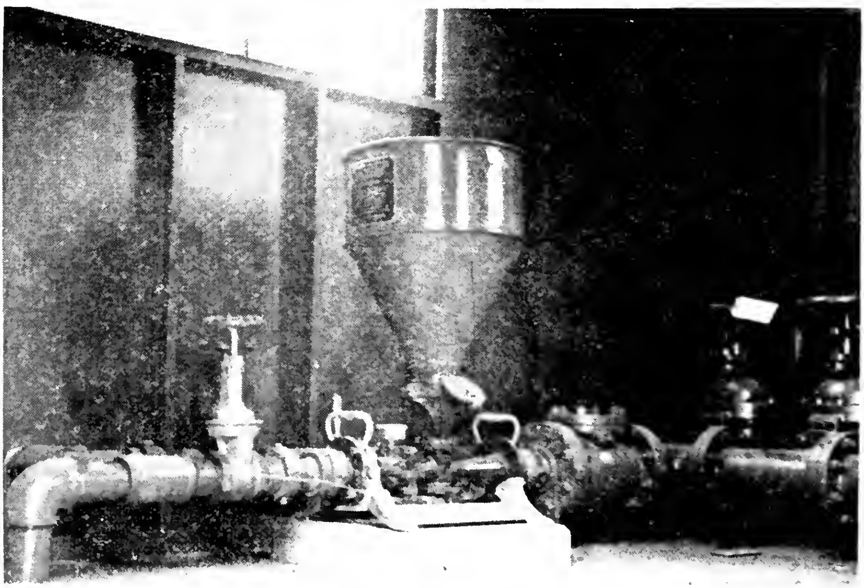


Fig. 7—Fixed foam generator installation.

Where fuel tanks are large and are located in a hazardous location it is well to consider the use of a stationary foam generator installation. A separate building housing a foam generator of adequate size to store a supply of either liquid or powdered foam stabilizer is desirable. The main water supply should enter this building and should be at a distance from the danger area. The branches from the manifold which receives the foam-treated water are piped to various strategically located hydrants in the fueling location. The storage tanks can be piped from the manifold with fixed sprinkler systems using a combination foam and water fog head. Nozzles used for this type of construction should be for a combination foam and water fog so that either can be used in the event there is a failure of the foam generator or should the foam stabilizer become exhausted.

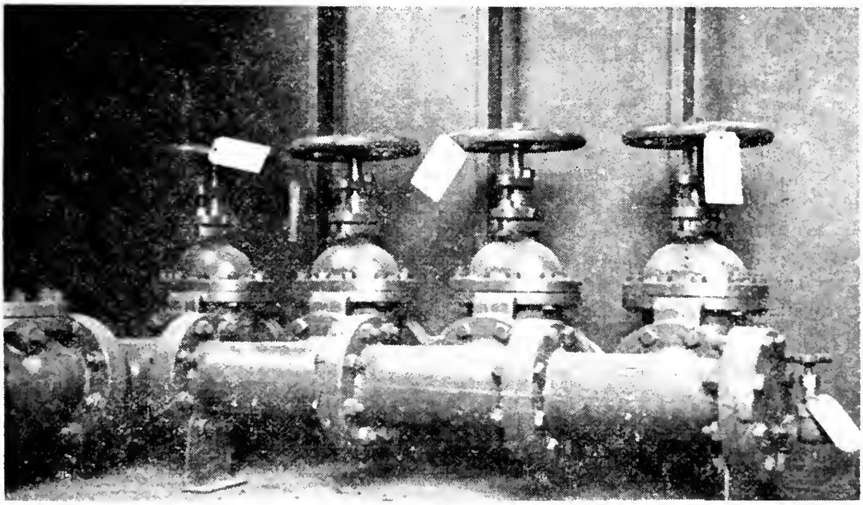


Fig. 8—Manifold distributor for fixed foam generator installation valves used to distribute foam to fire site.

There is a new permanent-facility method now being tried out by one of the large oil refining companies, which appears to be particularly adapted to the protection of fuel oil storage tanks. This method is best described as "Control by Agitation." The theory involved goes back to the basic fact that burning can take place only when inflammable fuel oil vapors and oxygen are both present above the surface of the liquid in correct amounts and at proper temperature to form a combustible mixture. To extinguish such fires, it is necessary that the mixture be unbalanced so that it is no longer combustible. In the agitation theory it is proposed to do this by introducing air or an inert gas (nitrogen or carbon dioxide), into the lower part of the storage tank. The boiling or heaving effect as the air or gas rises will carry some of the comparatively cool oil from the bottom area to the top. Thus, in case of fire, the hot upper strata of burning liquid (which obviously must be at a temperature above its flash point) can be broken up and to a large extent replaced by cool oil from below. The fire is extinguished because there is not enough vapor from the cool oil to support combustion.

Tests of the control by the agitation theory described were made during the latter part of 1951 and are reported on in the July 1952 National Fire Protection Association

Quarterly, published by the National Fire Protection Association, Boston, Mass. In one of the tests an open, 30-ft dia. by 25-ft high steel tank two-thirds filled with 126-deg flash point kerosene (approximately 100,000 gal) was ignited and allowed to burn 2½ min. Air was then injected at the bottom center of the tank at the rate of 75 cfm at 6 psi. The fire was extinguished in less than 10 sec. It is presumed that the cool oil boiling up from below flowed in all directions from the center and extinguished the flames by upsetting the combustible mixture of vapor and oxygen. Other tests gave results almost as startling. The conclusions are that fires in diesel fuel oil storage tanks can be completely extinguished by agitation.

Further tests are to be made which should give more specific data as to how much air or gas should be injected and where to apply it for best results. In the meantime, although the procedure for controlling fuel oil tank fires by agitation has not been fully developed, it is believed that its potentialities warrant further study and consideration, especially in view of the fact that in most cases the costs of installing an air line to the storage tank would be very little.

Should the fueling plant be isolated from a water supply, consideration should be given to providing a fire car with a 10,000-gal capacity water tank completely equipped with a gasoline engine-driven fire pump. The discharge head of the pump should be sufficiently high to overcome the friction in 300 to 500 ft of 2½-in fire hose with 50 psi excess head to furnish the minimum pressure required for operation of the fog nozzles. Two 1½-in fire hoses can be connected to the 2½-in hose by means of a siamese connection and these used to approach into close proximity to the fire. If a portable foam generator has been considered, this can be connected at this point and the nozzles on the 1½-in hose should be combination foam and water fog. It is preferable that the foam generator be a permanent part of the car and be installed next to the fire pump. Foam equipment and water fog increase the effectiveness of a fire car with its limited amount of water. Adequate supplies of foam liquid or powder should be stored in a convenient locker or cabinet.

Cabinets for hose fittings, nozzles and wrenches should be of ample size, and the equipment should be frequently inspected for the miscellaneous equipment which includes coats, boots, helmets, axes, poles and tools. A portable gasoline-driven generator for flood lighting for night fires is essential.

A portable fire car can be handled by a switch engine to give added protection for diesel house fires and can be switched to a burning disabled diesel locomotive any place in the yard.

Portable gasoline-engine-driven booster pumps with standard fire hose connections are available, which can be connected to low-pressure fire hydrants or between hose lengths to provide the head necessary for proper efficiency of the fire-fighting equipment.

Painting

Since the beginning of the use of iron and steel for tanks and piping, corrosion has been a major problem and a source of costly replacements. This situation existed because the mechanism of corrosion was not fully understood. When the phenomena was clarified by the electro-chemical theory it was only natural that better coatings and paints would be developed. This theory was also responsible for the method of applying a counter electromotive force of slightly higher voltage in the process known as cathodic protection. Exterior corrosion can be stopped by applying a protective coating, applying counter electromotive forces, or by a combination of the two.

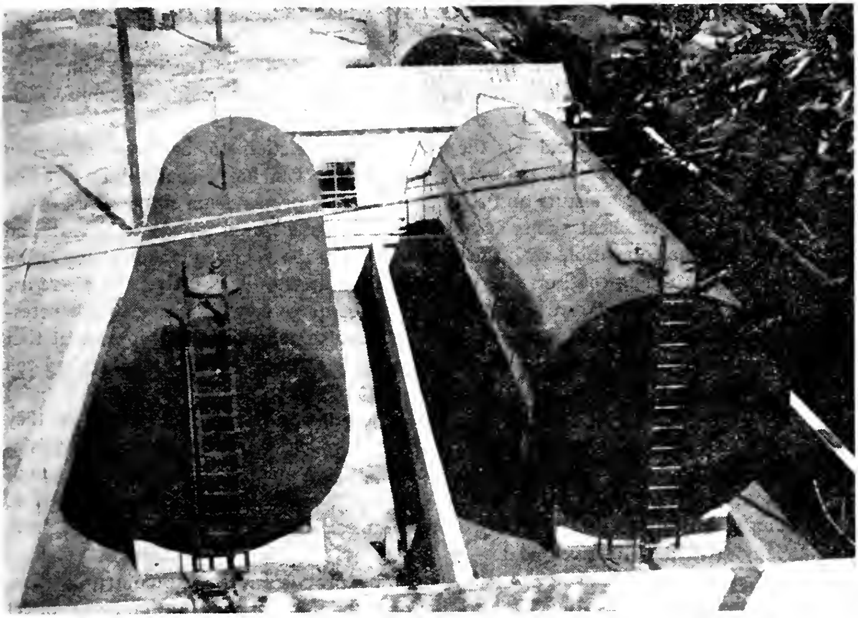


Fig. 9—Left tank with asphalt finish coat applied directly to the insulation. Right tank insulation protected with jacketing and painted with coal-tar enamel.

Even the corrosion-inhibiting properties of paint can be broken down into various categories, but these properties are more usually manifested in the primers used. Certain pigments have an oxidizing property which renders the iron passive, and this property also converts the soluble ferrous salts into the insoluble ferric oxides which assist in protecting the iron. Other pigments, to a lesser extent, act as miniature sacrificial anodes and protect the metal in this manner. The last, and probably the most important, is the ability of the paint to form an impervious film which shields the metal from the electrolyte.

It can be seen readily that in order to provide a satisfactory protective coating against corrosion it is very necessary to remove all dirt and shop grease by washing the metal with naptha or other mineral thinners. Mill scale and light coatings of rust should be removed with wire scratch brushes, and if the steel is in very bad condition it should be sand or shot blasted. The metal surface should be dry, but should it be very slightly moist from high humidity it should be given a turpentine wash which is a preferential wetting agent which displaces the small amount of moisture from the surface and encourages the adhesion of the priming coat. Sand-blasted steel should be primed immediately since rust formation on the cleaned surface is almost instantaneous.

The priming coat is probably the most important since it is the foundation for providing the maximum amount of protection. It forms the continuous film that shields the metal from its corrosive environment and it must have good bonding properties so as to give a firm base for the paint. It must be flexible to conform to changes in the metal and must hold firmly the basic compounds needed to inhibit corrosion. The exposure conditions dictate the type of vehicle to be used. Buried tanks continuously exposed to moisture require a film of high impermeability, which suggests a synthetic resin-type vehicle. If the steel surface is not too clean the vehicle should have a high oil content, and where quick drying is essential an oil resin vehicle will give the best results. The pigments can be red lead, blue lead, zinc chromate, zinc dust—zinc oxide, or similar rust-inhibiting compounds.

A three-coat system should be the minimum protection to be considered—two priming coats and a finish coat to protect the primer. The finish coat should provide the final barrier to resist moisture and should protect the primer from soil stresses.

There are many excellent paints and enamels that can be used for the final coat, and this coating must be compatible with the primer, that is, the vehicle should not redissolve or soften the last priming coat, or raise it and thereby destroy its effectiveness. There are many coal-tar enamels that can be applied either hot or cold, which provide the necessary moisture barrier and have a high degree of conformability. It is very important that extreme care be taken to avoid "holidays" or any spots where the paint is brushed too thin. Success of the coating will be voided by failure at these points.

When galvanized sheets are used to jacket tanks and protect the insulation they should be allowed to weather for six months or more before being painted. If this is not feasible the metal can be treated with any of the proprietary phosfate compounds or with copper salts and allowed to dry. Galvanized prefabricated buildings used to house pumps and equipment may be painted immediately after erection if they have been already treated to receive paint.

Buried tanks, even though painted, should be provided with cathodic protection, either with sacrificial anodes (magnesium, zinc or aluminum) or with an impressed direct current using a carbon or scrap metal electrode. A carefully applied protective coating assists in obtaining the greatest efficiency from a cathodic protection system, and conversely, a cathodic protection system materially extends the life of a tank on which the coating has been carelessly done. It is very easy to cause breaks in the surface of tank coating, especially if they were painted above ground and lowered by cables or a sling. Rope or cable burns may cause holidays or breaks in the surface continuity or they may be caused from back filling with sharp gravel or frozen earth. Large size fuel storage tanks setting on gravel or sand pads should have cathodic protection systems since it is impossible to condition the surface properly and provide a suitable paint application.

Summary

The two reports made by Subcommittee 8 covering diesel fueling offer, in a general way, sufficient information for the design of a facility which, when properly maintained, should give satisfactory service.

Report on Assignment 9

Rodent Control on Railway Property

T. L. Hendrix, Jr. (chairman, subcommittee), G. A. Ausband, R. S. Glynn, F. E. Gunning, M. A. Hanson, E. R. Schlaf, W. H. Shoemaker, J. M. Short, H. W. Van Hovenberg, E. L. E. Zahm.

Rodents pertain to the order (rodentia) of gnawing mammals, such as rats, mice, squirrels, beavers, porcupines and rabbits. This report is confined to the control of rats and mice and is submitted as information.

Rats are the deadliest, most destructive of all animal enemies of humanity. It is estimated that there are as many rats as people in the United States—150,000,000. Each rat will eat, destroy or contaminate around $20 worth of material each year. This figures to a three billion dollar annual loss. Even worse, rats spread typhus, infectious jaundice, ratbite fever, and fatal food poisoning. They are the reservoir of bubonic plague.

The fundamental principles of rodent control are by no means specific or peculiar to the railroad industry. The prevention of rodent infestation through rat proofing, good sanitation and orderly storage to eliminate hiding spaces and openings and access to food is a basic approach wherever the problem is encountered and constitutes the best and surest means of control. However, the environmental and physical characteristics of some railway properties are not always favorable to sole dependence on good housekeeping, and supplementary measures such as poisoning, trapping and fumigation may be necessary. In this case, the employment of reputable professional pest control operators is frequently the most satisfactory procedure.

For use by railway personnel not specifically trained in extermination work, warfarin is probably the best rodenticide available. Baited with dry cereal grains, it is applicable to use with permanent bait stations. Repeated small doses act on the rodents' blood to prevent coagulation, and death due to internal hemorrhages is so gentle that survivors experience no bait shyness.

So far as practicable, control work should be regarded as a continuous program with a sustained effort to eliminate the causes of infestation, rather than be one of recurrent intensive rat killing campaigns. The stakes of economic loss, potential disease and more subtle esthetic considerations justify the effort required.

Occurrence

The incidence of rodent infestation on railway property and the magnitude of the effort necessary for control will vary widely between different locations and installations. Any local rat population will maintain itself at the highest level which available food and harborage will support.

Warehouses, freight depots and transfer sheds are favored locations, especially where grain or foodstuffs are handled. Shops, lunch rooms and bunk houses are frequently infested, and stock pens where garbage is fed to hogs may have large rat populations. Offices and camp cars are a common habitat of mice.

Common Types of Rats

1. Norway rat (brown, sewer, wharf or barn rat). *Rattus norvegicus.* This large rat usually weighs from 10 to 17 oz. Its color ranges from reddish brown to brownish gray, the body is broad, the muzzle blunt and the ears small and densely covered with short fine hair.

The Norway rat is a burrowing animal and usually confines its activities to the lower parts of buildings. It is an expert swimmer and often occurs in great numbers along the banks of canals and other waterways. It nests in burrows under floors or concrete slabs, in rubbish piles, and in or adjacent to refuse dumps. The Norway rat is distributed throughout the world.

2. Black or ship rat *(Rattus rattus)* and Alexanderine or roof rat *(Rattus alexandrinus)*. These are closely related subspecies with generally similar habits.

These rats are distributed throughout the warmer portions of the world and in the United States are found mainly in the south, particularly in the Gulf Coast seaports.

These two rats are smaller than the Norway rat, weighing from 4 to 8 oz. They have slender bodies and pointed muzzles. The thin tail is usually appreciably longer than the combined length of head and body. The ears are larger than on the Norway rat and lack the hairy coating.

The feeding and scouting range of these rats is more extensive than that of the Norway rat. They are excellent climbers and commonly frequent the upper parts of buildings.

Habits of Rats

Rats are active principally at night. They make their homes in dark, well protected and preferably warm places, just as close as possible to an easily accessible supply of food and water. A rat requires around 1 oz of dry food and 1 to 1½ oz of water every 24 hr.

They travel in narrow concealed paths or runs whenever practicable and use the same routes so habitually that accumulations of oil and dirt from their bodies soon create characteristic trails.

Rats will eat any food they can chew. They aggressively seek food and shelter and will travel miles when their food supply fails or their shelters are destroyed.

Favorable conditions are conducive to rapid breeding and large litters of young. Breeding may take place at all seasons and one female may raise four to seven litters a year. Litters consist of 6 to 22 young, which reach sexual maturity 100 to 120 days after birth. One pair of adult rats has produced, with their descendants, more than 1500 young in a single year.

Evidence of Rat Infestation

The following signs made by rats will give indication of degree of infestation:

1. *Droppings*. Rat droppings are rod-shaped, with rounded ends and from ¼ to ¾ in. in length by 1/16 to ¼ in. in diameter. They usually are dark in color and, when fresh, have a moist, glistening appearance and putty-like consistency. Old droppings are hard, discolored, and covered with dust or mold.

2. *Runways*. Rats repeatedly travel over customary routes and soon produce well-defined runways. Footprints are visible. Whenever they rub their bodies against a wall, climb a pipe or pass through a hole or barrier, they leave a dark grease mark. Active runways usually have a shiny dust-free appearance.

3. *Tracks*. In light dust, flour and smooth earth, the four-toed marks of the paws and the broken wavy line made by the dragging tail are quite distinctive.

4. *Burrows*. Burrows may be used as nesting or hiding places, or as a means of ingress to buildings. Active burrows frequently have a pile of newly excavated soil at the entrance; abandoned holes often are covered with cobwebs.

5. *Gnawings*. Gnawings may denote past as well as present infestation. Young rats can pass through a ¾-in opening and can easily enlarge the space beneath wooden doors and windows.

6. *Damage*. Damage to foodstuffs or other goods may constitute the only visible evidence of rat infestation in some cases. Rats will often carry small pieces of food into inaccessible places and leave scraps which are a good indication of their presence.

7. *Rat Odor*. The characteristic musty odor of rats may linger a considerable time in closed spaces where they have frequented.

8. *Live or Dead Rats.* Inspection of a suspected area at night with a spot light may disclose feeding rats. Finding the bodies of rats which have died of disease indicates the presence of other rats.

Control Program

Removal of Food Supply. Rat infestations can usually be traced to conditions of food and shelter favorable to the animals. Remove these factors and rats cannot long exist. The proper storage and disposal of garbage, the storage of food supplies in rat-proof containers and buildings, and the elimination of dumps will keep down rat populations.

Discarded scraps from lunches of employees are highly attractive to rats as well as to roaches, ants and other insects. An educational program may be necessary to materially improve this situation.

In this connection, Interstate Quarantine Regulations require that the handling, storage and disposal of garbage and refuse be accomplished in such a manner as to discourage infestation by rats, other vermin and flies which might contaminate food, ice and water used on railway cars.

Elimination of Shelter. Ratproofing consists of contructing buildings or changing their construction in such manner as to prevent the entrance of rats and to eliminate potential shelter to them within the building.

Every separate structure presents its individual problem, but there are two general principles that apply in all cases and that should be kept in mind when the ratproofing of any building is being considered. First, the exterior of those parts of the structure accessible to rats must be constructed of materials resistant to the gnawing of rats, and all openings must be either permanently closed or protected with doors, gratings or screens; second, the interior of the building must provide no dead spaces, such as double walls, spaces between ceilings and floors, staircases and boxed-in piping, or any other places where a rat might find safe harborage, unless they are permanently sealed with impervious materials.

All new buildings should be made rat proof. Modern structures are so nearly rat proof that to make them completely so requires only slight and inexpensive changes. Furthermore, ratproofing is closely associated with fire stopping and with sanitary measures that are now required by law in many places.

Accumulations of trash and waste materials must be eliminated to prevent their use as rat shelters.

In ratproofing, remember that rats can jump 2 ft vertically, dig 4 ft or more in the earth to get under foundations, climb smooth pipe up to 3 in. in diameter, and travel telephone or other wires.

Destruction of Rats. Although measures for the permament riddance of rats should be taken where practicable, they must be supplemented by destruction of the animals, and in many places continual rat killing is the only practical means of control. Moreover, before beginning extensive elimination of rat harborage and food supply, it is essential to accomplish an initial knockdown of the population to prevent mass migration to other areas.

Pest Control Operators. The uncanny elusiveness of rats necessitates a matching of wits if they are to be successfully eliminated. They are animals with instincts closely akin to human intelligence and the employment of a routine control procedure may not produce results. Professional pest control operators are trained experts in the art of insect and rodent control. They employ a varied series of lethal agents best to eliminate the infestations. Training and experience in this field are necessary to estimate accurately the degree of infestation, the choice of rodenticides and baits, and the optimum number of baits to be set out. Many rodenticides too dangerous for use by untrained persons are highly effective as used by pest control operators. Further, reputable operators are covered by insurance to hold clients free of liability for accidental poisonings of pets and livestock.

Services are usually contracted on a continuing service basis with routine visits at specified intervals and extra visits in case of complaints. One shot kills are also available but are not generally recommended. Contracts usually also include control of specified insects and other vermin. The cost of this service is often less than that of doing the work with railway personnel.

Poisoning. (See accompanying table of common rodenticides). This is a rapid and effective control measure where there are large numbers of rats. However, all known rodenticides are dangerous to man. Only fortified red squill and warfarin combine the qualities of safety to humans, pets and livestock with effectiveness against rats, in proportions that warrant their use by untrained personnel.

Red squill is the only rat poison that should be used with meat or other baits attractive to pets. If this poison is accidently eaten by humans or pets, it will cause vomiting. It is almost a specific poison for rats because these animals cannot vomit.

Warfarin has proved to be an outstanding effective rodenticide against all common varieties of rodents in the United States, in all types of rodent infestations, and in all parts of the United States. Warfarin, since it produces no bait shyness in the rodent and is adaptable for use in semi-permanent cereal type baits, is the first rodenticide available for use in permanent bait stations to maintain continuous control by killing off newcomers as and when the premises are reinfested.

Permanent bait stations for use with warfarin should be weatherproof, should protect the bait from children, pets and domestic animals and should be designed in such a manner that they will hold sufficient quantity of warfarin bait. Prefabricated ones of various sizes are available from several manufacturers.

Fumigation. Rats may be killed in buildings, railroad cars or in their burrows by means of gases such as methyl bromide or hydrogen cyanide. The structure being so treated must be made sufficiently air tight to maintain a lethal concentration of the gas for the required period of exposure.

Fumigation is a hazardous process and should be carried out only by properly trained and equipped personnel. It has the advantage of killing fleas and other vermin on the rats as well as the rats themselves.

The most common technique of fumigation is to spray calcium cyanide as a dust, which releases hydrogen cyanide in the presence of moisture. This works well in burrows but in buildings the residual powder may retain a dangerous concentration of cyanide.

Trapping. Ordinary snap traps work well on mice but are not effective with rats. Favored baits are bacon, peanut butter, candy, fresh bread, cake, apple, American cheese and sweet potato. Bait should be fresh and varied at least every third day. It is not necessary to avoid getting human odors on baits.

More important than the selection of the bait is the proper placement of the trap, which should be along the natural runways of the rodents. Every few days traps should be moved to different locations.

Glue pads, which work like fly paper, are often effective in catching mice.

SOME CHARACTERISTICS OF THE COMMON RODENTICIDES

POISONS	LETHAL DOSE (MG/KG)	PERCENT USED IN BAIT	DEGREE OF EFFECTIVENESS	DEGREE OF ACCEPTANCE	DEGREE OF REACCEPTANCE	CUMULATION (FATAL)	TOLERANCE DEVELOPED	ODOR	TASTE	CHEMICAL DETERIORATION IN BAITS	CARRIER USED IN BAIT MIXING: USE DRY	CARRIER USED IN BAIT MIXING: WATER BASE	CARRIER USED IN BAIT MIXING: OIL BASE	ACTION (CAUSE OF DEATH)	RELATION TO HUMANS AND TO OTHER ANIMALS: SECONDARY POISONING	RELATION TO HUMANS AND TO OTHER ANIMALS: SKIN ABSORPTION	RELATION TO HUMANS AND TO OTHER ANIMALS: DEGREE OF HAZARD IN USE	ANTIDOTES[11]
ANTU • (ALPHANAPTHYLTHIOUREA)	8[1]	1.5	GOOD[1]	GOOD	POOR	NO	YES	SLIGHT	MODERATE	SLIGHT	YES	NO	NO	■ PLEURAL EFFUSION (OVER PRODUCTION OF FLUID IN THE LUNGS)	NO	NO	MODERATE	NONE
ARSENIC TRIOXIDE ••	100[2]	3	FAIR	FAIR	FAIR	NO	YES	NONE	MODERATE[6]	NONE	NO	YES[7]	NO	■ KIDNEY DESTRUCTION, GASTRO-ENTERITIS, CENTRAL NERVOUS SYSTEM AFFECTED	NO	NO[10]	MODERATE	MILK OF MAGNESIA, MILK, AND WATER, OXIDE OF IRON
ARSENIOUS OXIDE •• (MICRONIZED)	25	1.5	GOOD	FAIR	FAIR	NO	YES	NONE	MODERATE[6]	NONE	NO	YES[7]	NO	■ DO	NO	NO[10]	MODERATE	DO
BARIUM CARBONATE •	750+	20	POOR	POOR	POOR	NO	NO	NONE	SLIGHT[6]	NONE	NO	YES	NO	■ INTESTINAL SPASMS, DIGITALIS-LIKE ACTION, PARALYSIS OF CENTRAL NERVOUS SYSTEM	NO	NO	SLIGHT	MAGNESIUM SULFATE
PHOSPHORUS, YELLOW ••	17[3]	.05	GOOD	GOOD	FAIR	NO	NO	STRONG	STRONG	STRONG	NO	NO	YES	■■ HEART PARALYSIS, GASTRO-INTESTINAL AND LIVER DAMAGE	NO	NO	MODERATE	COPPER SULFATE BEFORE EMETIC, CATHARTIC AND WATER, AVOID FATS AND OILS (AS MILK)
RED SQUILL • (FORTIFIED)	500[4]	10	FAIR	FAIR	PODR	NO	NO	MODERATE	STRONG[6]	MODERATE	YES	YES	YES	■ DIGITALIS-LIKE ACTION, HEART PARALYSIS	NO	NO	SLIGHT	ACTS AS OWN EMETIC TO ANIMALS CAPABLE OF VOMITING
SODIUM FLUOROACETATE ••• (COMPOUND 1080)	5-NORWAY 2-ROOF 10-MICE	1/2 OZ / GAL 1 OZ / 28 LBS	GOOD	GOOD	GOOD	NO	NO	NONE	SLIGHT	SLIGHT	NO	YES[7]	NO	■■ PARALYSIS OF HEART AND CENTRAL NERVOUS SYSTEM	YES	NO[10]	EXTREME	NONE[12]
STRYCHNINE •••• (ALKALOID)	6	0.6	FAIR	FAIR	POOR	NO	YES	NONE	STRONG[6]	NONE	NO	YES	NO[8]	■■■ CONVULSIONS DUE TO SUPER-STIMULATION OF NERVOUS SYSTEM, EXHAUSTION, ASPHYXIA	NO	NO	MODERATE	NO EMETIC AFTER 10 MINUTES, CHARCOAL IN WATER AND SEDATIVE KEEP IN DARK ROOM
STRYCHNINE SULFATE ••••	8	0.8	FAIR	FAIR	POOR	NO	YES	NONE	STRONG[6]	NONE	NO	YES	NO[8]	■■■ DO	NO	NO	MODERATE	DO
THALLIUM SULFATE •••	25	1.5 (2% IN WATER)	GOOD	GOOD	GOOD	YES	NO	NONE	SLIGHT	NONE	NO	YES[7]	NO[8]	■ GASTRO-INTESTINAL HEMORRHAGE, KIDNEY AND ENDOCRINE DAMAGE, RESPIRATORY FAILURE	YES	YES[9]	EXTREME	NONE RELIABLE, SODIUM IODIDE AND SODIUM THIOSULFATE RECOMMENDED
WARFARIN •••	1[5]	.025	GOOD	GOOD	GOOD	YES	NO	NONE	SLIGHT	NONE	YES	NO	YES	■ ANTI-COAGULANT, INTERNAL HEMORRHACE.	YES	NO	SLIGHT	VITAMIN K, AND WHOLE BLOOD TRANSFUSIONS
ZINC PHOSPHIDE •••	40	1.0	GOOD	GOOD	GOOD	NO	NO	STRONG	STRONG	STRONG	NO	NO	YES	■■ SAME AS PHOSPHORUS	NO	NO	MODERATE	SAME AS PHOSPHORUS

• EFFECTIVE AGAINST NORWAY RATS
•• EFFECTIVE AGAINST NORWAY RATS AND ROOF RATS
••• EFFECTIVE AGAINST NORWAY RATS, ROOF RATS, AND HOUSE MICE
•••• MICE ONLY

■ SLOW ACTING
■■ FAST ACTING
■■■ VERY FAST ACTING

1 NORWAY RATS ONLY, ON FIRST EXPOSURE
2 PARTICLE SIZES OF USP GRADES VARY, SOME COARSE POWDERS TEST AS HIGH AS 600MG
3 COMMERCIAL PREPARATIONS VARY FROM 1-5% IN PASTE FORM, USE AS LABEL DIRECTS
4 MINIMUM ACCEPTABLE LEVEL, MORE TOXIC SQUILLS ARE AVAILABLE AND GIVE BETTER RESULTS
5 SUCCESSIVE DOSES OF 1 MG REQUIRED FOR 5-10 DAYS OR MORE (AVERAGE TOTALS: NORWAY RAT, 4 MG; ROOF RAT, 20 MG, HOUSE MOUSE, 10 MG)
6 NORMALLY OBJECTIONABLE TO RATS
7 MAY ALSO BE EXPOSED AS A WATER SOLUTION OR SUSPENSION
8 STARCH PASTE MAY BE USED AS AN ADHESIVE
9 CHRONIC POISONING POSSIBLE
10 CAN BE TAKEN THROUGH CUTS OR BREAKS IN THE SKIN, ALSO DANGER OF INHALING LOOSE POWDER
11 EMETICS ARE USED AS FIRST AID EXCEPT AS NOTED; SPEED IS ESSENTIAL, 1 TABLESPOONFUL OF SALT IN A GLASS OF WARM WATER IS USUALLY EFFECTIVE, ALWAYS CALL A PHYSICIAN IMMEDIATELY
12 MONOACETIN OR ETHYL ALCOHOL AND ACETIC ACID RECOMMENDED

Fleas. The fact that the fleas on rats are an essential link in the spread of plague, typhus and other rodent borne diseases makes the employment of agents to kill the fleas a desirable supplement to the rodenticides. Dusting of rat runways with DDT powder has been effective for this purpose.

Policy of Rodent Control

An overall program of rodent control on a railroad must originate with a high-level decision of policy on the ratproofing of new and existing buildings and should operate under the supervision of a system sanitary engineer. The level of authority at which local control measures can be originated should be flexible enough to encourage initiative on the part of those immediately concerned with the infestations. Local supervisory personnel should be able to obtain conveniently, through established stores channels, such approved rodenticides and other rodent control supplies as necessary for action by their own personnel. Contracts for services of professional pest control operators should be approved at lowest level, consistent with policy. And most important of all, the practice of good housekeeping should receive much needed attention at all levels.

References

Sanitation and Rat Control. Federal Security Agency, Public Health Service Communicable Disease Center, Atlanta, Ga.

War Department Technical Bulletin TB Med 144 Rodent Control, April 1945.

Urban Rats and Their Control (Henderson), Modern Sanitation, June, July and August 1950.

Warfarin—Its Past and Future (Ross), Modern Sanitation, October 1951.

Rodent Control. Consumers Report, April 1952, Vol. 17, No. 4.

Characteristics of Common Rodenticides, Modern Sanitation, April 1952.

Facts About Rodent Control, State of Illinois, Department of Public Health.

Ratproofing Building and Premises, Conservation Bulletin #19, Fish and Wildlife Service, U. S. Department of the Interior.

Report on Assignment 10

Prevention of Corrosion of Automatic Car Washing Equipment and Facilities

L. R. Morgan (chairman, subcommittee), M. R. Bost, H. E. Graham, M. A. Hanson, T. L. Hendrix, Jr., G. F. Metzdorf, J. P. Rodger, W. H. Shoemaker, H. M. Smith, J. E. Tiedt, A. G. Tompkins, J. H. Upham.

Your committee submits the following report as information.

The development of automatic car washing facilities has made rather rapid progress within a comparatively short time, however, corrosion has already become a factor in the maintenance of such equipment.

The corrosion presents many different problems which are accentuated by the inherent characteristics of the cleaners which have been found essential in removing tenacious road films. The cleaning solution should be periodically checked to avoid overconcentration and resulting corrosive action. An analysis of these problems can best be made by subdividing the subject into four phases, as follows:

1. Corrosion of mixing vats.
2. Corrosion of pipe lines.
3. Corrosion of spray nozzles and other applicators.
4. Deterioration of concrete and corrosion of framework.

These phases can now be handled as individual items and certain methods outlined for each problem.

1. Corrosion of Mixing Vats

A study of many cleaners indicates that most of them incorporate carefully selected corrosion inhibitors in addition to wetting agents and detergents. These inhibitors seem to be effective in sharply reducing the corrosion of mixing vats, but evidently are not universally successful with some cleaners. In one case, the corrosion had been so extensive that an iron tank had to be replaced in a few months with a similar tank but of heavier gage material. This procedure, of course, does not stop the corrosion but merely lengthens the time between replacements. Another railroad reported that the mixing vat was lined with lead to prevent corrosion, and that this scheme worked out nicely. However, the use of lead lining is rather expensive. Therefore, it is recommended that consideration be given to the use of acid-resistant paints or coatings, at least until the present shortage of acid-resistant metals is overcome. Such paints or coatings include vinyl, asphalt, and wood oil phenolic. The vinyl coatings are best applied by spray, and the surface must be thoroughly cleaned and roughened prior to the application, sand blasting being recommended.

To date the vinyl application has lasted much longer than the asphalt, but it is considerably more expensive. The asphalt paint may be applied by brush; however, it does not have as good an appearance as the vinyl. The wood oil phenolic can likewise be brushed on and is intermediate in cost between vinyl and asphalt; however it is the least acid-resistant of the three.

There has also been a considerable use of rubber-lined tanks for mixing vats, and this method of protection should be given consideration. Wood tanks with corrosion-resistant hoops have likewise been found satisfactory.

All the above-mentioned paints and coatings are not permanent, and it is suggested that, when supply and economic conditions permit, mixing vats be of acid-resistant alloys.

2. Corrosion of Pipe Lines

The dynamic action due to the flow of the cleaning solution in pipes lessens the protective action of the inhibitors present in the solution to the extent that it is desirable to purchase pipes of, or lined with, a corrosion-resistant material, of which there are several trade-name brands available. It is noted that several railroads have used copper pipe very successfully, with but minimum corrosion. It is, of course, known that the exterior of iron piping is subject to rapid corrosion when laid in cinders; therefore, it is advisable to protect such pipe with a backfill of sand or clay immediately around and under the pipe. Local conditions may require the use of special protective coatings on the exterior, but this requirement would be incident to the environment rather than to the conveyance of cleaning solutions, and can be met readily by the use of one of several products immediately available. If it is found desirable to use conducting pipes of material other than cast iron, it is recommended that they be protected from external corrosion by encasement in a cast iron pipe of larger diameter.

3. Corrosion of Spray Nozzles and Other Applicators

Here again the dynamic action of the flowing solution largely nullifies the effect of inhibitors, and because of the construction of such nozzles it seems best to recommend acid-resistant material for their construction. As to brushes, it appears that mechanical wear would make replacement necessary before objectionable corrosion can develop.

4. Deterioration of Concrete and Corrosion of Framework

There is a problem associated with the deterioration of concrete work in the vicinity of the washer, and indications are that this can be minimized by coating the concrete with asphalt or mastic compounds. The use of dense concrete has also been found to give satisfactory results. The use of concrete hardeners has been found helpful, as has air-entraining cement; however, much care is needed when the latter is used so as to stay at or below an air content of 6 percent, otherwise any benefit gained by the air content may be nullified by a loss in strength of the concrete. Local conditions may make it advisable to place the concrete 1 in low and to set acid-proof quarry tile on a base of acid-resisting asphalt mastic, buttering the bottom and edges of each tile with a resinous cement before placing in position. The framework or other metal work exposed to corrosive action should be protected by an asphaltic or mastic coating.

Conclusion

In conclusion, it is suggested that the use of acid-resistant materials be given thorough consideration because, while the initial cost is much higher, the need for replacement is long delayed and satisfactory performance is assured with but the minimum of maintenance expense.

Report on Assignment 11

Means of Conserving Labor and Materials, Including the Adaptation of Substitute Noncritical Materials, and Specifications for the Reclamation of Released Materials, Tools and Equipment,

Collaborating with Committee 3A, General Reclamation, Purchases and Stores Division, AAR

H. E. Graham (chairman, subcommittee), R. C. Bardwell, B. W. DeGeer, C. E. Fisher, M. A. Hanson, T. W. Hislop, Jr., H. L. McMullin, G. F. Metzdorf, A. B. Pierce, H. M. Schudlich, R. M. Stimmel, T. A. Tennyson, Jr.

This report is submitted as information.

The National Production Authority has directed the railroads to reduce their requirements for new "Controlled Materials" to the minimum by the substitution of noncritical materials, conservation methods, and the reclamation of released materials. Since the availability of controlled materials is dependent upon the defense mobilization effort of the country at the time, no attempt will be made here to list the directives. However, this committee recommends that the field offices of the National Production Authority, United States Department of Commerce, be consulted for new NPA directives and revisions from time to time. All construction and maintenance come under the jurisdiction of this department and are subject to its restrictions and allocations.

"Controlled Materials" at this time are common mill forms of carbon steel, alloy steel, stainless steel, copper, copper-base alloys, and aluminum.

New construction requiring more than certain minimum requirements of steel, copper and aluminum, must have authorization from the NPA.

Materials required for normal maintenance and repair are provided for in CMP (Controlled Material Plan) Regulation 5, and the amount allowed is dependent on the amount used during the base period. The standard base period is the calendar year 1950.

The first consideration in any emergency conservation program is to do only work that is necessary for maintaining the essential services of the railroads, or where substantial savings in labor and materials can be effected. While the present is a period of emergency requiring the conservation of critical materials, it is recommended that the design for new facilities should follow standard practices as far as possible.

Substantial savings in material and labor can be effected by a preventive maintenance program. Often, a minor adjustment will prevent a premature failure. With such a program, irreparable damage to equipment can be reduced to the minimum.

It is self-evident that reclamation is of great importance in the conservation of materials. Therefore, the reclamation plant must receive all materials that are released from service that can be reclaimed or converted to other uses if this plant is to salvage all materials possible. Competent men must make a close inspection of the materials and decide what can be re-used or converted to other uses.

Every effort should be made to collect as much scrap metal as possible and turn it back to the mills and foundries to help increase the production of critical materials.

The following practices are recommended by this committee to conserve material and labor:

1. Install remote and automatic electric controls where practicable.
2. Protect iron and steel pipes, tanks, and other equipment from corrosion.
3. Consider the use of mechanical joint cast iron pipe in place of bell and spigot pipe.
4. Use welded piping and welding fittings.
5. Repair valves, pumps, water columns, etc, by welding.
6. Metallize worn pump shafts, rods, plungers, pistons, and sleeves.
7. Scrap obsolete equipment and materials.
8. Avoid having an excessive stock of any class of material.
9. Transfer all excess and released material to a central store point for reclamation or redistribution.

In conclusion, it should be remembered, that while some of the recommendations in this report may not be economical in normal times, they are, for the most part, practices that can be used to advantage at all times.

Report of Committee 9—Highways

W. H. Huffman, *Chairman*,
F. N. Beighley
O. C. Benson
H. D. Blake
D. A. Bryan
C. O. Bryant
M. H. Corbyn
J. A. Droege, Jr.
W. R. Dunn, Jr.
P. W. Elmore
J. S. Findley
L. W. Green
A. S. Haigh
C. I. Hartsell
W. J. Hedley
G. A. Heft
J. T. Hoelzer
T. J. Jaynes*
J. A. Jorlett
A. E. Korsell
J. E. K. Krylow
J. R. C. Macredie
R. W. Mauer
R. W. Middleton
F. T. Miller
H. G. Morgan
R. E. Nottingham
G. P. Palmer
B. Blum, *Vice-Chairman*,
Walker Paul
R. J. Pierce
W. C. Pinschmidt
N. E. Smith
H. E. Snyder
D. A. Steel
B. M. Stephens
C. V. Talley**
R. R. Thurston
J. M. Trissal
V. R. Walling
R. E. Warden
J. W. Wheeler
Committee

* Died March 5, 1952.
** Died October 4, 1952.

To the American Railway Engineering Association:

Your committee reports on the following subjects:

The Committee on Highways,
W. H. Huffman, *Chairman*.

AREA Bulletin 504, November 1952.

MEMOIR

Thomas Judson Jaynes

Thomas Judson Jaynes was born in Beacon, N. Y., on May 5, 1889, and passed away March 5, 1952.

His higher education was received at Newburgh Academy and Rensselaer Polytechnic Institute.

He entered railway service with the New York Central in 1912, being employed successively as chainman, rodman, inspector and assistant engineer until 1917. He was an observer, Intelligence Section, 29th Engineers, 1917–1919, after which he returned to the New York Central and held various positions, including that of engineer of grade crossings between 1935 and 1942. In the later year, he was appointed designing engineer, which position he held at the time of death.

Mr. Jaynes joined the AREA in 1927 and was a member of Committee 9—Highways, since 1944. He was very active in the committee's work and had a genuine interest in his assignments. He will be long remembered by his associates.

MEMOIR

Charles Vaughn Talley

Charles Vaughn Talley was born May 24, 1904, at Linton, Ind., and passed away suddenly on October 4, 1952.

His higher education was obtained at the University of Illinois, from which he received a B.S. degree.

Before finishing school, he held several minor positions with the New York Central, and in 1926 was appointed assistant engineer. In 1940 he was appointed supervisor of track, being promoted to division engineer in 1945, with headquarters at Mattoon, Ill. In 1947 he was transferred in the same capacity to Springfield, Ohio, where he was located at time of death.

Mr. Talley poined the AREA in 1945 and served on Committee 9—Highways, since 1947. He was a very energetic and willing worker on committee assignments. His untimely death will be greatly felt by his many associates.

Report on Assignment 1

Revision of Manual

H. G. Morgan (chairman, subcommittee), Bernard Blum, J. A. Droege, Jr., C. I. Hartsell, W. J. Hedley, W. H. Huffman, J. A. Jorlett, J. E. K. Krylow, W. C. Pinschmidt, B. M. Stephens, J. M. Trissal.

Your committee offers the following recommendations with respect to the Manual, for adoption.

Pages 9–36 and 9–37

HIGHWAY CROSSING ACCIDENT REPORT

Reapprove without change.

Pages 9–38 and 9–39

FORM FOR RECORDING HIGHWAY GRADE CROSSINGS

Reapprove with the following change:

Revise title to read:

HIGHWAY GRADE CROSSING RECORD

Pages 9–40 and 9–41

RECORD OF TRAFFIC AND DELAYS AT GRADE CROSSINGS, RAILWAY WITH HIGHWAY

After review the committee finds the above forms are typical and provide up-to-date information of value. Therefore, it is recommended that these forms be reapproved without change.

SUSPENDED OVERHEAD CROSSING SIGN

Delete the following six drawings from the Manual since a canvass of various manufacturers shows that suspended overhead crossbuck signs are no longer being used and that only a few have ever been installed.

Page 9–67 Fig. 11—Suspended Overhead Highway Crossing Sign.

Page 9–68 Fig. 12—90 Deg. Suspended Overhead Steel Sign Assembly.

Page 9–69 Fig. 13—90 Deg. Suspended Overhead Steel Sign Details.

Page 9–70 Fig. 14—90 Deg. Suspended Overhead Steel Sign Details.

Page 9–71 Fig. 15—90 Deg. Suspended Overhead Reflector Sign Assembly.

Page 9–72 Fig. 16—90 Deg. Suspended Overhead Reflector Sign Details.

Page 9–51

RECOMMENDED USE OF HIGHWAY–RAILWAY GRADE CROSSING SIGNS

Reapprove with necessary changes in page references and delete fifth and sixth sections.

Page 9–111

REQUISITES FOR AUTOMATIC CROSSING GATES

Reapprove with the following changes:

Revise Art. 2(a) to read as follows:

An automatic gate, when installed, shall be mounted as shown on drawings of Highway Crossing Signal—Flashing Light Type with Suspended Lights and Mast-Mounted Gate, and Highway Crossing Signal—Flashing-Light Type with Extended Lights and Pedestal-Mounted Gate.

Withdraw Art. 3(a) and reletter (b) and (c) to (a) and (b).

Page 9–112

LAMPS ON CROSSING GATES

Reapprove with the following changes:

Revise title to read:

LAMPS ON MANUALLY-OPERATED CROSSING GATES

Delete subheading "Manually-Operated Crossing Gates."

Delete subheading "Automatic Crossing Gates" and Arts. 6, 7, 8 and 9.

The deletions of Arts. 6, 7, 8 and 9 are due to the fact that this material is covered on page 9–111.

Page 9–54 Fig. 2—Highway Crossing Sign, 50° Reflector Type—Assembly.

Page 9–59 Fig. 7—90° Reflector Crossing Sign Assembly.

Page 9–97 Fig. 2—Highway Crossing Signal Assembly, Flashing-Light Type.

Page 9–98 Fig. 3—Highway Crossing Signal Assembly, Flashing-Light Type.

Page 9–99 Fig. 4—Highway Crossing Signal Assembly, Wig-wag Type.

Page 9–100 Fig. 5—Highway Crossing Signal Assembly, Wig-wag Type.

Page 9–103 Fig. 8—Highway Crossing, Flashing-Light Signal Assembly, 6-Ft and 12-Ft Cantilever Span.

Page 9–104 Fig. 9—Highway Crossing, Flashing-Light Signal Assembly, 10-Ft and 12-Ft Cantilever Span.

Page 9–116 Fig. 4—Automatic Crossing Gate and Signal Assembly.

Page 9–118 Fig. 6—Highway Crossing Signal, Flashing-Light Type with Extended Lights and Pedestal-Mounted Gate Assembly.

Replace the above ten drawings with the following ten drawings, respectively:

Highway Crossing Sign, 50° Reflector Type.

Highway Crossing Sign, 90° Reflector Type for 4 to 8-In Pipe.

Highway Crossing Signal, Flashing-Light Type with Stop on Red Signal Sign.

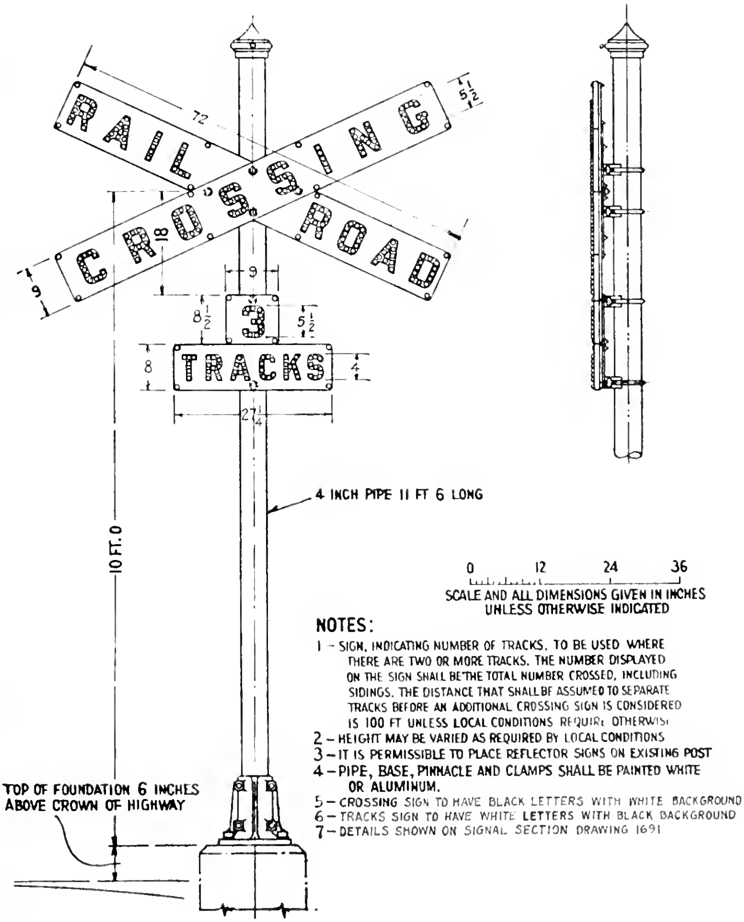
Highway Crossing Signal, Flashing-Light Type with Stop Sign.

Highway Crossing Signal, Wig-wag Type with Stop When Swinging Sign.

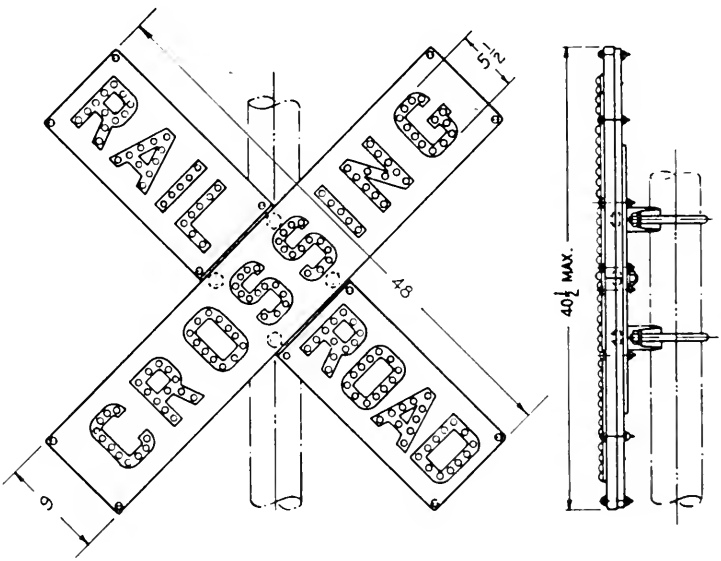
Highway Crossing Signal, Wig-wag Type with Stop Sign.

Highway Crossing Signal, Flashing-Light Type, 6-Ft and 8-Ft Cantilever Span.

(Continued on page 479)



HIGHWAY CROSSING SIGN
50° REFLECTOR TYPE



NOTES:

1 - CROSSING SIGN TO HAVE BLACK LETTERS WITH WHITE BACKGROUND.

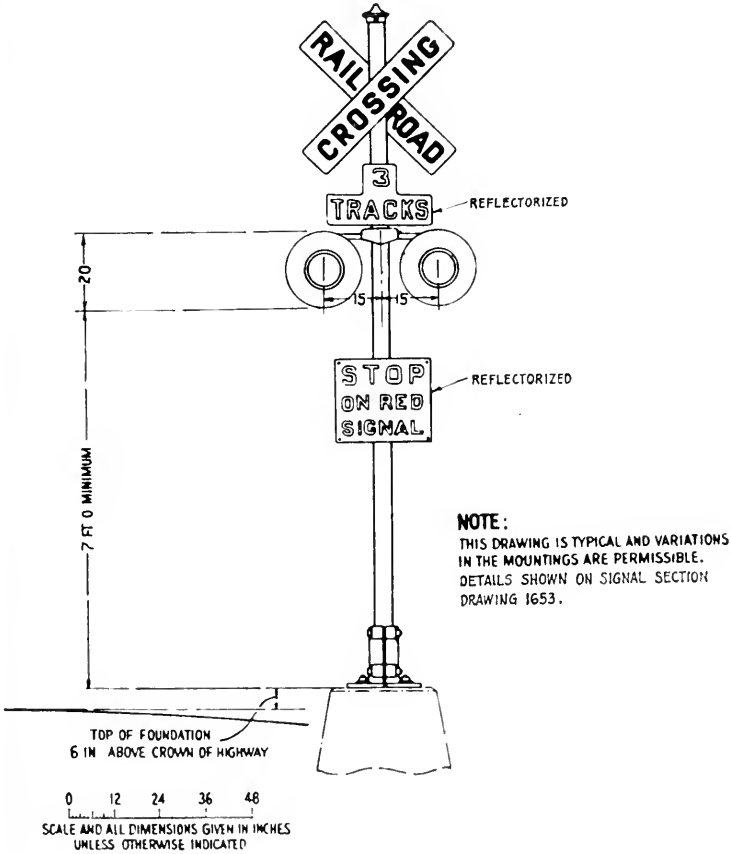
2 - DETAILS SHOWN ON SIGNAL SECTION DRAWING 1642.

0 6 12 24

SCALE AND ALL DIMENSIONS GIVEN IN INCHES

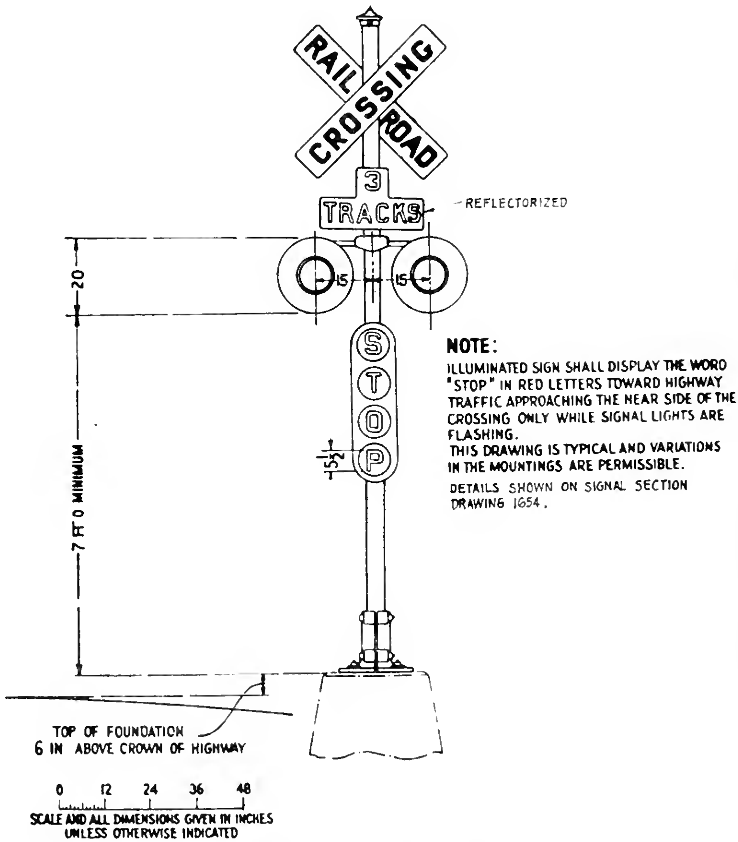
HIGHWAY CROSSING SIGN

90° REFLECTOR TYPE FOR 4 TO 8-IN PIPE



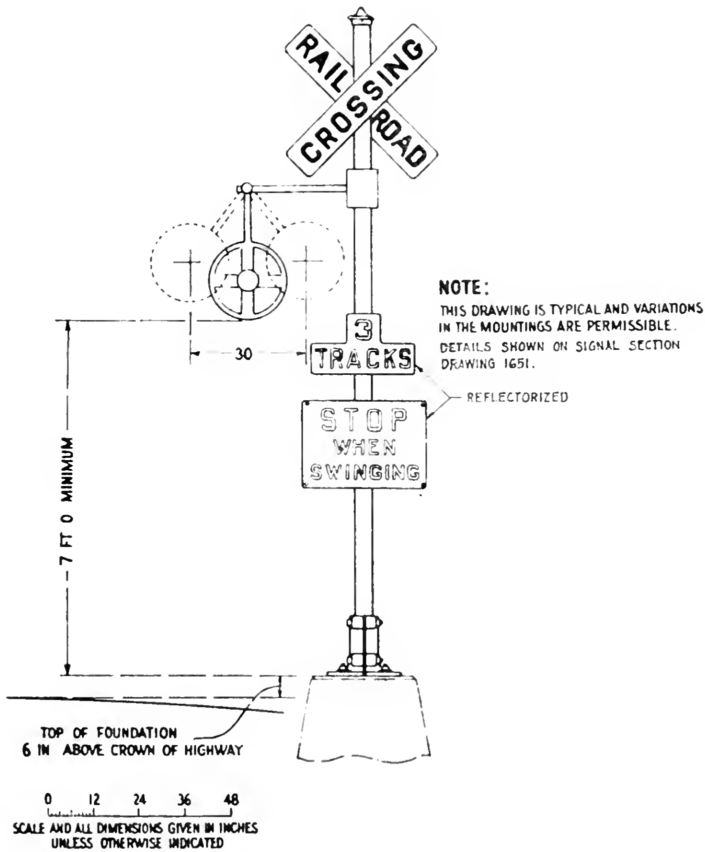
HIGHWAY CROSSING SIGNAL

FLASHING-LIGHT TYPE WITH STOP ON RED SIGNAL SIGN.



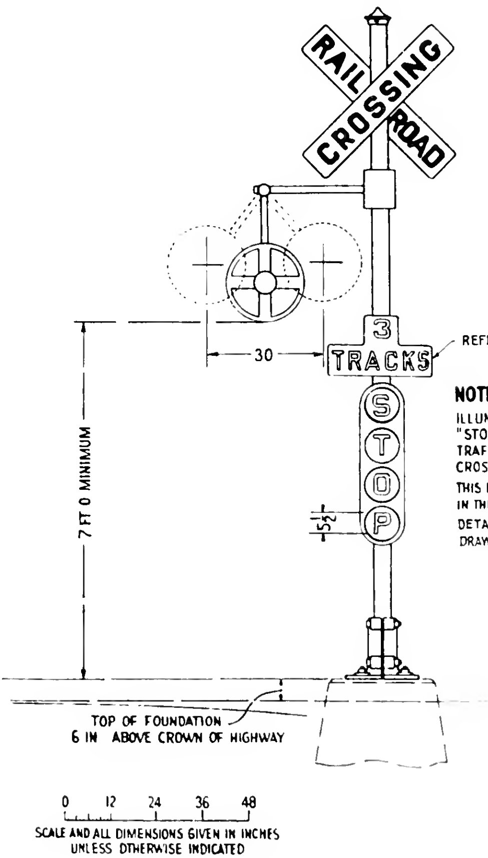
HIGHWAY CROSSING SIGNAL

FLASHING-LIGHT TYPE WITH STOP SIGN.



HIGHWAY CROSSING SIGNAL

WIG-WAG TYPE WITH STOP WHEN SWINGING SIGN.



NOTE:

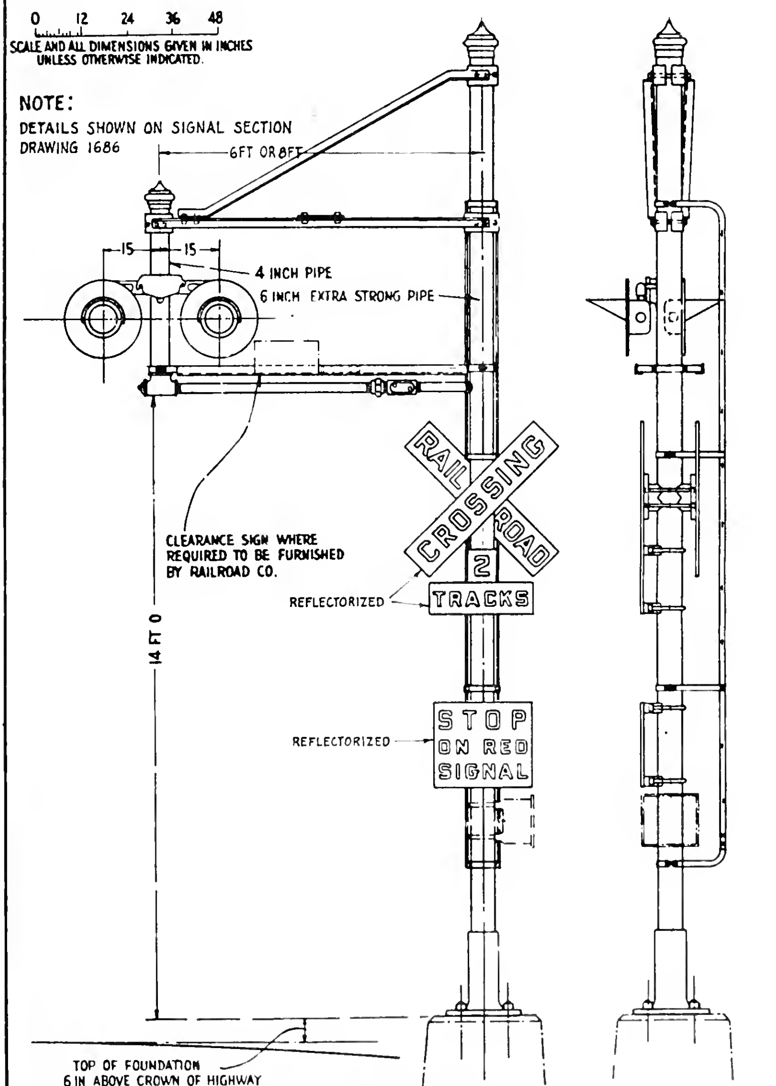
ILLUMINATED SIGN SHALL DISPLAY THE WORD "STOP" IN RED LETTERS TOWARD HIGHWAY TRAFFIC APPROACHING THE NEAR SIDE OF THE CROSSING ONLY WHILE WIG-WAG IS SWINGING.

THIS DRAWING IS TYPICAL AND VARIATIONS IN THE MOUNTINGS ARE PERMISSIBLE

DETAILS SHOWN ON SIGNAL SECTION DRAWING 1652.

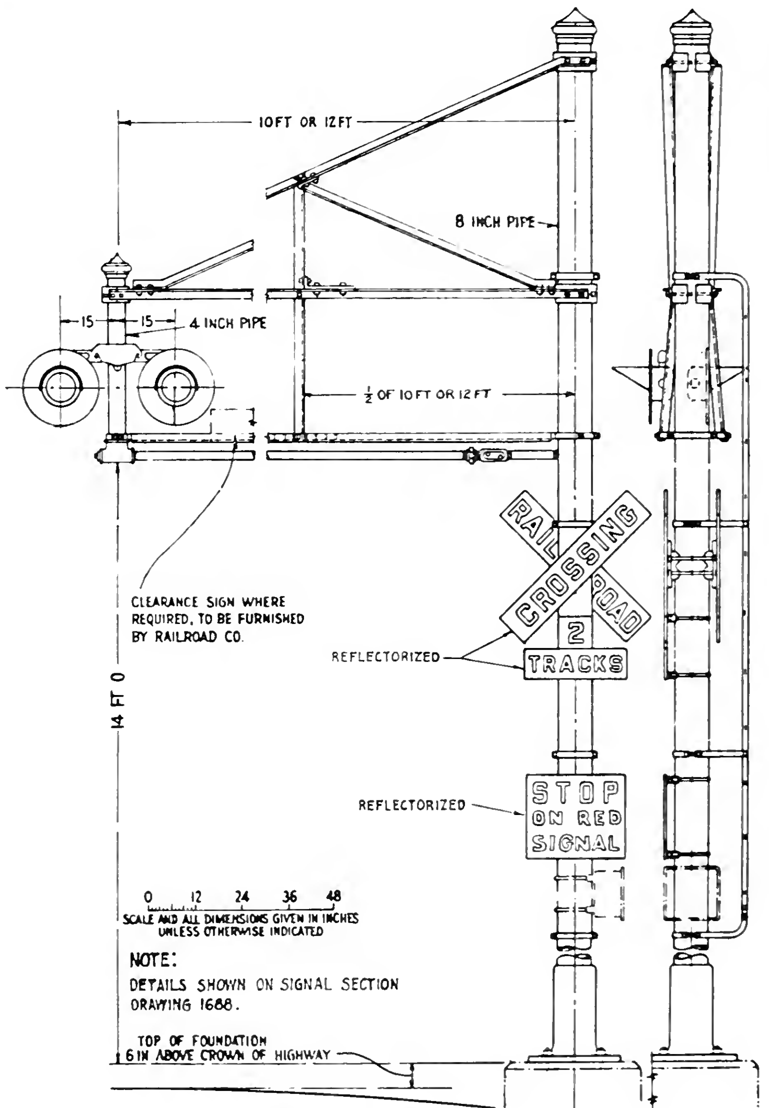
HIGHWAY CROSSING SIGNAL

WIG-WAG TYPE WITH STOP SIGN.



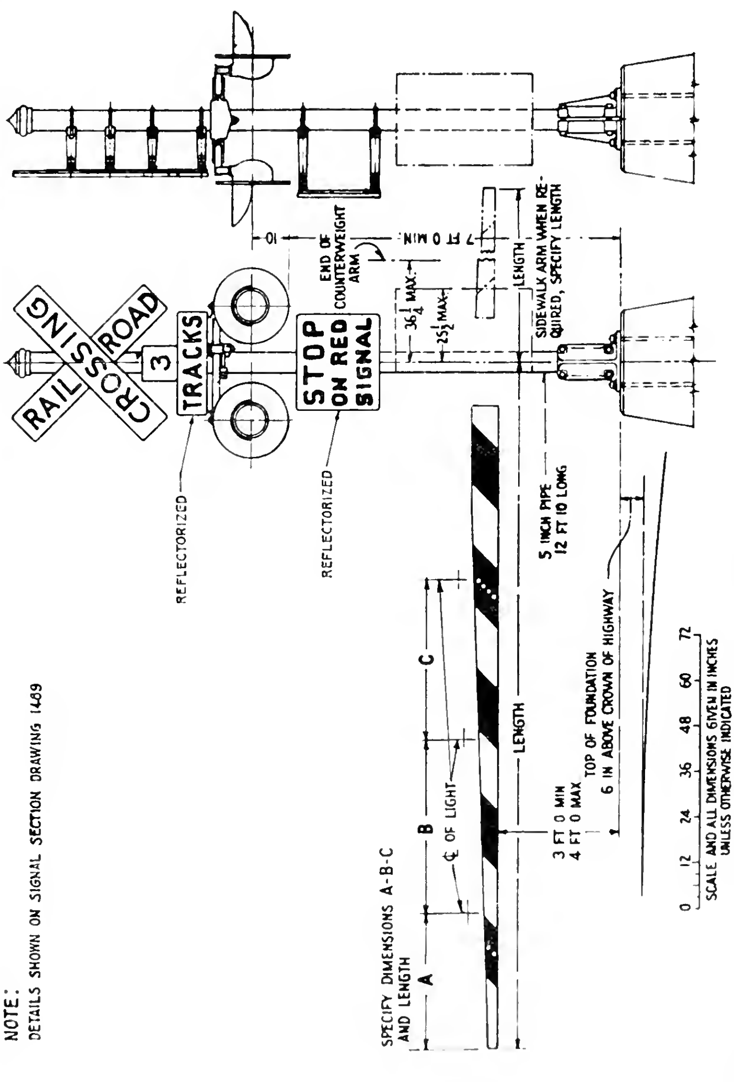
HIGHWAY CROSSING SIGNAL

FLASHING-LIGHT TYPE, 6 FT AND 8 FT CANTILEVER SPAN.



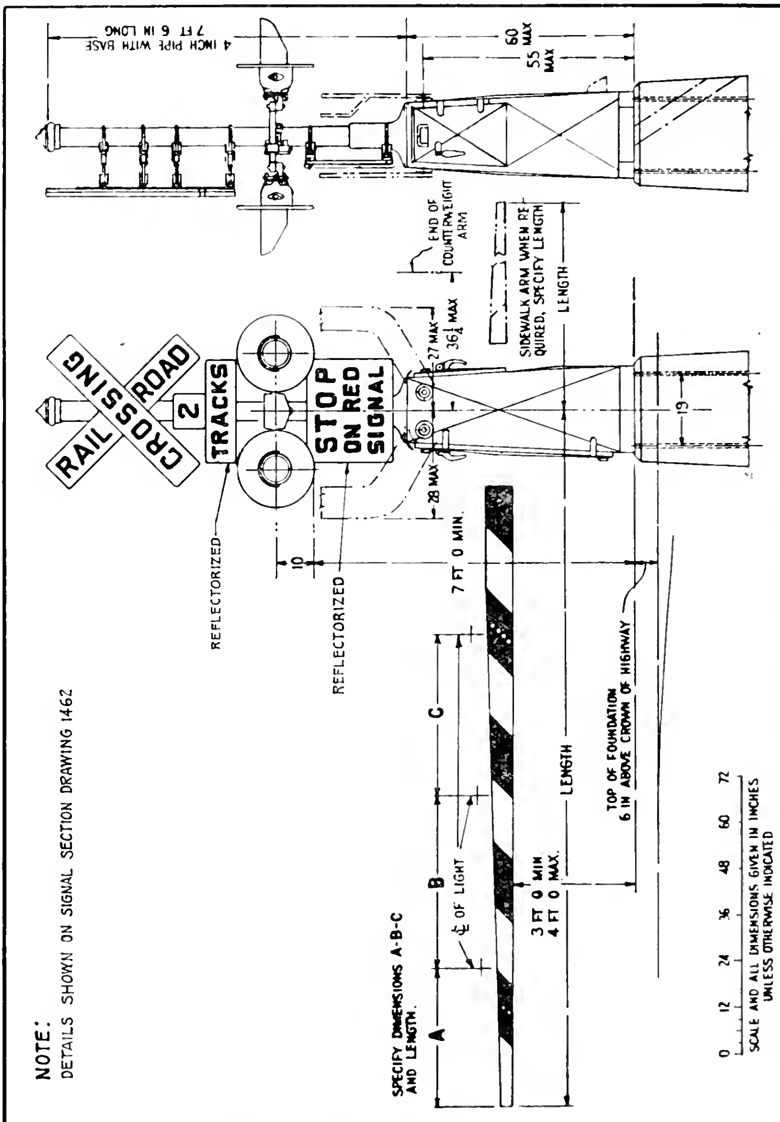
HIGHWAY CROSSING SIGNAL

FLASHING-LIGHT TYPE, 10 FT AND 12 FT CANTILEVER SPAN.



HIGHWAY CROSSING SIGNAL

FLASHING-LIGHT TYPE WITH EXTENDED LIGHTS AND MAST-MOUNTED GATE.



HIGHWAY CROSSING SIGNAL

FLASHING-LIGHT TYPE WITH EXTENDED LIGHTS AND PEDESTAL-MOUNTED GATE.

Highway Crossing Signal, Flashing-Light Type, 10-Ft and 12-Ft Cantilever Span.

Highway Crossing Signal, Flashing-Light Type with Extended Lights and Mast-Mounted Gate.

Highway Crossing Signal, Flashing-Type with Extended Lights and Pedestal-Mounted Gate.

The new drawings, which are presented on pp. 469 to 478, incl., show only important details and dimensions and refer to the corresponding Signal Section drawings. This will simplify the AREA drawings and avoid the necessity for constant revision to cover detail changes on the Signal Section drawings.

Page 9–55 Fig. 3—50° Reflector Crossing Sign Assembly.

Page 9–56 Fig. 4—50° Reflector Crossing Sign Details.

Page 9–58 Fig. 6—Cast Iron Multiple-Track Sign.

Page 9–60 Fig. 8—90° Reflector Crossing Sign Details.

Page 9–61 Fig. 9—Reflector Multiple-Track Sign.

Page 9–62 Fig. 10—Details of Numerals for Track Signs.

Page 9–101 Fig. 6—Reflector Stop on Red Signal Sign.

Page 9–102 Fig. 7—Reflector Stop When Swinging Sign.

Page 9–117 Fig. 5—Crossing Gate Arm.

Withdraw the above nine detail drawings as they may be found in the Signal Section Manual when needed, by reference to AREA assembly drawings.

Page 9–53

Fig. 1—Painted Highway Crossing Sign 6 Ft, 50° Type.

Replace with new drawings (see p. 480) having same title.

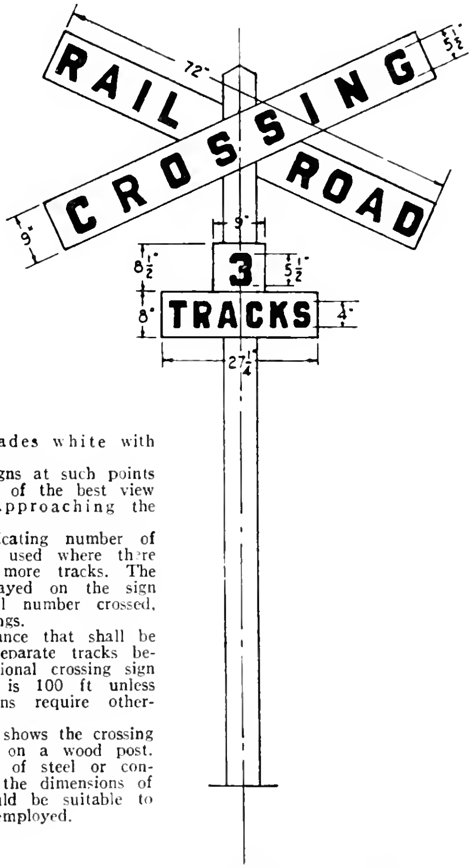
Page 9–57

Fig. 5—90° Cast Iron Crossing Sign.

Replace with new drawing (see p. 481) entitled:

Painted Highway Crossing Sign 4 Ft, 90° Type.

(Text continued on page 482)



Paint blades white with black letters.

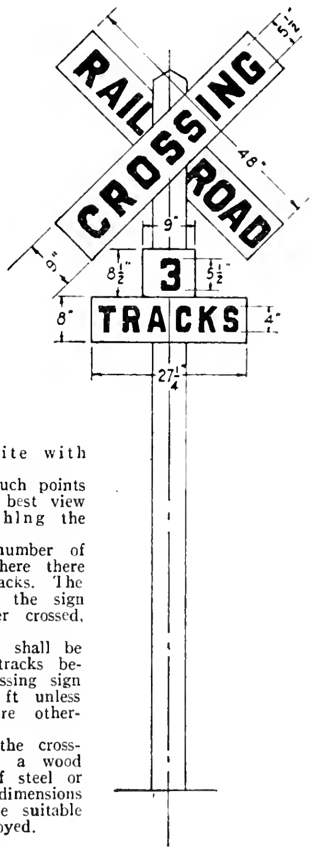
Locate signs at such points as will admit of the best view by persons approaching the crossing.

Sign indicating number of tracks to be used where there are two or more tracks. The number displayed on the sign shall be total number crossed, including sidings.

The distance that shall be assumed to separate tracks before an additional crossing sign is considered is 100 ft unless local conditions require otherwise.

The plan shows the crossing sign mounted on a wood post. When a post of steel or concrete is used the dimensions of the post should be suitable to the material employed.

PAINTED HIGHWAY CROSSING SIGN
6 FT 50" TYPE.



Paint blades white with black letters.

Locate signs at such points as will admit of the best view by persons approaching the crossing.

Sign indicating number of tracks to be used where there are two or more tracks. The number displayed on the sign shall be total number crossed, including sidings.

The distance that shall be assumed to separate tracks before an additional crossing sign is considered is 100 ft unless local conditions require otherwise.

The plan shows the crossing sign mounted on a wood post. When a post of steel or concrete is used the dimensions of the post should be suitable to the material employed.

PAINTED HIGHWAY CROSSING SIGN
4 FT 90° TYPE.

Page 9–95 Fig. 1A—Typical Location Plans for Highway Crossing Signals.

Page 9–96 Fig. 1B—Typical Location Plans for Highway Crossing Signals.

Page 9–113 Fig. 1 —Typical Location Plan for Automatic Crossing Gates, Case 1.

Page 9–114 Fig. 2 —Typical Location Plan for Automatic Crossing Gates, Case 2.

Page 9–115 Fig. 3 —Typical Location Plan for Automatic Crossing Gates, Case 3.

Replace the above five drawings with the following four drawings, respectively:

Typical Location Plan for Automatic Crossing Gates and Flashing-Light Signals. Right Angle Crossing.

Typical Location Plan for Automatic Crossing Gates and Flashing-Light Signals. Acute Angle Crossing.

Typical Location Plan for Automatic Crossing Gates and Flashing-Light Signals. Obtuse Angle Crossing.

Typical Curb and Gutter Location Plan for Automatic Crossing Gates and Flashing-Light Signals.

Page 9–26

REQUISITES FOR FLOODLIGHTING OF HIGHWAY-RAILWAY GRADE CROSSINGS

Reapprove with the following changes:
Withdraw Art. 12 and substitute the following wording:

12. Floodlighting, when used, should illuminate the crossing to show the presence of trains at the crossing. It must not be used as a substitute for warning signals to indicate the approach of trains.

Reapprove the following documents without change (all of these documents, except one, were either adopted or revised since 1947):

Pages 9–5 and 9–6

SPECIFICATIONS FOR THE CONSTRUCTION OF BITUMINOUS CROSSINGS

Pages 9–7 and 9–8

SPECIFICATIONS FOR THE CONSTRUCTION OF PLANK CROSSINGS

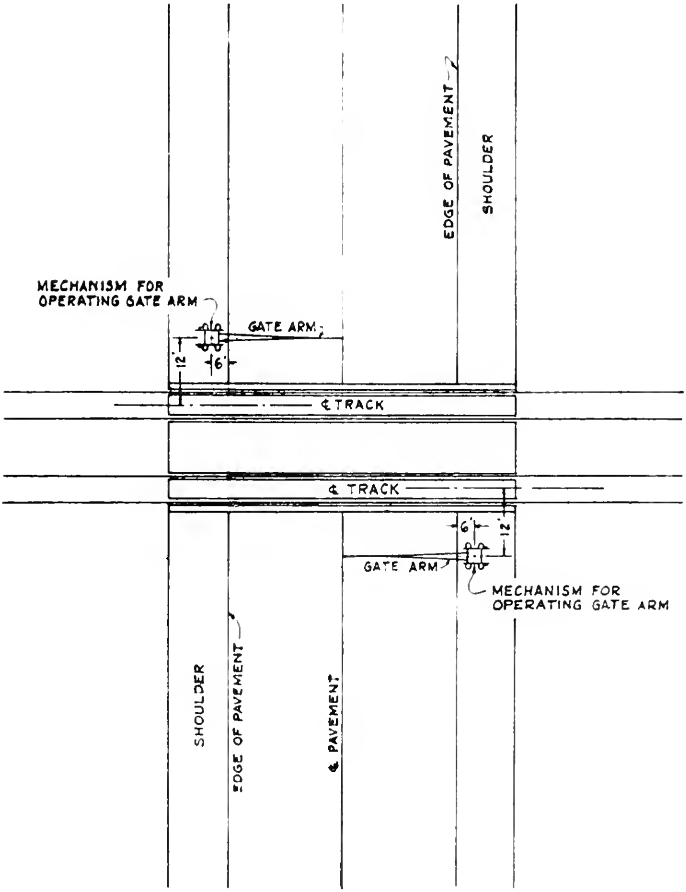
Pages 9–9 and 9–10

SPECIFICATIONS FOR THE CONSTRUCTION OF PREFABRICATED SECTIONAL TREATED TIMBER CROSSINGS

Pages 9–13 and 9–14

SPECIFICATIONS FOR THE CONSTRUCTION OF PRECAST CONCRETE SLAB CROSSINGS

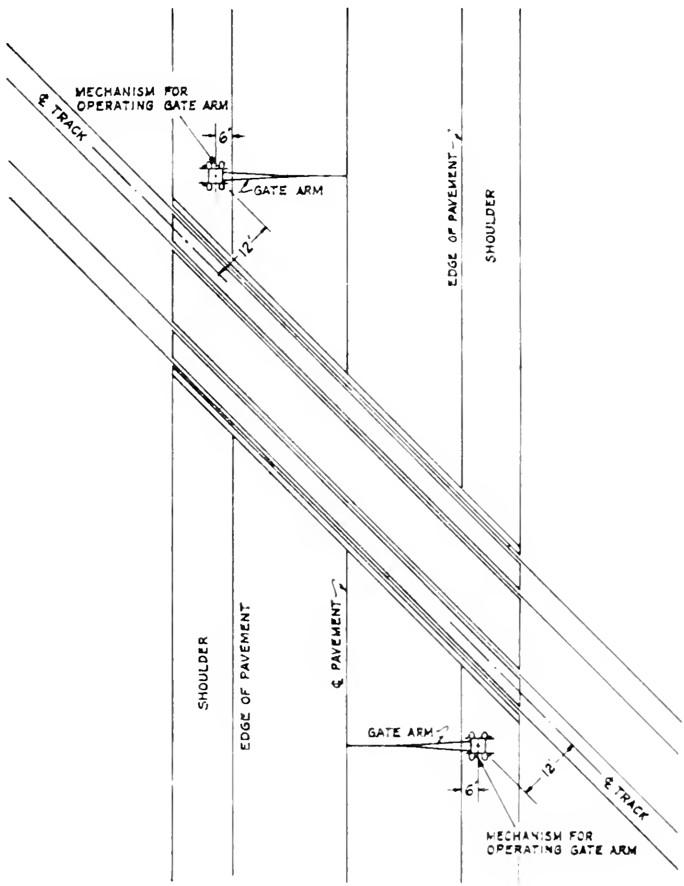
(Text continued on page 487)



PLAN

TYPICAL LOCATION PLAN FOR AUTOMATIC CROSSING GATES AND FLASHING-LIGHT SIGNALS.

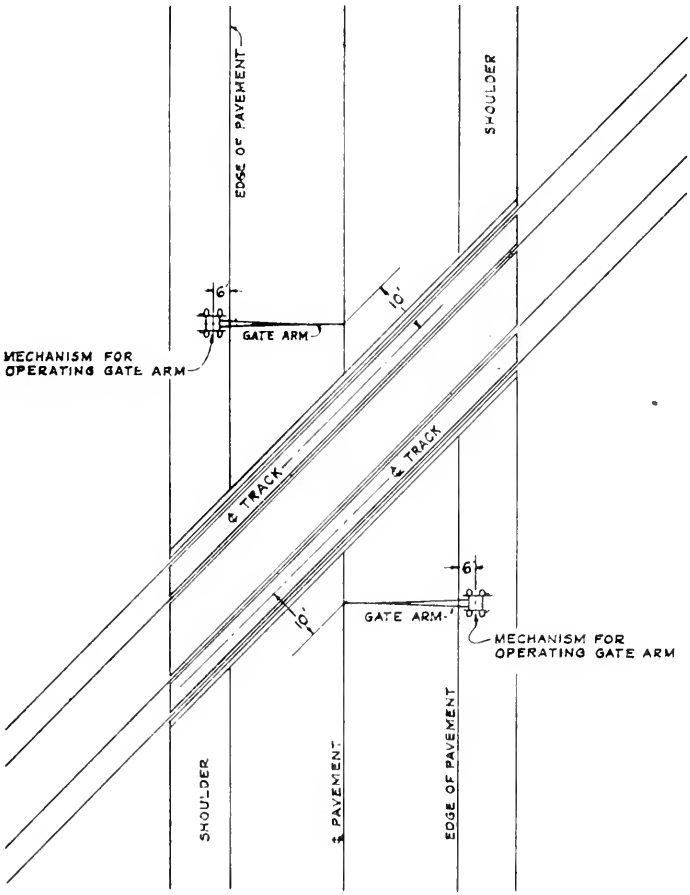
RIGHT ANGLE



PLAN

TYPICAL LOCATION PLAN FOR AUTOMATIC CROSSING GATES AND FLASHING-LIGHT SIGNALS.

ACUTE ANGLE.

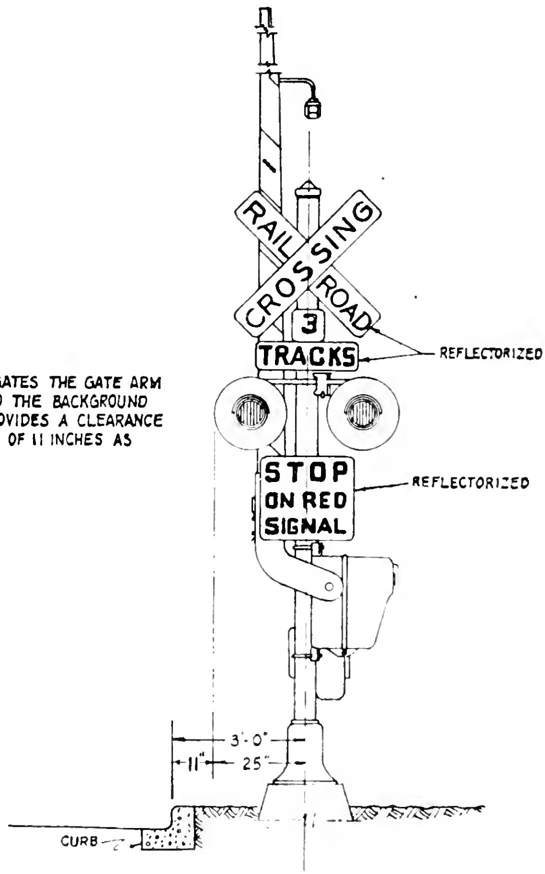


PLAN

TYPICAL LOCATION PLAN FOR AUTOMATIC CROSSING GATES AND FLASHING-LIGHT SIGNALS.

OBTUSE ANGLE.

NOTE:
ON SOME TYPES OF GATES THE GATE ARM EXTENDS OUT BEYOND THE BACKGROUND 3 INCHES, WHICH PROVIDES A CLEARANCE OF 8 INCHES INSTEAD OF 11 INCHES AS SHOWN ON DRAWING.



TYPICAL CURB AND GUTTER LOCATION PLAN
FOR AUTOMATIC CROSSING GATES AND FLASHING-LIGHT SIGNALS.

Pages 9–17 to 9–19, incl.

SPECIFICATIONS FOR THE CONSTRUCTION OF MONOLITHIC CONCRETE CROSSINGS

Pages 9–21 and 9–22

SPECIFICATIONS FOR THE CONSTRUCTION OF TRACKS IN A PAVED AREA

Page 9–25

PROTECTING HIGHWAY—RAILWAY GRADE CROSSINGS AND FLANGEWAYS

Page 9–25

USE OF CENTER COLUMNS FOR HIGHWAY GRADE SEPARATIONS

Pages 9–29 to 9–32, incl.

TYPES OF BARRIERS FOR DEAD-END STREETS

Pages 9–43 and 9–44

LOCATION OF HIGHWAYS PARALLEL WITH RAILWAYS

Page 9–77

REFLECTOR "WATCHMAN OFF DUTY" SIGN

Page 9–78

REFLECTOR "GATES NOT WORKING" SIGN

Page 9–79

MOUNTING OF REFLECTOR SIGNS

Page 9–80

COVER PLATES FOR SIGNS

Page 9–105

REQUISITES FOR "NO RIGHT TURN" OR "NO LEFT TURN" SIGNALS

Reapprove the following with the necessary changes in Manual page references:

Page 9–20

RECOMMENDED USE OF VARIOUS TYPES OF HIGHWAY–RAILWAY GRADE CROSSINGS

Page 9–91

RECOMMENDED USE OF HIGHWAY–RAILWAY GRADE CROSSING SIGNALS

Page 9–91

RECOMMENDED USE OF FLOODLIGHTING

Pages 9–93 and 9–94

REQUISITES FOR HIGHWAY GRADE CROSSING SIGNALS

Reapprove the following drawing, with the elimination of the Signal Section, AAR, reference:

Page 9–106

"NO RIGHT TURN" AND "NO LEFT TURN" SIGNAL ASSEMBLY

Other recommendations for Manual revision in Chapter 9 are shown under Assignments 4 and 8.

Report on Assignment 2

Design and Specifications of Open-Grating Type Crossings

R. E. Nottingham (chairman, subcommittee), H. D. Blake, Bernard Blum, D. A. Bryan, P. W. Elmore, L. W. Green, W. H. Huffman, R. J. Pierce, B. M. Stephens, V. R. Walling

This assignment is now under active study to determine the service life of various types of open-grating installations now in use.

The committee considers the present available data inadequate for a formal recommendation and desires to continue its study until longer service life has been observed.

Report on Assignment 4

Highway Profile at Highway–Railway Grade Crossings

J. S. Findley (chairman, subcommittee), F. N. Beighley, O. C. Benson, H. D. Blake, M. H. Corbyn, L. W. Green, J. T. Hoelzer, W. H. Huffman, J. R. C. Macredie, R. W. Middleton, R. J. Pierce, H E Snyder, D. A. Steel.

Your committee offers the following recommendations with respect to the Manual, for adoption:

Pages 9–1 and 9–2

GENERAL SPECIFICATIONS FOR HIGHWAY GRADE CROSSING OVER RAILROAD TRACKS

(9–1) Reapprove Art. 1 without change.

Delete sketch shown as Fig. 1 and revise Art. 2 to read as follows:

2. Profile of Crossing and Approaches

Where crossings involve two or more tracks, the top of rails for all tracks shall be brought to the same plane where practicable. The surface of the highway shall be in the same plane as the top of rails for a distance of 2 ft outside of rails for either multiple or single-track crossings. The top of rail plane shall be connected with the grade line of the highway each way by vertical curves of such length as is required to provide riding conditions and sight distances normally applied to the highway under consideration. In no event shall the surface of the highway be more than 3 in higher nor 6 in lower than the top of nearest rail at a point 30 ft from the rail, measured at right angles thereto, unless track superelevation dictates otherwise.

(9–2) Insert new Art. 3 as follows:

3. Width and Surfaces of Approaches

The width of embankments and cuts, exclusive of ditches, shall not be less than 24 ft. The width and surface of roadway on the approaches shall correspond to that of the adjacent highway, and shall have the same number of traffic lanes as the adjoining highway, without extra passing lanes at the crossing.

(9–2) Revise Art. 3 to read as follows:

4. Drainage

In situations where the grade of the highway approach descends toward the crossing, provision shall be made to intercept surface and subsurface drainage and discharge it laterally so that it will not be discharged on the track area. A catch basin with grating extended continuously across the highway surface will serve effectively to intercept surface drainage.

Surface ditches shall be installed. If required, subdrainage with suitable inlets and the necessary provisions for clean-out shall be made to drain the subgrade thoroughly and prevent the formation of water pockets. This drainage shall be connected to a storm water sewer system, if available; if not, connecting metal, concrete or vitrified pipes shall be installed to carry the water a sufficient distance from the roadbed. Where gravity drainage is not available, a nearby sump may provide an economical outlet, or the crossing may be sealed and the roadbed stabilized by using asphalt ballast or its equivalent.

(9–2) Renumber Arts. 4 to 8, making them 5 to 9.

Report on Assignment 5

Factors to be Considered in Classifying Highway–Railway Crossings with Respect to Public Safety

B. M. Stephens (chairman, subcommittee), H. D. Blake, J. A. Droege, Jr., W. R. Dunn, Jr., J. T. Hoelzer, W. H. Huffman, J. A. Jorlett, A. E. Korsell, R. W. Mauer, F. T. Miller, G. P. Palmer, Walker Paul, V. R. Walling, R. E. Warden.

This report is final and is offered as information.

Your committee has concluded that no satisfactory formula can be developed for universal use in determining relative hazards at highway-railway grade crossings or in establishing priorities for improved grade crossing protection. It recognizes, however, that there are certain generally accepted factors which should be considered in reaching a conclusion under any given set of facts and circumstances.

The first progress report on this assignment was submitted in 1949 and appears in the Proceedings, Vol. 50, 1949, pages 244–252. The report consisted of the presentation and brief analyses of a number of formulas developed and applied by various state highway organizations in the matter of classifying highway–railway grade crossings with respect to hazard, and in the matter of determining priorities with respect to providing grade crossing protection.

A subsequent progress report, published in the Proceedings, Vol. 51, 1950, pages 204–206, presented information with respect to a rough draft of suggested policy for automatic protection of highway–railway grade crossings formulated by the Committee on Planning and Design Policies of the American Association of State Highway Officials, and presented to the membership of the AASHO in early 1947. This progress report also presented the critical views of several state highway organizations with respect to the suggested AASHO policy.

It has been ascertained by your committee that only 18 of the nation's state highway organizations have developed or rely upon a formula method for classifying grade crossings. Of the 30 other state highway organizations not using a formula method, 14 rely exclusively upon independent engineering judgment.

It has also been found that a number of the state highway organizations which use a formula method are not at all satisfied with the erratic and inconsistent results obtained from presently used formulas and are endeavoring, consequently, to approach realistic and supportable modifications leading to substantial improvement of the formulas as presently constituted; at least, improvement to the point where their application will produce results more nearly compatible with actual accident records.

So far as your committee has been able to determine, very little progress has been made along such lines, although studies pertaining thereto are still underway. While there has been a substantial accumulation of data pertaining to accident records over a considerable period of time, it appears to be the consensus of those highway people working on the problem that there is still an insufficiency of factual crossing accident data over a long enough period of time and through a wide enough range of conditions to permit the development of a satisfactory, all-purpose formula.

It is pretty well agreed that there are many variable and relatively intangible factors beyond those of traffic volumes, accident records, traffic speeds, and other tangible items usually common to and incorporated in formulas used in evaluating needs for grade crossing protection. Included in these variable and intangible factors are such items as —to list only a few of the more important—coincidence of vehicular and train traffic, range of visibility, elements of distraction or surprise, relationship between total vehicular traffic and volume of vehicular traffic stopped by train movements, and human behavior and mental and physical condition.

Founded upon the various items of information assembled by your committee and the independent studies made by highway authorities, it seems apparent that the development of a satisfactory and universal formula for classifying grade crossings with respect to public safety will likely not be fully accomplished in the foreseeable future.

On this premise, therefore, your committee brings its assignment to a conclusion with the listing of factors which, to one degree or another, enter into evaluation of highway–railway grade crossing hazard. These factors, listed roughly in the order of importance, as mainly indicated by their occurrence in such formulas as are presently in use, are as follows:

Highway Factors

Vehicles per day over crossing.
Vehicular speed over crossing.
Condition of approaches.
Angle of approaches.
Width of approaches.
Sight distances.
Delays to vehicles.
Distraction elements.
Surprise elements.

Railway Factors

Trains per day over crossing.
Sight distances.
Train speed over crossing.
Number of tracks at crossing.
Types of trains over crossing.
Time crossing is blocked.
Condition of crossing.
Time of train appearance.
Train delay account speed restricting ordinances.

Combined and Miscellaneous Factors

Existing type of protection.
Driver visibility conditions
Accident record of crossing.
Coincidence of trains and vehicles.
Condition of vehicles.
Driver behavior.
Driver mental and physical condition.
Economic justification.
Peak traffic period influences.

All of the above listed factors involving physical characteristics affecting crossing hazard may be measured within reasonable limits of accuracy in units of time, distance, angles, etc, each of the factors being subject to laws of limited possibility.

Such factors as surprise elements, driver visibility conditions, vehicular conditions, and driver behavior and mental and physical condition, however, appear to be immeasurable by external physical standards or are so impractical of measurement, unit by unit, as to preclude their establishment as measurable influences on the hazard factor.

Each of the factors listed undoubtedly plays some part, however major or minor, in the establishment of a hazard index. How much weight should be given to any given factor, if any weight is given at all, seems presently to be a moot question, although it is almost universally agreed among the students of the overall problem that several of the factors, namely, daily volumes of train and vehicular traffic, and train and vehicular speeds, play extremely important roles as basic terms in crossing evaluation.

For a statement of the more popular formulas for evaluating grade crossings presently in use, reference is made to the committee's first report on this assignment, published in the Proceedings, Vol. 50, 1949, pages 244–252.

Your committee recommends as highly interesting and informative material a paper titled "Evaluating Hazards at Railroad Grade Crossings", presented at the December 1948 meeting of the Highway Research Board, by W. J. Crecink, Jr., traffic engineer, Highway Planning Division, Mississippi State Highway Department; a paper titled "Hazard Evaluation Formulas for Railway Grade Crossings", presented at December 1947 meeting of the Committee on Planning and Traffic Engineering of the Southeastern Association of State Highway Officials, by C. A. Rothrock, state planning engineer, Planning Division, The State Road Commission of West Virginia; and a paper entitled "The Railway-Highway Grade Crossing Problem", by A. Kenneth Beggs, Senior Economist, Stanford Research Institute, dated 1952.

Report on Assignment 6

Economics of Highway–Railway Grade Separations

J. E. K. Krylow (chairman, subcommittee), H. D. Blake, J. A. Droege, Jr., G. A. Heft, W. H. Huffman, J. A. Jorlett, A. E. Korsell, R. W. Mauer, F. T. Miller, Walker Paul, D. A. Steel, R. R. Thurston, J. M. Trissal, J. W. Wheeler.

This is a progress report, submitted as information. Highway–railway grade separations are problems involving railroads, highways and the transportation of people and commodities. The economics of such grade separations are far reaching and involve many factors.

Highway–railway grade separations are generally the result of public demands. Since the beginning of the railroads in the Eighteen Thirties, highway–railway crossings at grade have been a problem to both the public and the railroads, increasing in importance as the number of highway vehicles increase, and as communities develop and the population increases.

During the early growth of the railroads, and until 1893 when the first successful motor vehicle appeared on the highway, the problems of such grade crossings were of mutual interest to the public and the railroads. Such problems were usually restricted to traffic hazards and involved slow moving highway vehicles, with infrequent density of traffic. Under these conditions, the determining factor in the demand for grade crossing separations was based on the elimination of accidents. As the number and use of motor vehicles increased, the inconvenience and delays to highway users, at grade crossings, with the resultant effect on their economics, took precedent over the factor of safety in the demands for grade separations.

As the development of the motor vehicle progressed and this new form of transportation made use of the existing highways, many of which were not suitable for motor vehicle travel, it attracted attention and created interest towards the improvement of highways and the development of highway systems. During this same period the railroads continued their steady expansion, with the result that the number of highway–railway crossings at grade was greatly increased. With this changed condition, affecting a greater number of highway users, the problems of highway–railway crossings at grade became vital from a traffic delay standpoint, and the need for crossing improvements or elimination, already a matter of State and Federal legislation, received more attention.

During the last 30 years the primary conditions which usually determine the need to provide highway–railway grade separations, and the order of importance by which they are generally authorized, have been as follows:

1. Elimination of motor vehicle delays.
2. Elimination of crossing hazards.
3. Improvement of railroad operation.

Prior to the extensive use of the motor vehicle, the investment made by the railroads for highway–railway grade separations was justified on the theory that they were benefited inasmuch as the highways were used to deliver freight to the railroads. Under these conditions, the three means of moving people and goods over land, namely, horse-drawn vehicles, motor vehicles and railroads, formed a common transportation system that was cooperative, and not competitive within itself. As the number of motor vehicles increased and extended their radius of operation, they replaced the horse-drawn vehicle and became a separate and successful competitive form of transportation in the moving of people and goods, both private and public. This condition, with legislation that provides favorably for the highway transportation and penalizes the railroads, has a direct unfavorable effect on the economics of the railroads.

As the economics of highway–railway grade separations directly involve motor vehicles, highway systems and the general public, it is felt that certain statistics issued as public information by the Federal Authorities will be of interest, and they are thus appended to this report.

In 1900, when the population was 76 millions, statistics isued by the U S Bureau of Public Roads indicate there were 8000 motor vehicles in the United States, and that up to that time only one state had created a State Highway System. By 1925, when the population had reached 115 millions, there were 19,940,724 motor vehicles, and every state had organized a State Highway System.

As shown by the above figures, there was a great change in our system of land transportation between 1900 and 1925. The motor vehicle, first a luxury, and later a convenience, and almost a necessity, had replaced the horse and buggy, and had so well established itself as a means of convenient and efficient transportation that it demanded, and received, a great deal of attention and support. Due to the conditions outlined, it was during this period that the problem of highway–railway grade separation became vital from a physical as well as a financial standpoint.

Fig. 1 indicates in graphic form the rapid increase of highway use by motor vehicles

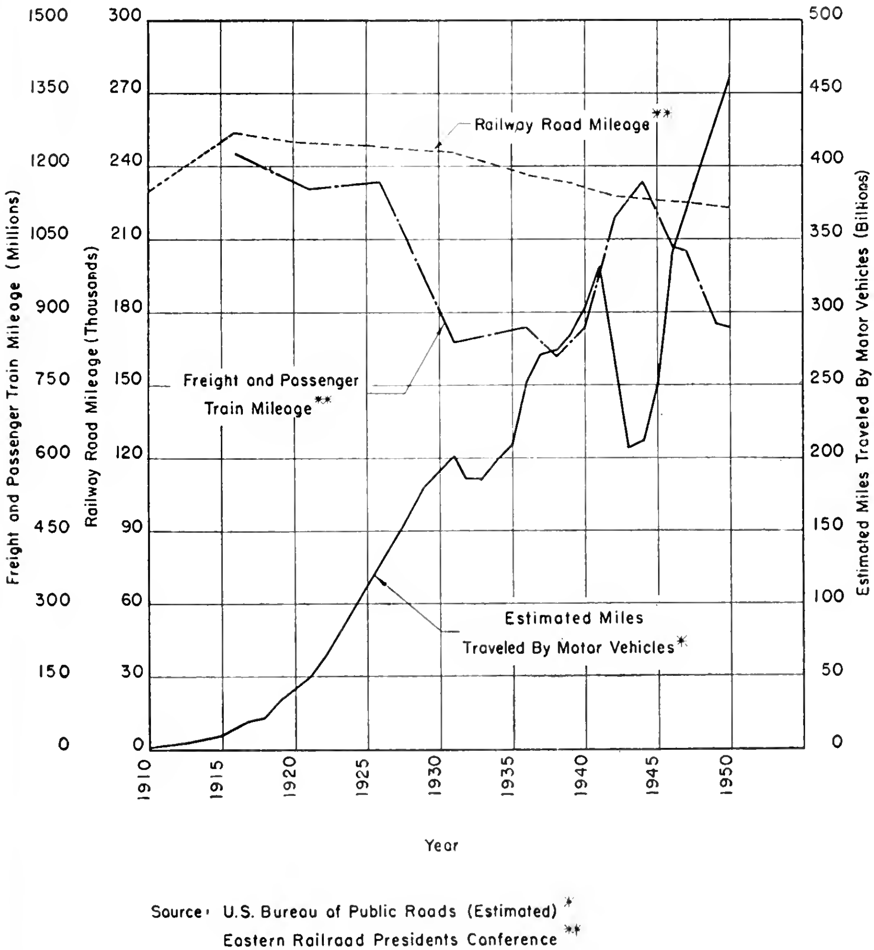


Fig. I

Railway Road Mileage and Train Mileage in Relation to Motor Vehicle Mileage and the resultant effect on railroad operation in the last 35 years. Since the Eighteen-Thirties, when the interest in railroads spread over the United States, until 1916, there was a steady increase in railroad construction. According to Moody's compilation, and the Eastern Railroad Presidents Conference, railway road mileage reached 230,000 miles in 1910, and in 1916 reached the peak of 254,251 miles. After 1916 abandonments exceeded new construction and mileage steadily declined to about 224,500 miles in 1950, a decrease of 29,751 road miles, or 11.7 percent. Train mileage in this 35-year period also declined 28.7 percent. In 1916, when railroad mileage reached its peak, there were only 3,617,937 motor vehicles in the United States. After 1916 the number of motor vehicles increased very rapidly, reaching 49,161,691 in 1950.

The graph also shows that estimated motor vehicle mileage had increased from 16.5 billions in 1916 to 463.5 billions in 1950. The effect of restrictions as to manufacture and use of motor vehicles during the Second World War period are reflected on the graph, as a very heavy decrease in motor vehicle mileage. During this same period there was a sharp increase in train mileage, which was the result of these restrictions and the necessity for the railroads to handle the extra load caused by the war.

Fig. 2 indicates the population, number of motor vehicles and other associated information compiled from statistics issued by the U S Bureau of Public Roads and Bureau of Census. In 1950, when the population was 150 millions, 49,161,691 motor vehicles were registered, including 8,604,448 trucks and 223,652 busses. There were over 62 million licensed motor vehicle operators. The total distance traveled by motor vehicles during the year was estimated to be over 463 billion miles. There were 3,322,000 miles of highways and streets, which the Interstate Commerce Commission reports crossed the railways at grade at 226,844 locations.

Grade crossings offer an obstruction to highway traffic when trains are approaching or are occupying the crossing. Highway traffic under these conditions must stop until the crossing is clear. Motor vehicles approaching such crossings at maximum lawful speed must stop, wait for the crossing to clear, then start and accelerate to former speed. In most states, busses carrying school children and other passengers are required by law to stop before proceeding over the crossing, even if the crossing is known to be clear. Certain states have further restrictions, such as "reduce speed to 5 mph," "stop before crossing", etc. Even with no trains on or approching such grade crossings, highway traffic, due to approach warning and crossing signs, will, by the observance of such signs, be delayed.

The reduction in speed of a motor vehicle, the starting and stopping of such a vehicle, as well as its stopping and waiting, result in increased cost of operation due to wear on tires and brakes, additional consumption of gasoline, and time lost. These cost figures have been determined to be as follows:

Speed MPH	*Vehicle Operating Costs (Cents)*	*Value of Time Making Stop (Cents)*	*Value of Time Stopped, Based on One Minute (Cents)*	*Total (Cents)*
10–0–10	0.08	...	2.70	2.78
20–0–20	0.23	0.07	2.70	3.00
30–0–30	0.36	0.18	2.70	3.24
40–0–40	0.57	0.34	2.70	3.61
50–0–50	0.97	0.56	2.70	4.23
60–0–60	1.24	0.79	2.70	4.73

The foregoing table was developed from information obtained from the Iowa Engineering Experiment Station in cooperation with the United States Public Roads

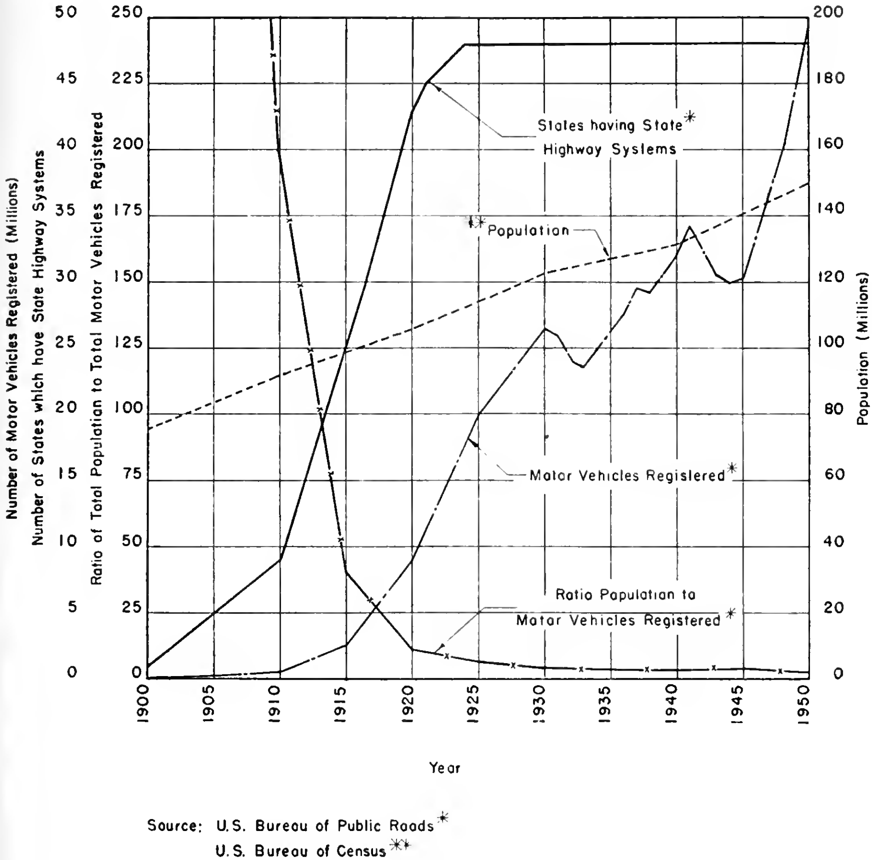


Fig. 2

Growth of the Motor Vehicle Industry in Relation to Population and State Highway Systems

Administration, and was covered in Iowa Engineering Experiment Station Bulletin No. 161, Iowa State College, 1945; Technical Bulletins Nos. 7 and 17, Oregon State Highway Department, 1937 and 1944; Report on the Highway Needs of the National Defense, by the Commissioner of Public Roads Administration, Washington, 1949; Associate Director Wilbus S. Smith, Yale University, Bureau of Highway Traffic, 1951; Deputy Commissioner H. E. Hilts, United States Bureau of Public Roads, 1951; and others.

These figures are for average passenger cars making a normal stop. The "Value of Time Making Stop" is the time lost in the complete act of decelerating to zero velocity and immediately accelerating back to original speed. The "Value of Time Stopped" is based on 1 min standing time, which has been valued at 0.45 cents for each 10 sec.

From the figures given it is estimated that an average passenger car traveling at 50 mph, making a stop at a highway–railway grade crossing and remaining in the stopped position for 1 min, would incur an added cost of 4.23 cents. The added costs, exclusive of standing time, for large loaded trucks and busses, are estimated to be about six times that of an average passenger car. It would be a reasonable estimate that the additional cost for a large commercial motor vehicle traveling at 50 mph, making one stop and standing for 1 min, would be 12 cents, based on the cost of standing time being equal for each type of vehicle.

The average time delay to highway traffic when a train moves over a highway at grade, in high-speed railroad territory, is estimated from field observations to be 1 min for each passenger train and 3 min for each freight train.

The high cost of stopping motor vehicles is well recognized by traffic engineers, and is an important factor in their recommendations for highway traffic control. This high cost has also been recognized by the U S Commissioner of Public Roads in his report on "Highway Needs of the National Defense" 1949, in which it is stated that if the average speed of motor vehicles on 5969 miles of the National System of Interstate Highways in urban territory could be increased from the present computed speed of 21.7 mph, by reducing stops and slowdowns, to 35 mph, the savings in time, based on only 1 cent a minute, excluding costs due to increased wear on tires and brakes and gasoline consumption, would amount to $209 million annually.

Fig. 3 presents very interesting information regarding the costs of highway–railway grade separation and accident reductions as the result of a program completed by the State of New York, which ranks second in the United States in motor vehicle registration. There is no doubt that the grade separations were a large contributing factor to the reduction in accidents; however, it may be assumed that the installation of automatic crossing protection devices at some of the important remaining grade crossings, as well as education of the automobile driving public, also contributed to the accident reduction.

The elimination of highway–railway grade crossings, either by their abandonment or by grade separation, is very desirable and in many instances necessary. However, with 226,844 such grade crossings in service at the close of 1948, as reported by the Interstate Commerce Commission, the problem of determining which crossings should be given preference requires extensive studies by the responsible public authorities.

Formulas now available, or independent engineering judgment used by many of the states, to determine the order of importance in programming grade separation projects, are based primarily on obtaining the greatest benefits to the largest number of highway users. The use of these methods gives no consideration to the physical or economic effects on the railroad.

The recommendations for grade crossing separation on the 37,800 miles of the National System of Interstate Highways was covered by the Commissioner of Public Roads in his report on the "Highway Needs of the National Defense" 1949, and is quoted in part:

> "Railroad Grade Separations
>
> Separation of grade shall be provided at all railroad crossings of two or more main line tracks and at all crossings of single main line tracks on which there are six or more regular train movements daily."

Although these recommendations were based on the needs of the National System of Interstate Highways, there has been a tendency by some highway departments and

STATE OF NEW YORK

HIGHWAY - RAILWAY GRADE SEPARATIONS

1926 - 1949

YEAR	CROSSING PROJECTS						MOTOR VEHICLE REGISTRATION	GRADE CROSSING ACCIDENTS			
	RURAL	COST	URBAN	COST	TOTAL NO.	TOTAL COST		NO. ACCIDENTS	NO. KILLED	NO. INJURED	NO. OF ACCIDENTS PER MILLION REGISTRATION
1926	0		0		0		1,828,543	895	186	571	489
1927	0		1	176,365	1	176,365	1,973,223	791	178	431	401
1928	65	2,597,552	0		65	2,597,552	2,129,331	876	188	570	411
1929	67	5,320,512	2	461,025	69	5,781,537	2,316,484	966	198	550	417
1930	65	4,747,616	4	2,442,014	69	7,189,630	2,365,718	903	183	509	382
1931	45	7,665,409	1	888,631	46	8,554,040	2,361,978	698	119	429	296
1932	26	2,158,659	2	10,367,282	28	12,525,941	2,311,830	603	122	369	261
1933	22	3,252,438	0		22	3,252,438	2,286,524	415	109	253	181
1934	24	3,338,775	2	18,261,630	26	21,600,405	2,341,624	534	86	291	228
1935	17	2,065,097	1	1,373,510	18	3,438,607	2,408,890	447	76	288	186
1936	36	7,193,819	3	2,197,282	39	9,391,101	2,539,942	485	95	317	191
1937	17	3,484,080	1	443,600	18	3,927,680	2,655,879	481	80	282	181
1938	4	653,480	2	3,016,257	6	3,669,737	2,685,004	394	72	224	147
1939	17	3,484,080	1	228,700	18	3,712,780	2,765,088	368	57	227	133
1940	18	4,358,840	3	4,295,229	21	8,654,069	2,866,209	428	71	238	149
1941	9	5,468,792	1	4,540,926	10	10,009,718	2,991,881	506	75	249	169
1942	0		0		0		2,712,566	517	99	225	190
1943	0		0		0		2,379,325	404	64	151	170
1944	0		0		0		2,376,897	411	77	193	173
1945	2	777,800	0		2	777,800	2,471,850	444	85	201	180
1946	0		0		0		2,809,309	436	64	172	155
1947	0		0		0		3,077,254	440	65	172	143
1948	2	8,225,000	0		2	8,225,000	3,354,583	420	60	199	125
1949	8	6,298,400	3	7,580,275	11	13,878,675	3,540,082	398	52	177	112
TOTALS	445	71,090,349	27	56,272,726	472	127,363,075		13,260	2,461	7,288	

THE 472 PROJECTS ELIMINATED 974 HIGHWAY-RAILWAY GRADE CROSSINGS.

FIG. 3

municipalities to use these recommendations as a yard stick for grade separations. The effects of grade separations on the operation of the railroads and the economies which they may derive from such improvements are dependent, to a great extent, on the railroad's financial participation and the resulting physical condition.

The railroads and highways being of vital importance to the nation, each serving a common purpose, and governed by legislative action, the justification of their existence must be accepted.

Grade crossings are a part of the highway system, jointly used by the railroad and the highway user. Each have a certain right and responsibility. As to whether the responsibility of the railroads ends when they provide crossing signs, designating the location of a crossing, as required by legislative action, and maintain the crossing in serviceable condition, is a matter of opinion. To say they shall provide additional protection or provide a grade separation, and the extent to which they shall participate in the cost, have been a matter of state and federal legislative opinions, ranging from one extreme to the other.

Prior to the Nineteen-Thirties, the average apportioned cost of grade separations to the railroads was usually 50 percent, exclusive of right-of-way and miscellaneous costs. This placed a severe financial burden on the railroads.

The Interstate Commerce Commission declared in the 15 percent case in 1931, "that where the burden of grade separation did not add to railway traffic and did not reduce expenses, the cost should be borne by others than the railroads," and the Supreme Court of the United States in the Brandeis opinion said in 1935—"The main purpose of grade separation is now the furtherance of uninterrupted movement by motor vehicles. The railroad has ceased to be the prime incident of danger and the main cause of accident. It is the railroad which now requires protection from the dangers incident to motor transportation." After these opinions were rendered, the trend of legislation and agreements has been to apportion costs on the basis of benefits derived by each interest.

Complete records for the nation on grade separations, their costs, and the apportionment of costs are not available. The result of the most recent survey of this matter, and the most complete now available, was issued March 1, 1952, by the Tax Research Association of Houston and Harris County, Inc., Texas, and mentions in part "from 1939 to 1950 the T. R. A. survey shows that taxpayers bore over 90 percent of highway–railway grade crossing elimination costs, and the railroads less than 10 percent." The T. R. A. survey covered 37 states, the District of Columbia, and 25 metropolitan cities. The apportionment of costs are quoted as follows:

Source of Revenue	*Percent of Total Cost in 37 States and the District of Columbia*	*Percent of Total Cost in 26 Metropolitan Cities*
Federal Government	54.75	21.13
State Government	35.53	46.38
County Government	.93	4.93
City Government	1.41	20.65
Railroads	7.24	6.79
Special Taxes	0.12	0.12

In analyzing these apportionments of costs, it must be recognized that the taxation of railroads is one means of providing the funds for the five other sources of revenue.

The development of high-speed motor vehicles and the construction of improved highways have shifted the greater portion of the burden of responsibility for hazards at grade crossings to the highway user, and the railroads now require safeguards from the dangers and delays due to motor vehicle transportation. In this connection, we cannot overlook the Supreme Court of the United States in the Brandeis opinion, which was issued in 1935, when the total motor vehicle registration was less than 27 millions. Further, to justify this changed condition, the Rail–Highway Grade Crossing Accident Report for 1950, as issued by the Interstate Commerce Commission, Bureau of Transport Economics and Statistics, shows that of the 3696 motor vehicles—train accidents at grade crossings, 1204, or 32.58 percent, were due to motor vehicles running into the side of the train.

With the large number of motor vehicles now on the highways, averaging approximately one motor vehicle for every three persons, Public Press Publication by the Philadelphia Automobile Trade Association states that more than 95 percent of the 40 million privately owned passenger cars are used partly or entirely for essential transportation, and 63 percent of all their trips are for the purpose of enabling their owners to do the work that is their source of livelihood. Approximately 9 million trucks and busses carry on freight and passenger transportation. As each motor vehicle averages approximately 10,000 miles yearly, motor vehicle transportation appears to be a highly commercialized facility, which should not depend on other transportation facilities to improve its operating conditions.

Report on Assignment 7

Sight Distance at Highway–Railway Grade Crossings

J. M. Trissal (chairman, subcommittee), H. D. Blake, C. O. Bryant, M. H. Corbyn, P. W. Elmore, A. S. Haigh, C. I. Hartsell, W. H. Huffman, J. R. C. Macredie, R. E. Nottingham, Walker Paul, W. C. Pinschmidt, H. E. Snyder.

Your committee is giving study to the question of sight distance at highway–railway grade crossings. This subject is also receiving consideration by the several State Commissions, as well as the American Association of State Highway Officials.

Several formulas have been advanced for the determination of the size of triangle to be left vacant to provide unobstructed view of the crossing. These formulas involve consideration of the speed of vehicles as well as of trains.

Due to the complexity of the situation, your committee is not prepared to make recommendation at the present time. However, the committee is considering recommending that, for highway–railway grade crossings which are not provided with automatic crossing protection, and where the speed of highway traffic is low, the railway might consider entering into an agreement to restrict the occupancy of its right-of-way by buildings for a distance of not more than 300 ft, measured along the track from the highway crossing, provided that the highway department likewise restricts the existence of buildings along the highway.

Report on Assignment 8

Widths of Multiple-Lane Highways at Highway–Railway Grade Crossings

C. I. Hartsell (chairman, subcommittee), H. D. Blake, Bernard Blum, W. R. Dunn, Jr., P. W. Elmore, J. S. Findley, W. H. Huffman, R. W. Middleton, W. C. Pinschmidt, N. E. Smith, H. E. Snyder.

Your committee collaborated with the subcommittee on Assignment 4—Highway Profile at Highway–Railway Grade Crossings, and has included in the report of that subcommittee its recommendation with respect to number of traffic lanes to be provided at multiple-lane highway–railway grade crossings.

This recommendation is embodied in proposed new Art. 3—Width and Surfaces of Approaches, of the General Specifications for Highway Grade Crossings Over Railroad Tracks.

Report of Committee 14—Yards and Terminals

J. E. Hoving, *Chairman,*
M. H. Aldrich
C. J. Astrue
F. E. Austerman
R. F. Beck
A. E. Biermann
W. O. Boessneck
E. G. Brisbin
W. S. Broome
N. C. L. Brown
J. C. Bussey
K. L. Clark
R. J. Coffee
V. G. Dyer
Oscar Fischer
H. C. Forman
W. H. Giles
W. H. Goold
E. D. Gordon
H. J. Gordon
J. E. Griffith
L. C. Harman
H. H. Harsh*
L. M. Harsha
D. C. Hastings
F. M. Hawthorne
W. W. Hay
W. J. Hedley
H. W. Hem
F. A. Hess
V. C. Kennedy
A. S. Krefting
B. Laubenfels
E. K. Lawrence
J. L. Loida
L. L. Lyford
C. E. Merriman
C. H. Mottier
A. G. Neighbour
B. G. Packard
J. N. Todd, *Vice-Chairman,*
C. F. Parvin
R. H. Peak, Jr.
J. L. Perrier
C. M. Ratliff
C. L. Richard
G. L. Roberts
L. W. Robinson
R. E. Robinson
H. T. Roebuck
M. S. Rose
W. B. Rudd
W. C. Sadler
H. L. Scribner
J. G. Sutherland
J. C. Warren
C. F. Worden
G. R. Wurtele

Committee

* Died October 29, 1952.

To the American Railway Engineering Association:

Your committee reports on the following subjects:

1 .Revision of Manual.
Progress report, including recommended revisions .... page 502

2. Classification yards, collaborating with Committee 16.
Progress in study, but no report.

3. Scales used in railway service.
No report.

4. Water terminals.
Progress in study, but no report.

5. Study of the handling of lcl freight by conveyors.
Progress report, presented as information .... page 511

6. Diesel locomotive servicing facilities, collaborating with Committees 6 and 13.
No report.

7. Recent trends in layout and location of freight houses.
Final report, presented as information .... page 514

8. Store facilities, including reclamation, scrap and material yards.
Final report, presented as information .... page 520

9. Means of conserving labor and materials, including the adaptation of substitute noncritical materials, and specifications for the reclamation of released materials, tools and equipment, collaborating with Committee 3-A, General Reclamation, Purchases and Stores Division, AAR.
No report.

The Committee on Yards and Terminals,
J. E. Hoving, *Chairman.*

AREA Bulletin 504, November 1952.

Report on Assignment 1

Revision of Manual

F. E. Austerman (chairman, subcommittee), C. J. Astrue, A. E. Biermann, W. O. Boessneck, W. S. Broome, N. C. L. Brown, H. C. Forman, W. H. Giles, D. C. Hastings, W. J. Hedley, F. A. Hess, J. E. Hoving, L. L. Lyford, C. E. Merriman, C. H. Mottier, B. G. Packard, J. L. Perrier, W. B. Rudd, W. C. Sadler, J. N. Todd, C. F. Worden.

Your committee has reviewed all of Chapter 14 Manual material, except the Scale Specifications, and makes the following recommendations.

Pages 14–1 and 14–2

TERMINALS

Reapprove without change.

Pages 14–4 to 14–18.06, incl.

PASSENGER TERMINALS

(14–4 to 14–6, incl.) Reapprove Secs. 21—General, 22—Track Arrangement, 23—Street Approaches, with the following revision:

Revise Sec. 21, Par. (i) 3, to read:

3. Ease of approach from all the associated rail lines, without excessive curvature, or gradient, and preferably without grade crossings.

(14–6) Reapprove Sec. 24—Station Proper, with the following revisions:

(14–7) Revise Art. 2402—Main Building Areas, Par. (a) to read:

The principal floor areas should include a lobby, a waiting room or rooms, a passenger concourse, and a separate women's waiting room, or any combination of these facilities.

(14–13) Delete Item 4, Graph No. 8, of Table 1401, and renumber in sequence Items 5 to 27.

(14–15 and 14–16) Delete Figs. 1401 and 1402.

(14–17) Revise Art. 2421—Steam, Air and Water Connections as follows:

Change heading to read Steam, Air, Water and Telephone Connections, and add the following paragraph to the present article:

At the points where air and steam connections are located on station tracks, a telephone jack may be provided to permit the connecting of the train telephone line to the main station switchboard.

(14–17) Reapprove Sec. 25—Coach Yards, with the following revisions:

(14–18.01) Revise Art. 252, Par. (f) 5, to read: "Curvature of tracks should preferably not exceed 12 deg 34 min through turnout, or otherwise."

(14–18.01) Revise Art. 252, Par. (h) 3, as follows:

Eliminate the words "in tubs."

(14–18.02) Revise Art. 252, Par. (h) 4, to read:

4. Low-pressure air connections for cleaning should be spaced the same as cold water hydrants. For testing air brakes, high-pressure air connection should be provided through a double connection at the center of the track, or through a single connection at each end of each track.

(14–18.05 and 14–18.06) Reapprove Sec. 26—Modernization, adding new paragraph (r) reading:

(r) During a modernization program, consideration should be given to possibilities of overloading the existing electric, water, and steam facilities. Provisions should be made to increase the capacity of these facilities to a safe level.

Pages 14–18.06 to 14–32, incl.

FREIGHT TERMINALS

(14–18.06 to 14–24.1, incl.) Delete Secs. 31—General, 32—Yards and Approaches, and 33—Yards, Receiving, Classification, Departure, etc., and substitute therefor the material appearing in Exhibit A.

(14–25 to 14–27, incl.) Reapprove Sec. 34—LCL Freight Facilities, with the following revisions:

(14–25) Renumber and relocate Art. 341, as Art. 347, deleting Par. (b) and substitute therefor the following:

(b) The width of transfer platform should be sufficient to accommodate (a) the parking of trucking equipment at track sides, and (b) two lanes for movement of the type of equipment used in moving freight from car to car.

(14–25) Renumber Art. 342 as Art. 341, and renumber balance of Articles to proper numerical sequence.

(14–25) Revise present Art. 342—Freight House—General, Par. (e) to read as follows:

(e) The factors of design for a freighthouse, such as tailboard frontage, floor area, width of house, platform, bridges and roadway; and in the case of the two-level house, the capacity of elevators should be so correlated that no one factor will limit the capacity of the house.

(14–26) Revise Art. 346—Freight Houses—Two-Level, as follows:

Add new Par. (a), as follows, and redesignate the following paragraphs in proper alphabetical sequence.

(a) Conditions under which a two-level freight house are required are exceptional rather than ordinary. Under certain physical and economical conditions, such as separate track and highway levels, it may provide the only solution.

(14–27) Art. 347, Freight Houses—Elevators, Par. (a), delete the last phrase reading: although conveyors and other devices have been suggested and perhaps tried. Also delete Pars. (c) and (d).

(14–27) Revise Art. 348—Warehouses, as follows: In Par. (d), change "track siding" to "house track," and in Par. (f), change "siding" to "house track."

(14–27 to 14–32, incl.) Reapprove Secs. 35—Team Yards and Driveways, 36—Produce Terminals, and 37—Grain Elevator Storage Yard and Plant Tracks, with the following deletions:

(14–28) Delete in Art. 352—Freight House and Team Yard Driveways, Par. (e) and (f).

Pages 14–32 to 14–32.84, incl.

LOCOMOTIVE TERMINALS

Reapprove with the following revisions:

(14–32.1) In Art. 1(c), first line, change "can" to "may".

(14–32.4) In Art. 3(c), Par. 16, fourth line, change "50-ton" to "5-ton".

Exhibit A

FREIGHT TERMINALS

A. GENERAL

The designation "freight terminal" as here employed includes all the facilities provided by a railway company, or by railway companies in common, as the case may be, to handle freight to or from or through and within a given district on behalf of such railway company or companies.

Conditions of demand and feasibility vary widely, and generally each case of constructing an altogether new layout on a large scale, or of remodeling or consolidating an extensive existing layout, constitutes an essentially basic problem.

The engineer is confronted with the problem of designing various yards, each for its special functions; miscellaneous tracks for particular uses; freight stations for the receipt and delivery of less than carload freight, or for its transfer or storage, or for the special handling of perishable freight, or for the receipt and delivery of carload freight in different categories; icing facilities for refrigerator and top icing carload business; enginehouses and shops for the housing, servicing and repair of locomotives in service; locomotive fueling facilities; shops and facilities for the current repair of cars in service; power cranes for the loading, unloading and transfer of bulky or heavy cargo units; weighing facilities; heating and power plants; and a system of thoroughfare tracks that shall weave this complex assemblage into a unity of smooth and expeditious performance.

Each of these features and its appurtenances, with a full knowledge of the average and maximum demands to be made upon it, must be carefully designed to fulfill its particular functions expeditiously and economically.

Each unit of the complete assembly must be located with relation to the whole, and must be interconnected to provide for all movements through and within the terminal in the shortest possible time and with minimum interference of one with another. Terminal delays constitute a very serious handicap to the expeditious movements of freight and a material decrease in such delays will justify a large investment.

In any case where relief is sought because an existing terminal imposes excessive delays, a thorough study should be made to determine the advisability of providing a layout wholly new and correct in design, before attempting to remodel the existing facilities.

B. YARDS

1. General

Freight yards are essentially supplementary units and should be so located, so designed, and so operated in relation to each other and to the lines tributary to them, as to give the most economical results for the railway as a whole.

To meet traffic requirements a yard should be able, even in peak periods, to receive trains promptly upon arrival, perform any auxiliary service (such as weighing, icing, feeding and watering stock, making running repairs, etc.), switch cars into their proper classification without appreciable delay, and dispatch these cars in their proper position in outgoing trains in minimum time.

The number of yards should be as small as is consistent with the efficient handling of traffic.

An additional yard is warranted only when it will result in greater economy than the enlargement or reconstruction of, or substitution of a new yard for, an existing yard or yards.

Future expansion of a yard should be provided for so that the number and length of the tracks in it may be increased as required with minimum interference with operation or minimum relocation of existing trackage.

An existing yard which is inadequate to handle the current or immediately prospective traffic should be enlarged, or redesigned and rebuilt, or abandoned in favor of a yard in a different location, according to which of these alternatives will result in the greatest economy.

In computing car capacity, not less than 45 ft per car should be allowed for all freight car tracks other than repair tracks.

Yard lighting is desirable. The economical distribution of light over the area involved, so as to provide proper intensity of illumination, requires careful design. Recommendations of the Electrical Section, AAR, should be consulted.

An adequate drainage system will assist materially in keeping maintenance costs to the minimum and improve operations.

A "Catechism" designed to bring out hints as to the improvement in detail of existing yards, and the elimination of slight difficulties which hinder the steady operation of yard service or cause detentions which are small in themselves but become serious in the aggregate, appears in the Proceedings, Vol. 19, 1918, pages 316 and 1120.

See "Expediting of Freight Car Movements", AREA Proceedings, Vol. 39, 1938, pages 224–229.

2. General Track Arrangement

Main tracks should not pass through a yard.

Connections to the main track from the receiving, classification or departure tracks should be as direct as practicable.

Crossovers should be provided as required to facilitate all normal and regular movements in the yard or between the yard and the main track, and their location should be such as to cause minimum interference between different movements which it may be desirable to make simultaneously.

The angle between a ladder track and the body tracks should be not more than will provide the distance on the ladder track required for the length of turnout used.

Ladder tracks should be spaced not less than 15 ft center to center from any parallel track, and when such parallel track is another ladder track, they should be spaced not less than 18 ft center to center. The requirements of governing bodies must be observed.

Body tracks should be spaced not less than 13 ft center to center, and when parallel to a main track or important running track, the first body track should be spaced not less than 15 ft center to center from such track. The requirements of governing bodies must be observed.

3. Receiving, Classification, Departure and Repair

Receiving

The number of receiving tracks should be such that there will be one available whenever an arriving train offers to enter the yard.

The length of receiving tracks should be such that each will accommodate a complete train, including assisting locomotive where used.

It is desirable that the gradient of the receiving tracks be such that hand brakes will not have to be set to keep the cars from moving.

Consideration may be given to track indicators and remotely controlled switches at the entrance to the receiving yard.

Classification

The type of yard which should be adopted in any given case depends upon the volume and character of traffic to be handled through it, and the train schedules.

1. A single flat yard is adapted for handling traffic where the total number of cars is small and the number of switching cuts per train is also small.

2. A double flat yard is adapted for handling traffic where the total number of cars is large but the number of switching cuts per train is small.
3. A gravity yard or a hump yard is adapted for handling traffic where the total number of cars is large and the number of switching cuts per train is also large —also in special cases where the total number of cars is relatively small but normally received in a short period of time, and the number of switching cuts per train is large.
4. In special cases, due to the location of the yard, the character of traffic, or the arrangement of schedules, it may be necessary to provide a double flat yard or a hump yard, because of limited time for handling.

The number of classification tracks should be such that there will be at least one available for each important classification.

The length of classification tracks should be such that each will normally hold all accumulated cars of the assigned classification until they are to be moved off the classification track under normal operation.

Where cars of single classification accumulate rapidly enough to permit forwarding them in whole trains, it is desirable to make up and dispatch trains from the classification tracks.

Departure

Departure tracks may be located as part of the classification yard or in a separate yard, depending upon the type of trains dispatched.

The number of departure tracks should be such that there will be one available for assembling a departing train whenever necessary.

The length of departure tracks should be such that each will accommodate a complete train, including assisting locomotives where used.

The gradient of departure tracks, if adverse to the forward movement of a train, should be at least 20 percent less than the ruling gradient to be encountered by that train during its road trip.

Compressed air at suitable pressure should be piped along the departure tracks, and sufficient outlets should be provided to permit the testing of the air brake equipment on the cars of departing trains.

Repair

The location of the repair yard should be such that the movement of bad-order cars will be as direct as practicable, that switching the repair yard will not interfere with other work, and that repaired cars may be returned readily to the classification or departure yard, as required.

The capacity of the repair yard depends on the number of cars to be repaired daily. Tracks should be as short as possible. In computing capacities, 55 ft should be allowed for each car.

Repair tracks should be connected at both ends where feasible. The tracks may be alternately spaced on narrow and wide centers, the narrow spacing to be not less than 18 ft and the wide spacing to be such as to accommodate mechanical equipment.

A paved driveway should be placed between the repair tracks with wide centers, and paving is also desirable between the tracks with the narrow centers.

C. MISCELLANEOUS TRACKS

Caboose tracks should be provided.

Drill tracks should be so located that movements on them will cause minimum interference with other work being done in the yard and with road trains pulling into or out of the yard, and that an engineman working on the drill track will have a clear view of the switchmen working along the ladder track.

Icing facilities, stock pens, lcl transfer, etc., should be so located that cars may be placed with minimum delay after arrival and be readily accessible for switching or placement in outbound trains.

Advance tracks somewhat longer than the maximum train length, or freight main tracks extending to or beyond the outside of the yard, in either or both directions, should be provided as required.

Running tracks should be provided as required to permit free movement from one position in the yard to another, and between the yard and the locomotive terminal, with minimum interference with other work being done in the yard.

Scale tracks should be so located that weigh cars can be weighed with minimum delay to yard operation. A track parallel to the scale track, or a dead rail, should be provided for non-weigh traffic or the movement of locomotives.

D. HUMP YARDS

1. General

A hump classification yard should be designed for the volume and character of traffic to be handled and should provide for continuous movement while humping and minimum loss of time between successive humping operations; also for the movement of cars by gravity from the crest to their proper tracks in the classification yard without damaging impacts.

Tracks at the outbound end of the classification yard should be connected to ladders so that classifications normallv assembled in one train may be assigned to permit gathering from one ladder, thus providing for minimum movement of pull-down engines. A sufficient number of ladders, with lead connections to departure tracks, should be provided to permit working at least two pull-down engines with minimum interference.

The hump end of the receiving yard should be located at sufficient distance from the crest of the hump to provide, if required, hot oil pit, under-car inspection pit, connection to set-out track for explosives, and for a connection to release road engines. A second track leading from the receiving yard to the hump will permit the use of a second hump locomotive for continuous humping operations. If trains from two or more directions are to be humped in one direction over the hump, provision should be made so that cars can be moved into the end of the receiving yard next to the hump with minimum interference with humping operations.

It is desirable to make up and dispatch trains from the classification tracks if local conditions permit, and such a method of operation usually expedites movements through the yard and reduces the expense. This requires that a sufficient number of classification tracks be long enough for each to accommodate a full-length outgoing train, or that lead tracks be provided at the outgoing end such that the combined length of a classification track and a lead track be sufficient for a full-length train, thus avoiding unnecessary doubling over or interference with hump operation. This may involve a temporary reassignment of classification during the inspection and preparatory time of a departing train.

Departure tracks may be required for making up and dispatching trains, depending on local conditions.

Considerable reclassification of cars in a hump yard is an indication of an insufficient number of classification tracks.

The hump office, hump signal control, and other communication facilities should be located at the crest of the hump on the right hand side. (It is desirable that cars be uncoupled from the right hand side so that the forward knuckle will be open, as the impact of normal coupling will often close the rear knuckle.)

The average gradient of the track leading to the crest of the hump should be such as to permit shoving the longest and heaviest train at humping speeds consistent with available power.

2. With Car Riders

Riders may walk back to the hump or a motor car may be provided to bring them back. Should a motor car be used a separate track should be provided through the classification yard, so arranged and operated as to reduce the hazard of personal injury to car riders.

The gradient from the crest of the hump should be such that cars under usual weather and temperature conditions will run by gravity to the far end of each classification track, and under severe weather and temperature conditions will run by gravity several hundred feet beyond the clearance point of each track. Steep grades should be provided below the hump so that cars will quickly separate, thereby permitting the lineup of switches for each car or cut of cars without slowing up humping operations. A stretch of level track at the leaving end of the classification yard, with a slight ascending gradient to ladders at this end of the yard, is desirable.

3. With Retarders—General

Many factors local to each situation affect efficient operation of a retarder yard, so that each terminal must be studied individually to produce a proper design.

The classification tracks at the hump end generally should be connected in groups, with minimum distance from the first switch of the group to the farthest clearance point. The leads to these groups should be connected to the hump lead by sub-leads in the shortest possible distance. Space should be provided for retarders to be located ahead of each group, on the hump lead, and in some cases on the subleads. Lap switches, short turnouts, curved switch points, and a relatively high degree of curvature, are of desirable assistance in obtaining the minimum distances.

Maintenance of way rules governing the widening of track gage through turnouts and curves should be applied to yard tracks at the hump end of the classification yard.

The number and location of retarders depend upon the number of groups of tracks and the type of layout. The length of each retarder depends upon the height of hump and the speed of operation needed. The height of hump depends upon the climate, direction of prevailing wind, character of traffic (empty or loaded cars), and to meet definite elevation.

A retarder tower or towers should be located so that each operator will have a clear view of cars under his control. The towers should have sufficient height so that the operator can observe whether tracks are filled or have room for more cars.

Individual switches and retarders may be operated by remote control requiring one or more tower locations. Where more than one tower is provided the work should be evenly apportioned among the operators so far as practicable. Push buttons may be used to select route codes from which switches are operated automatically. Likewise, retarders may be operated by push-button selection of speeds.

Loud-speaker telephone circuits or radios between the hump, the switch control room and each retarder tower are essential.

Pneumatic tubes between the general yard office and strategic points will reduce time in handling waybills, inspection lists, etc.

Teletype machines or pneumatic tubes between the yard office, the hump office, the switch control room, and retarder towers will permit handling cut lists promptly.

Adequate yard lighting is always desirable, but is particularly necessary for the safe operation of a hump yard with retarders. It is essential that the visibility be particularly good in the retarder zone. Supplementary lights, if necessary, should be provided so that the retarder operators may check the numbers and initials of cars passing their towers.

Hot oil facilities and inspection pits should be located at a distance in advance of the crest of the hump sufficient to permit pulling the pin for the longest cut without interference.

4. Design of Gradients

The hump should have sufficient height to move cars by gravity to the far end of each classification track under usual weather and temperature conditions, and several hundred feet beyond the clearance point under severe weather and temperature conditions. The average gradient between the crest and the farthest clearance point is used as a measure of hump height and varies from approximately 1.0 percent to 1.8 percent.

A sufficient length of retarder is required in each route from the crest of the hump to the first switch in each group of tracks to control the speed of the heaviest car combined with the lowest car resistance.

The gradient from the group retarder through the classification tracks should not produce acceleration of easy rolling cars after leaving the last retarder. This gradient will result in deceleration of other cars, requiring the release of such cars from the last retarder at higher speeds. The gradient from the group retarder through the classification track may be made decelerating for all cars, at least within the switching area of the group, to permit release of all cars at a higher speed, thus clearing ladders quicker and providing more space between cars for operating switches. The design of this part of the gradient is important to obtain maximum humping capacity with minimum damage to cars and contents.

The gradient through the last retarder should be sufficient to start a car should it be stopped in the retarder, but should not be sufficient to provide appreciable acceleration after a car has been released at the desired speed.

A track scale installed in the hump lead requires a gradient in advance of and over the scale which will provide sufficient time on the scale for the weighing of cars of the maximum length normally handled, and provide sufficient space between short cars to insure that each car will have sufficient time on the scale for weighing, and with due consideration of variations in car resistance. This gradient should permit a uniform movement of cars at normal humping speed whether or not cars are being weighed. A retarder located ahead of the scale may be used to control the speed on the scale and to provide spacing between cars, but should not be used as part of the retarder capacity between the crest and the track groups for the purpose of calculating gradients.

The gradients between the crest and the track group are regulated by the track layout, the height of hump, the length and location of retarders, the gradient selected through the last retarder, the gradients required for a track scale, and the speed of cars leaving each of the retarders, as follows:

1. There should be a sufficient length of retarder in each route to stop a car of maximum gross weight having a car resistance of 0.3 percent in the last retarder, when released from the crest at normal humping speed.
2. There should be a sufficient gradient from the crest through the hump retarder to insure that a car of maximum gross weight having 0.3 percent resistance will move through the hump retarder, closed to maximum retardation, and leave the hump retarder at a speed of at least 6 mph, when car is released from the crest at normal humping speed.
3. There should be a sufficient gradient between the hump retarder and the leaving end of the intermediate retarder to insure that a car of maximum gross weight having 0.3 percent resistance, released from the hump retarder at the speed defined in (2) above, will move through the intermediate retarder, closed to maximum retardation, and leave the intermediate retarder at a speed of at least 6 mph.

Compensation for curve resistance may be made by compensating the gradients or by additional speed. Compensation by gradients provides assistance in moving cars around curves, but too much compensation may provide acceleration. Compensation by speed provides higher releasing speeds from the last retarder.

This factor is of major importance in the design of gradients between the last retarder and tangent on the classification track, and of minor importance applied between the crest and the track groups. Curvature through turnouts may be included with other curvature when calculating curve resistance.

The calculation of gradients is simplified by converting all factors into feet vertical height or velocity head. Gradients for distances involved are easily converted to difference in elevation. Car resistance for distances involved may be converted to velocity head. Speed may be converted to velocity head. Manufacturers will supply velocity head values for their retarders as applied to various weights of cars. Curve resistance is usually stated in velocity head for a unit of central angle through which the curve extends.

Gradients may be calculated to satisfy the various principles of design by the following suggested methods:

1. Height of hump equals the average gradient between the crest and the farthest clearance point, as selected to be desirable for the locality, multiplied by the distance.
2. The elevation at the first switch of the track group may be determined by selecting a basic gradient for tangent in the classification track and then calculating the difference in elevation between the farthest clearance point and the first switch of the track group. This may be modified by curve compensation if it is desired to compensate curves by gradient. If compensation is to be made by speed, the gradient for tangent track is used through curved track.
3. The length of retarder in each route may be determined by subtracting from the drop between the crest and the first switch in the group a car resistance value calculated by multiplying the distance by 0.3 percent and dividing the remainder by the manufacturer's unit value.
4. The length of the last retarder should be selected to permit an entering speed as high as practicable. The entering speed in velocity head equals the velocity head of the retarder as determined from multiplying the length of the retarder by the manufacturer's unit value for weight of car under study, plus car resistance over the distance, less the drop through the retarder.

5. The drop through the last retarder is calculated from a gradient selected to produce the operation described above. Usually the vertex of the vertical curves at each end is placed approximately half a car length outside of the retarder.
6. The drop from the crest of the hump to the leaving end of track scale is determined from a detail study of operation over the scale.
7. The length of the hump retarder may be considered as the difference between the total length in each route and the length of the last retarder, if only hump and group retarders are used. If an intermediate retarder is to be used, this length should be apportioned between the hump and intermediate retarders.
8. The drop from the crest to the leaving end of the hump retarder may be determined by adding the velocity head of car resistance over the distance, the velocity head of the hump retarder, and the velocity head of the speed desired at that location.
9. The drop from the crest to the leaving end of the intermediate retarder may be determined by adding the velocity head of car resistance over the distance, the velocity head of both the hump and intermediate retarders, and the velocity head of the speed desired at that location.
10. Elevations obtained by assembling the above drops will form a complete profile. A graphic plotting of velocity head values with the profile provides a good check of calculations.

Report on Assignment 5

Study of the Handling of LCL Freight by Conveyors

C. E. Merriman (chairman, subcommittee), J. E. Hoving, M. H. Aldrich, C. J. Astrue, F. E. Austerman, A. E. Bierman, W. O. Boessneck, W. S. Broome, J. C. Bussey, K. L. Clark, V. G. Dyer, W. H. Goold, H. H. Harsh, A. S. Krefting, L. L. Lyford, A. G. Neighbour, B. G. Packard, C. F. Parvin, C. M. Ratliff, L. W. Robinson, R. E. Robinson, W. C. Sadler, H. L. Scribner, G. R. Wurtele.

Your committee submits as information the following progress report on the handling of lcl freight by conveyors, with the recommendation that the subject be continued so that information to be gained from installations now under way can be included in a final report.

In 1948 a report was submitted on the subject "Facilities for Conveyor Handling of LCL Freight at Freight Houses." This appears in the Proceedings, Vol. 49, 1948, page 113.

The study was continued in 1949, and in 1950 a further report was made on the more general subject, "Facilities for Mechanical Handling of LCL Freight." This appears in the Proceedings, Vol. 51, 1950, page 184.

Great strides have been made in the past ten years in converting lcl freight houses from hand to motorized operation. This change-over has done much to speed up and reduce costs of freight handling. However, in houses handling large volumes of freight, still further improvement in methods is desirable.

Since 1948 several railroads have installed conveyors at one of their lcl freight houses. The installations made up to this time are the overhead continuous conveyor chain type, which tow four-wheel trucks. These systems are proving very satisfactory and it is said that from 90 to 95 percent of the tonnage passing through the houses is being handled on the conveyor systems. These installations have been observed in operation and appear to give sufficient evidence to warrant the statement that conveyor systems of the towing type can be adapted to the handling of lcl freight.

With hand or motorized operation, the length of haul is an important factor in the handling costs. Minimum lengths of haul are obtained in a layout having a width almost equal to its length. Therefore, a layout which handles a large volume of freight using motorized equipment, generally, will be most efficient if it is nearly square and has a relatively large number of tracks and platforms.

With conveyor operation, however, movement is continuous and length of haul is not as important a factor as having the fewest number of conveyor circuits and the least angular travel consistent with the work to be performed. Therefore, it appears that a long and narrow type of layout having relatively few platforms and tracks is the shape best adapted to conveyor operation.

The type of conveyor covered by this report consists of a continuously moving chain which tows four-wheel flat-bed trucks, such as those commonly being used with motorized equipment in lcl freight houses.

In towing conveyor operation, sentiment is developing in favor of smaller trucks than those now in general use at freight houses. Most shipments consist of only a few packages which go on a single truck, for when two or more shipments are put on one truck the sorting becomes more complicated. Therefore, in considering a towing conveyor operation, thought should be given to the use of at least some smaller trucks. For shipments which can best be handled on pallets, the possibility of providing pallets with wheels so they could be hooked directly onto the line should also be considered.

The reason for the trend toward smaller trucks or dollies where the character of the freight permits is that smaller trucks afford greater maneuverability on the platform, in box cars and in street vehicles. As most shipments consist of only a few pieces, the smaller truck also simplifies sorting.

Very little, if any, freight is stacked on the floor with conveyor operation. Instead, everything that can be handled over the conveyor is loaded onto the platform trucks and placed in the line. Each truck is given a block number and is removed from the line as it passes the car or point designated for that particular block. If not removed, the load will continue in the line, making a complete circuit, and can be removed the second time it passes. Frequent missing of loads for a given block can thus be quickly spotted by the foreman and steps taken to correct the condition. Eliminating the need of stacking considerable freight on the floor, even that palletized, reduces handling and speeds up the entire operation.

As platform trucks are made empty, they are placed in the line, from which they are removed as needed when they reach points of loading. Thus, empties do not accumulate at one point when they are needed for loading at another.

The conveyor method also conserves manpower since trucks and dockmen do not have to accompany each load, but can continue to load or unload while both loads and empties are enroute.

Stop switches are placed along conveyor routes about every other car so the line can be stopped by anyone quickly in case of emergency.

There are, of course, some pieces of freight which, due to size, weight or shape, do not lend themselves to movement over a conveyor system. These must be given special handling, using that unit of motorized equipment best suited. Experience in houses equipped with conveyors shows that from 5 to 10 percent of the freight requires such special handling. However, with a few underslung or special dock trucks, it appears that this proportion could be reduced considerably.

Platform widths should be arrived at by allowing not less than 6 ft, and preferably 7 or 8 ft, in the clear for each lane. This applies to both conveyor and motorized movements. In addition, sufficient standing room should be allowed outside of travel lanes for parking trucks which have been removed from the line or trucks waiting to be placed in the line.

Conveyor installations now in service, as well as those under construction, for handling lcl are electrically driven, and are geared for various chain speeds ranging anywhere from 35 to 165 ft per min. Some drives are constant speed, a change of gears being necessary to alter the chain speed. Other drives are of the variable-speed type, equipped so that any number of speeds, within certain limits, such as from 80 to 130 ft per min can be obtained by making a simple adjustment.

The lugs or towing dogs on the conveyor chain to which the trucks are attached are usually spaced from 12 to 18 ft apart. For long loads, such as pipe, a second truck is sometimes coupled behind the one attached to the conveyor.

Chain speeds of 80 to 130 ft per min will usually prove satisfactory. It is desirable to keep trucks spaced as far apart, and the chain speed as low, as possible in handling a given volume of business. Where truck spacing and chain speed result in more than 10 trucks passing a given point per minute, longer working periods for that particular volume are usually indicated.

The following describes two types of conveyors which appear best suited for handling lcl freight.

Overhead Type

The overhead type of towing conveyor consists of a moving chain supported about 8 ft above the floor. Each truck usually has a telescopic tongue or mast, with a hook on the end for attaching to the conveyor chain. This type conveyor is well adapted to converting all or a portion of an existing house from hand or motorized operation to conveyor operation, especially if the floor construction is unfavorable to the floor-type conveyor. When a conveyor circuit of the overhead type passes from one platform to another, a bridge or a cross platform, with removable section, is required to span the intervening tracks. Therefore, when the house is switched, the conveyor chain must be disconnected at each end of the spanning structure and be reconnected after the house has been set. These operations usually require from 15 to 30 min each time an opening is made, the length of time required depending on the type of structure spanning the tracks.

The daily average volume of freight being handled at houses equipped with overhead conveyors varies from 150 to 1250 tons, and the tonnage handled per hour ranges from 20 to about 100.

Lengths of conveyor circuits in these installations are from 790 to 3450 ft.

Floor Type

The floor type of towing conveyor consists of a continuously moving chain housed in a chase made of steel channels built into the floor. The chain has lugs or pusher dogs spaced at proper intervals, which engage a perpendicular pin at the head end of each truck. The pin is a floating type and can be locked in the raised position to clear the floor when the truck is removed from the line.

With the floor type of conveyor there are no overhead obstructions, and as the driving machinery is below the floor, the operation is more quiet. The slot in the floor for the engaging pin is only 1 in wide so any type of equipment can be operated over it.

Brush-like fittings attached to the chain keep the chase clean by sweeping dirt or foreign particles to clean-out pits placed at intervals along the circuit.

A substantial proportion of lcl freight consists of pieces which are longer than 6 ft, and when loaded on a truck it is frequently desirable or necessary to have the load extend beyond the truck bed both in front and behind. In this respect the floor type of conveyor is most desirable as the conveyor engaging pin can be installed in such a manner that no part extends above the bed of the truck, even in the raised position. A lever to raise and lower the pin, located just beneath the truck bed and along the side, not only permits long loads to extend out over the front, but also permits a workman to engage or disengage a truck from the line from a safe position alongside, rather than from in front of the moving vehicle.

When a loaded truck is placed in the line on a floor-type conveyor, the jerk caused when the dog on the chain engages the pin can be largely eliminated by placing the truck at right angles to the line when the pin is dropped into the slot. At most installations of overhead towing conveyors, the device used to hook the trucks onto the line is equipped with a spring to reduce the jolt of sudden starting.

As far as we have been able to determine, no railroad lcl freight houses have been equipped with floor-type conveyors, although there are many such installations at industrial plants, warehouses and freight houses where the work done is essentially an lcl operation.

At the present time a western railroad has under construction a new freight house designed to use a floor-type conveyor. This house is to be about 1300 ft long, with three platforms in the shape of the letter E. Three tracks are to be placed in each bay between the center and outside platforms. Two conveyor circuits are to be employed. One will be confined to one of the outside platforms, while the second will traverse the other two platforms. All platforms will ramped, down on a 6 percent gradient to top of rail level at their outer ends. The conveyor circuit serving two platforms will descend a ramp, curve 90 deg on an 8-ft radius, cross 3 tracks at grade, curve 90 deg, and ascend a ramp to the other platform. In this way no bridge at platform level will be necessary, nor will it be necessary to disconnect the conveyor chain each time tracks are switched. Special crossing construction will provide for the conveyor chase through the tracks. The entire area, including the ramps and track crossings, are to be roofed over.

Report on Assignment 7

Recent Trends in Layout and Location of Freight Houses

W. O. Boessneck (chairman, subcommittee), M. H. Aldrich, F. E. Austerman, K. L. Clark, R. J. Coffee, V. G. Dyer, H. J. Gordon, J. E. Griffith, L. C. Harman, L. M Harsha, W. W. Hay, J. E. Hoving, B. Laubenfels, J. L. Loida, C. H. Mottier A. G. Neighbour, C. F. Parvin, R. H. Peak, Jr., J. L. Perrier, L. W. Robinson, M. S. Rose, H. L. Scribner, J. G. Sutherland, J. C. Warren.

Your committee submits the following final report as information:

The information on this subject was obtained in 1951 through a questionnaire sent to 79 railroads. The questionnaire requested information regarding freight houses that had been constructed since 1940, were under construction, or were contemplated for construction. Replies were received from 52 railroads covering 22 freight houses. Twenty-one are widely distributed throughout the United States and one is in Canada.

An analysis has been made of the data received and the important features in the new freight houses are presented in condensed form.

General

One layout is purely a transfer station.

Four of the freight houses use the conveyor-type systems.

Three layouts are completely enclosed under one roof, which covers the warehouse, tracks and platforms as a protection against inclement weather for station employees, equipment and freight.

Freight House Layout

All are combined inbound and outbound facilities, except the one transfer station mentioned heretofore.

All reported that lcl operation was on one floor, indicating no multiple-floor lcl operation.

In all cases except one, the buildings are of fire-resistant construction.

Platforms

Widths vary between 12 and 73 ft.

Lengths vary between 48 and 1327 ft.

Top of rail to platform—minimum 3 ft 6 in, maximum 4 ft, most common 3 ft 9 in.

Top of driveway to platforms—minimum 3 ft 6 in, maximum 4 ft 3 in—most common 4 ft.

Practically all platforms are covered, entirely or partially. In some cases supplemental short open platforms are indicated where heavy materials are handled by crane or other equipment. Continuous doors are used in many installations where there is no platform between the warehouse and the tracks or driveway.

Driveways

Type of pavement	*Installations reported*
Concrete	12
Bituminous, tarvia or asphalt	7
Crushed stone	1
Not stated	2
Width of pavement	
16 to 29 ft	3
30 to 49 ft	2
50 to 59 ft	3
60 to 69 ft	5
70 to 79 ft	4
80 ft	3
100 to 107 ft	2

Tracks

Tracks between platforms are in pairs, in groups of three or groups of four. Capacities of tracks—minimum 1 car, maximum 27 cars.

1 to 6 car capacity—	7 tracks
7 to 12 car capacity—	39 tracks
15 to 20 car capacity—	43 tracks
21 to 27 car capacity—	28 tracks

Total—117 tracks for 22 locations.

Mechanized Equipment

Various types of mechanized equipment are used at 12 projects and, as stated heretofore, four projects use conveyor-type systems.

Special Rooms

	Installations reported
Refrigerator room	6
Warm room	11
Valuables room	7
Cooper shop	11
Unclaimed and damaged freight room	9

Welfare Facilities

	Installations reported
Toilets	22
Showers	4
Lockers	19
Rest rooms	2
Wash rooms	13
Electric drinking fountain	4
First aid	1
Lunch rooms	9

Communication System

Installations reported—18

Various types are (1) talk-back systems, (2) telephones and annunciator system, (3) loudspeakers, (4) loudspeaker intercommunication and private branch exchange telephones, (5) paging horns and phones.

At more than one freight house an experimental talk-back loudspeaker system is being operated. The talk-back loud speaker, which can be hung in a freight car at the lcl unloading shed, is connected to a similar device at a table or desk where the clerk checking the car is located. The laborer loading packages from the car onto pallets or hand trucks calls out the number and description of the packages to the clerk, who checks it against the way bill. By this system one clerk can check two or three cars at one time. The clerk using this speaker system is able to check more than twice the amount of freight per hour than clerks not using the system.

Pneumatic tube system—Installations reported—9.

Platform crossover bridges—Installations reported—8.

Crossover bridges are all mechanically operated. A type of retractable crossover bridge used at one project is described later in this report.

Summary

A review of the foregoing indicates a general trend in modern freight house layouts toward:

1. Combined inbound and outbound facility.
2. LCL operation on one floor.
3. Buildings of fire resistant construction.
4. Covered platforms of adequate width with pavement or floors suitable for operation of mechanized equipment.
5. Driveways of ample width with hard-surface pavement.
6. Tracks with capacities of 1 to 27 cars, with 61 percent of tracks having a car capacity of 15 to 27 cars.
7. Use of various types of mechanized equipment for handling freight; also some installations of conveyor systems.
8. Warm rooms and cooper shop in many layouts, some layouts having refrigeration room, valuables room or unclaimed and damaged freight room.

9. Majority have toilets, lockers and wash rooms. Some provide lunch rooms and a few have showers, rest rooms, electric drinking fountains and first aid.

10. Increased use of communication systems.

11. Use of pneumatic tube systems.

12. Installation of mechanically-operated platform crossover bridges.

Freight House Location

Questions asked relating to the location of new freight houses and replies received were as follows: (Two were reported as entirely new facilities not replacing any existing facility. One of these made no reply, and the other replied "no" to items 2, 3, 4 and 5).

1. Was the present site satisfactory and was new house constructed on existing site?
   Replies: Yes 5, no 14, entirely new facility 2, and no answer 1.

2. Was house outmoded by increased business and could not be expanded because of crowded conditions due to industrial or other development in vicinity?
   Replies: Yes 15, no 3, no answer 3.

3. Was old facility unsuitable for efficient use of modern mechanized equipment?
   Replies: Yes 15, no 3, no answer 3.

4. Was it a downtown freight house too far removed from main yards, necessarily located at an outlying point, prompting construction of freight station more conveniently located with respect to yards?
   Replies: Yes 9, no 9, no answer 3.

5. Was new location of building on outskirts of city due to provision for its future expansion, with consideration for its ultimate possible use?
   Replies: Yes 11, no 5, partly 1, no answer 4.

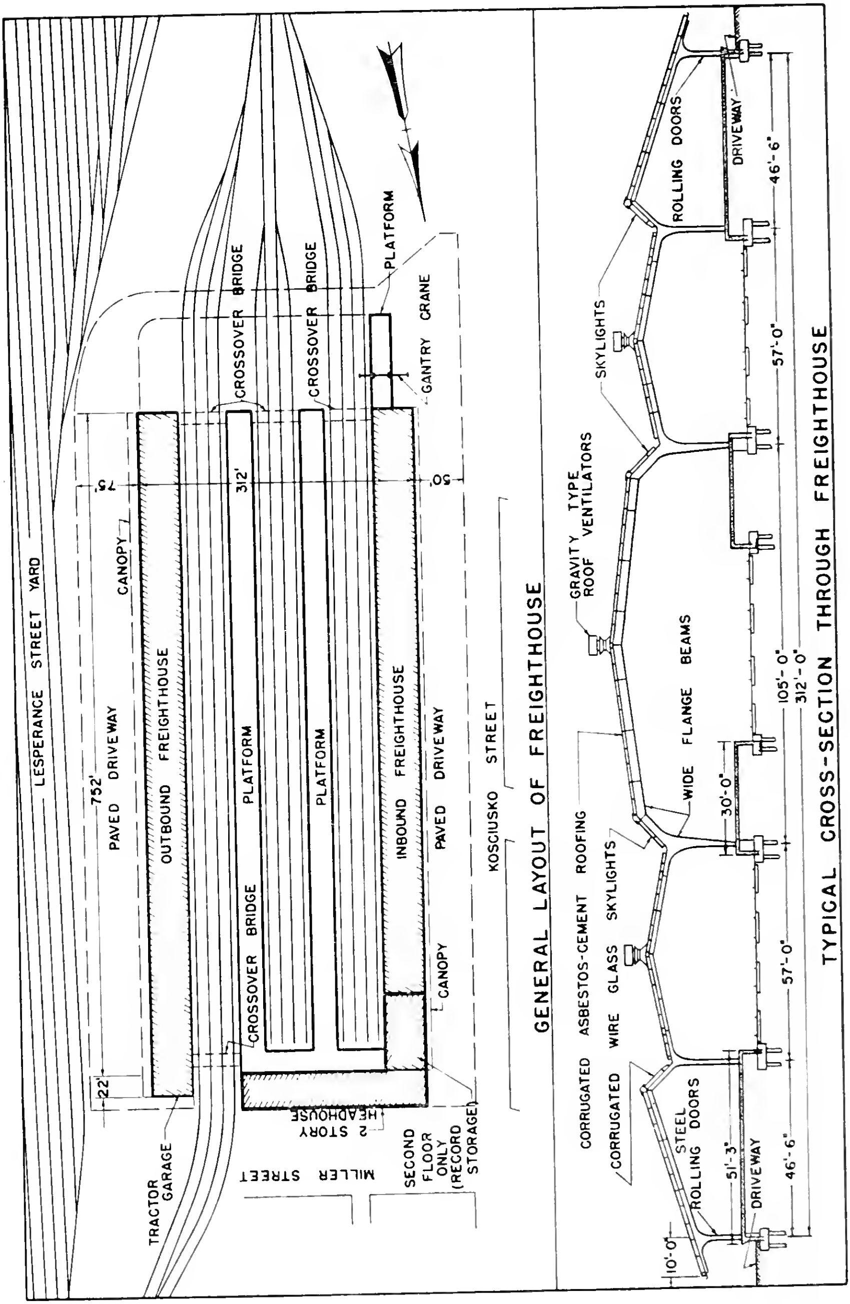
DESCRIPTION OF A RECENTLY CONSTRUCTED MODERN FREIGHT HOUSE

A recently completed modern freight house which embodies practically all of the features indicated by recent trends was constructed by the Missouri Pacific Railroad at St. Louis, Mo., and started operation in January 1952. It covers an area of about 6 acres, and its 12 tracks, with a total capacity of 180 cars, are all under roof.

See Fig. 1 (p. 518) for plan and cross section of this freight house.

The new consolidated freight house replaced two lcl freight houses formerly maintained by this railroad at St. Louis for many years.

The north end is an attractive two-story headhouse with general office and rest rooms on the second floor, and an agent's office, cashier's office, salvage room, cooperage shop, boiler room, and wash and locker rooms on the first floor. The other facilities which are enclosed under the single roof are an inbound platform 51 by 752 ft on the east side, an outbound platform 51 by 752 ft on the west side, 2 island platforms each 30 by 728 ft, a service garage for motorized platform equipment at the north end of the outbound platform, 2 offices for the platform foreman and his clerks, 1 each on the inbound and outbound platform, and a record storage room over a portion of the inbound platform. The platforms are joined at the headhouse end by a runway 24 ft wide and a retractable bridge across the group of 4 tracks entering the building from the north. Three retractable bridges 16 ft wide join the platforms at the south end of the structure. The 4 bridges are power operated. The 4 platforms are served by 12 tracks consisting of 3 groups of 4 tracks each. The 4 tracks of the easterly group are double ended and extend through the structure. The remaining 8 tracks are stub end at the north end of the structure. Running parallel with the tracks are 2 air lines for each group of 4



LESPERANCE STREET YARD
PAVED DRIVEWAY
752'
75'
CANOPY
OUTBOUND FREIGHTHOUSE
PLATFORM
312'
PLATFORM
CROSSOVER BRIDGE
CROSSOVER BRIDGE
CROSSOVER BRIDGE
PLATFORM
GANTRY CRANE
INBOUND FREIGHTHOUSE
50'
CANOPY
PAVED DRIVEWAY
KOSCIUSKO STREET
22'
TRACTOR GARAGE
2 STORY HEADHOUSE
MILLER STREET
SECOND FLOOR ONLY (RECORD STORAGE)
GENERAL LAYOUT OF FREIGHTHOUSE
CORRUGATED ASBESTOS-CEMENT ROOFING
CORRUGATED WIRE GLASS SKYLIGHTS
GRAVITY TYPE ROOF VENTILATORS
SKYLIGHTS
ROLLING DOORS
DRIVEWAY
WIDE FLANGE BEAMS
STEEL ROLLING DOORS
DRIVEWAY
10'-0"
51'-3"
46'-6"
57'-0"
30'-0"
105'-0"
312'-0"
57'-0"
46'-6"
TYPICAL CROSS-SECTION THROUGH FREIGHTHOUSE

FIG. 1

tracks. This enables brake tests to be made on each car as soon as it is spotted, thus reducing the possibility of having a loaded car rejected for a brake defect after it has left the station. The openings in the building at each of the track groups are provided with leaf-type power-operated sliding doors.

Along the east outside is a 75 ft wide concrete paved area to accommodate trucks delivering freight to the station, and on the west outside is a 50 ft wide roadway for trucks receiving freight. On the outbound, or east, side are 66 truck spots, each of which has 11 ft tailboard space. On the inbound, or west, side of the building are 65 truck spots. Each spot has a 10 ft wide steel door of the overhead roll type, providing practically continuous lines of doors. Wide eaves, overhanging the tailboard space by about 10 ft, provide protection against rain or snow.

The structural steel framework supporting the roof is designed so that the columns are all located near the edges of the platforms where they interfere least with the freight handling. Roofing and siding of the warehouse portion of the structure are of corrugated asbestos sheets. Over each platform there is a continuous skylight of corrugated wire glass. All flashing and gutters are of stainless steel. Three lines of gravity-type ventilators in the roof provide for ventilation.

Artificial lighting in the warehouse and platform area is by suspended incandescent fixtures. At each car position there is a drop light, with its lead cable on a convenient reel. To light the inside of a car it is only necessary to pull the light down and hook it to a convenient spot.

The retracting or "roll-a-way" platform crossover bridges mentioned heretofore in the report are interesting features of the layout. Three of these bridges span the track groups at the south end of the station and the other crosses the four through tracks at the north end.

The bridges are operated electrically and roll out of the way under the platforms. They run on rails set on a gage of 8 ft 6½ in, and the lowering and retracting takes only about 3 min. The push-button controls are located on the nearest supporting column, and provision has been made for emergency operation of the bridges by hand power. Three of the bridges are single-section units, while the other, which connects the two transfer platforms, was constructed in two sections, each of which retracts under one of the transfer platforms. As a protective measure, a red indicating signal light was installed on the south side face of the end wall over the center line of tracks, which shows a red indication when the bridge is obstructing the tracks. In addition, hand-operated derails were installed on the approach tracks, which are controlled by the freight house foreman who also controls the position of the track doors and bridges.

The handling of merchandise in the new freight house is a highly mechanized operation in which dependence for hauling merchandise is placed mainly on 3-wheel rubber-tired 2000-lb, platform trucks. The equipment consists of 62 gasoline-powered platform trucks of 2000-lb capacity, one 6000-lb fork-lift truck, and ten 2000-lb fork-lifts, a 5000-lb crane truck with 10-ft boom, a 2000-lb portable chain hoist, and a 6000-lb hydraulic automobile jack. One thousand wood pallets were provided to facilitate the handling of merchandise with fork-lift trucks. At the southerly end of the inbound platform is an uncovered concrete ramped platform on which is located a 10-ton capacity gantry crane for handling shipments that are too heavy or unwieldy to move through the freight house in the usual manner.

The large platform area in the new terminal is cleaned by a power sweeper, which is a combination rotary brush and vacuum-cleaner type.

The station is provided with a public address system, which may be activated from the offices of the platform foremen, assistant agent, and outbound clerk in the general office on the second floor of the headhouse, and from the agent's office on the first floor of the headhouse. A single-circuit telephone system, with phones placed at strategic points on the platforms, is used for communication between the platforms and the five transmission stations of the public address system.

A pneumatic tube system, for the two-way transmission of waybills and messages, connects the general office on the second floor of the headhouse to the two platform foremen's offices.

The entire structure is classed as "highly fire resistant", and fire hoses, fed by automatic booster pumps as soon as the water is turned on, are placed at strategic points along all platforms. Frost-resistant fire extinguishers, and special extinguishers for fighting oil fires, also are provided along the platforms.

The equipment in the boiler room includes a gas-fired steam boiler and a gas-fired hot water heater. The office space on the second floor of the headhouse is heated by steam-convector type units. The large record storage room on the second floor of the headhouse, and the locker room, salvage room, cooper shop, and freight storage room are heated by steam unit heaters.

Report on Assignment 8

Stores Facilities, Including Reclamation, Scrap and Material Yards

D. C. Hastings (chairman, subcommittee), C. J. Astrue, R. F. Beck, E. G. Brisbin, N. C. L. Brown, J. C. Bussey, Oscar Fischer, E. D. Gordon, H. J. Gordon, J. E. Griffith, L. C. Harman, L. M. Harsha, F. M. Hawthorne, J. E. Hoving, A. S. Krefting, J. L. Loida, R. H. Peak, Jr., R. M. Ratliff, C. L. Richard, G. L. Roberts, W. B. Rudd, W. C. Sadler, G. R. Wurtele.

This is a final report, submitted as information with the idea that it will be submitted later as Manual material.

The stores department is responsible for the ordering, caring for, and distribution of materials and supplies needed for, or reclaimed from, the construction, maintenance and operation of the railroad. Where desired, it may also be responsible for the accounting in connection with materials.

The stores department requires facilities which will vary in size and extent in accordance with the requirements of the road. On most large properties there will be three general types of stores, namely, general, district, and local.

The chief stores officer should be consulted with and should approve any plans for the construction, revision or elimination of stores facilities.

General Stores

The general store might also be known as a system store or regional store. It is the largest operating unit of the stores department. This store should be located at some convenient point on the railroad, taking into consideration available property as well as the necessity for receiving and shipping large quantities of material and supplies. The traffic problem created by the handling of these shipments and the freight charges involved on items from off-line will have a great influence on the location of this store. The general store should have the necessary office space to house properly the stores personnel that handle the records and accounting for its operation. This might be office space in one of the large storehouse buildings or it, more preferably, would be in a separate building. It also should have large warehouse-type buildings for the receipt, storage and shipment of all items requiring storage indoors.

Stationery, office supplies, the items required in dining car service, including foodstuffs, and maintenance of way materials may be handled in the general store. Maintenance of way materials, however, are generally handled in separate facilities.

The general store will also operate the scrap and reclamation yards, where desired. Facilities for these operations must provide for the receipt, sorting, reclamation and final disposition of all items that have scrap or reclamation value, that are released from all departments.

Buildings

Storehouse buildings for the handling of all materials requiring inside storage should be constructed in accordance with the recommended practices of Committee 6—Buildings, and the Purchases and Stores Division, AAR. All of these buildings should be provided with tracks for receiving and shipping materials by rail, as well as hard-surface driveways for truck operations. It is often possible to pave the track area so that one platform at car-floor level can serve both means of handling.

Material Yards

There are numerous items used in the maintenance of equipment and maintenance of way that can be stored out of doors. These items are handled in material yards. If possible, these material yards should be located adjacent to the storehouse area so that trackage can be kept to the minimum. The materials should be kept on permanent racks or platforms, and the areas between should be paved to facilitate the operation of auto trucks and various types of power-operated wheel-mounted lift trucks, cranes, etc.

Heavy items should be stored in the material yard at a separate location served by at least two tracks, and an overhead crane or other type cranes of suitable capacity. There should be a track on one side for receiving and one on the opposite side for shipping, with the material stored in the center area.

Scrap Yard

The scrap yard should have a receiving and a shipping track, with the sorting areas in between. It should be served by an overhead crane or other type cranes of suitable capacity. The sorting areas should be hard surfaced, and paved driveways should be provided to handle the heavy wheel loads of truck cranes and trailers used to handle scrap within the yard. All cranes should be equipped with magnets.

Reclamation Plant

The reclamation plant should be located at the same point and adjacent to the scrap yard, to minimize handling. It should have a receiving and a shipping track, with the reclamation shop building in between. The size of the shop will vary with the amount and type of reclamation to be done. The tracks should be provided with paved roads alongside for the operation of truck cranes, and with a large paved area adjacent to them and to the shop building so that materials can be handled into and out of the building with power equipment. The shipping track should be depressed, if possible, to facilitate the loading of materials coming out of the plant for forwarding to points of application or storage.

Typical layouts for scrap yards and reclamation plants can be found in the Standard Reclamation Manual of the Purchases and Stores Division, AAR.

Special Reclamation Plants

Rail requires very special handling in general reclamation, and the plant to handle it should be separate from the other plants. Receiving and shipping tracks served by overhead crane or other type cranes should be provided. The area between these tracks should be used for the straightening presses, the cropping operation, drilling rack, hardening apparatus, and for classifying prior to loading. A rail reclamation plant should be designed to provide for the rapid turnover of rail, and no storage areas are necessary. If the reclaimed rail is to be stored, it should be done at some other location.

Typical layouts for a rail reclamation plant can be found in the Standard Reclamation Manual of the Purchases and Stores Division, AAR.

Reserve Oil Storage

The general store may be called upon to provide large storage reserves of fuel oils. When the size and location of the facilities have been determined, the tanks should be installed in accordance with the requirements set forth under Locomotive Terminals, in Chapter 14—Yards and Terminals, of the AREA Manual.

Lumber and Timber Yards

Lumber products are not generally kept in large quantities at the general storehouse, but are frequently shipped direct from the dealer to the point of application. It may be necessary, however, to provide for the storage of lumber, as well as timbers for bridges, cross ties and switch timber. These products require outside storage, or covered storage on permanent racks so they can season properly, or if the timber has already been treated, it should be stored in the manner approved by the stores department to prevent loss by fire. The areas between the racks should be paved and the piles so arranged that fork-lift type trucks or truck cranes can handle the timber into and out of freight equipment on a track serving the storage yard. This track should be in the center of the yard, but if the area is too large, there should be two or more tracks serving storage areas on both sides of each track, and the tracks should, if possible, be connected at both ends.

District and Local Stores

The same characteristics outlined for general stores apply also to district and local stores, except on a much smaller scale. These stores are generally established on the larger properties at various points to expedite the handling of materials. They function the same as the general store and come under its jurisdiction.

Report of Committee 25—Waterways and Harbors

Arthur Anderson, *Chairman,*	Benjamin Elkind	A. L. Sams, *Vice-Chairman,*
G. H. Beasley	Oscar Fischer	C. W. Pitts
C. M. Bowman	R. L. Groover	R. C. Postels
H. G. Carter	C. J Henry	J. G. Roney
A. F. Crowder	B. M. Howard	C. R. Shaw
G. K. Davis	H. F. Kimball	W. D. Simpson
H. S. Davis	Shu-t'ien Li	G. L. Staley
J. A. Droege, Jr.	G. W. Mahn, Jr.	A. B. Stone
G. H. Echols	F. B. Manning	J. G. Sutherland
W. H. Eckenbrine	S. L. Mapes	P. V. Thelander
N. E. Ekrem	E. L. Mire	J. L. Vogel
	H. R. Peterson	V. R. Walling

Committee

To the American Railway Engineering Association:

Your committee reports on the following subjects:

1. Revision of Manual.

   Presented for adoption and publication in the Manual .... page 523

2. Analysis of river and harbor projects, collaborating with AAR Committee on Waterway Projects.

   No report.

3. Means of conserving labor and materials, including the adaptation of substitute noncritical materials, and specifications for the reclamation of released materials, tools and equipment, collaborating with Committee 3-A, General Reclamation, Purchases and Stores Division, AAR.

   No report.

The Committee on Waterways and Harbors,
Arthur Anderson, *Chairman.*

AREA Bulletin 504, November 1952.

Report on Assignment 1

Revision of Manual

Benjamin Elkind (chairman, subcommittee 1-A), G. H. Beasley, C. M. Bowman, H. G. Carter, W. H. Eckenbrine, Shu-t'ien Li, G. W. Mahn, Jr., H. R. Peterson, C. W. Pitts, J. G. Roney, C. R. Shaw.

Your committee recommends the following changes in the Manual.

Pages 25-1 to 25-5, incl.

DREDGING SPECIFICATIONS

Reapprove with the following revisions, deletions, and additions:
Delete the first three Articles and substitute the following:

1. General

The general location and dimensions of the .... to be dredged are shown in detail on plan (or plans) marked: ...., which shall constitute a part of these specifications.

2. Location

The work to be performed under the contract and these specifications is located ....

3. Work to Be Done

The work consists of furnishing all plant, labor, materials, and equipment, and performing all dredging in accordance with these specifications and the plan (or plans) forming a part thereof for .... a total channel length of .... ft, or a total area of .... sq ft. The contractor shall remove sufficient material to provide the required depth and the limiting side slopes described in Art. 7, Overdepth and Side Slopes.

Add the following new Art. 4.

4. Work in Navigable Waters

The dredging is to be executed pursuant to an Instrument of Approval of Locations and Plans issued by the Chief of Engineers and the Secretary of the Army. Copies of the provisions of this Instrument of Approval will be furnished to contractors upon request.

All dredging operations shall be in conformity with the provisions of this Instrument of Approval and, in addition, shall conform to requirements or directions of the District Engineer, Corps of Engineers, U. S. Army.

The contractor shall apply for and shall secure any necessary Department of the Army permits for the dumping of the dredged material and shall furnish the Corps of Engineers his schedule for his operation affecting navigation prior to the start of the work in order that navigation interests may be notified.

Should the contractor, during the progress of the work, lose, dump, throw overboard, sink, or misplace any material, machinery or appliance, which in the opinion of the Corps of Engineers may be dangerous to or obstruct navigation, he shall recover and remove same with the utmost dispatch. The contractor shall give immediate notice, with description and location of such obstructions, to the Corps of Engineers and, when required, shall mark or buoy such obstructions until the same are removed. Should he refuse, neglect or delay compliance with the above requirements, such obstructions may be removed by the Corps of Engineers and the cost of such removal may be deducted from any money due or to become due the contractor, or may be recovered under his hand. The liability of the contractor for the removal of a vessel wrecked or sunk without fault or negligence shall be limited to that provided in Sections 15, 19 and 20 of the River and Harbor Act of March 3, 1899.

The contractor shall keep the engineer of the .... Railroad Company informed in writing of his applications and reports to the Department of the Army and the District Engineer, Corps of Engineers, U. S. Army.

Delete present Art. 4 and substitute the following as Art. 5.

5. Physical Data

The contractor shall make inquiry into the general features affecting the work, such as range of tides, wave action, exposure to storms, unusual currents, range of flood stages, duration of usual working season, presence of cables, pipes, conduits, tunnels, aqueducts, bridges, etc., across the channel or across the route to the dumping ground or place of disposal; into the regulations concerning the same; and into the usual character of traffic in the channel (or within the basin) with particular reference to the effect such feature or features may have on contract operations.

The engineer will furnish to the contractor all related authentic information concerning the above to the best of available records, but the engineer and the railroad shall not be held responsible for whatever may result from the information thus furnished to the contractor.

5. Bench Marks

Change present Art. 5 to 6.

6. Traffic; 7. Overdepth Dredging; and 8. Side Slopes.

Delete these Articles and add the following new Art. 7:

7. Overdepth and Side Slopes

In doing the work, the contractor shall make the dredged channel bed as smooth and as close to the grade as possible at or slightly below the plane of the required depth, but no payment will be made for any material dredged from more than .... ft below the required depth as determined from information obtained by surveys made under the direction of the engineer upon the completion of all the work covered in the contract, except that, when the quantity of material excavated is to be determined by place measurement, the soundings made for the various estimates and the removal of shoals shall be conclusive and deductions for overdepth or material excavated outside the specified limits will be based upon the result of these soundings.

Material actually removed, within limits approved by the engineer, to provide for final side slopes not flatter than .... on .... nor steeper than .... on .... as called for on the plan (or plans) unless otherwise specified, but not in excess of the amount lying above this limiting side slope, will be estimated and paid for, whether dredged in original position or after having fallen into the dredged channel.

In computing the limiting amount of side slope dredging an overdepth of........... ft, measured vertically, will be used.

No payment will be made for material dredged outside the specified limits, as shown by the soundings, unless the same is specifically ordered in writing by the engineer before the excavation is made.

Payment will not be made for material taken from beyond these limits and such material will be deducted from the total amount dredged as excessive overdepth and side slope dredging.

9. Quantity of Material

Change to Art. 8, omit "at an angle" in first and second line.

10. Character of Materials

Change to Art. 9.

11. Work Covered by Price Bid

Change to Art. 10 and change "plant" to "equipment" in fourth line.

12. Method of Measurement

Change to Art. 11.

13. Scow Measurement

Change to Art. 12 and change "access" to "excess" in last line.

Add new Art. 13 as follows:

13. Allowance for Swell in Scow Measurement Dredge Work

Include text, without change, of "Allowance for Swell in Scow Measurement Dredge Work" on page 25–7.

14. Place Measurement

No change.

15. Final Examination and Acceptance

Change to Art. 22 and change "last" to "final" in second line third paragraph.

16. Shoaling

Change to Art. 23 and change "last" to "final" in the first and fourth lines.

17. Order of Work

Change to Art. 15.

18. Disposal of Excavated Material

Change last paragraph to read as follows:

"In all operations connected with the work the contractor will be required to observe all laws and governmental requirements."

19. Lights

Add second paragraph as follows:

During the entire contract operation in navigable waters, the contractor shall maintain at night, from sunset to sunrise, sufficient number and intensity of red lights properly located on his plant, equipment, buoys, piles, etc., at his own expense.

Add new Art. 20 as follows:

20. Fog Signals

When heavy foggy weather of very low visibility is encountered during the contract operation, the contractor shall provide on his dredging plant sound signals at sufficiently frequent intervals to warn approaching vessels.

20. Obstructions

Change to Art. 21 and add at end the following:

", remove all materials left unused, and clean up the site occupied by the contract operation to its original appearance."

21. Inspection

Change to Art. 17 and change "will" to "shall" in first line, and "The contractor shall" to "To" beginning of paragraph (d).

22. Plant

Change to Art. 16 and after "sufficient size" in first line add "and capacity".

Pages 25–6 and 25–7

TYPES OF DREDGES AND THEIR RESPECTIVE USES

Reapprove with the following revisions:

Delete second paragraph and substitute the following:

There are two general types of floating dredges—bucket and hydraulic, usually classified as follows:

Delete paragraph (b) under Art. 2 and substitute the following:

(b) Sea Going Hopper Dredge. This is a self-propelled hydraulic dredge which dredges the material to be excavated and delivers same into bottom dumping hoppers within its own hull and carries the excavated material to a dumping ground by its own propelling machinery. This type is specially developed for work on ocean bars where it can continue dredging long after rising seas would drive other dredges to shelter. It is efficient and economical for harbor work where the material is such as can be pumped (where the cut is 1000 ft long or more) and where the distance to the point of deposit is too great for pipe-line dredges, or otherwise the physical environment makes it difficult to moor and anchor the pipe line. To deepen a slip or remove a small shoal it has to work at anchor, which increases the cost by double or more. It can be used to better advantage in channels where traffic is congested than other types of dredge.

Page 25–7

ALLOWANCE FOR SWELL IN SCOW MEASUREMENT DREDGE WORK

Delete, as subject incorporated in Dredging Specifications, pages 25–1 to 25–5, incl.

Pages 25–7 and 25–8

ALLOWABLE OVERDEPTH IN DREDGING OPERATIONS TO OBTAIN THE DESIRED OPERATING DEPTH

Reapprove with the following revision: Delete second paragraph and substitute the following:

Overdepth of channel is permitted to allow for inaccuracies of dredging and to assure a continuous channel depth and as a protection against shoaling above the desired channel depth from any natural condition.

Page 25–8

USUAL SLOPES TAKEN IN DEEP WATERWAYS

Reapprove without change.

A. F. Crowder (chairman, subcommittee 1–B), G. H. Echols, H. F. Kimball, F. B Manning, E. L. Mire, R. C. Postels.

Your committee recommends the following relating to sounding methods, for adoption in the Manual:

Pages 25–8 and 25–9

SOUNDING METHODS IN RIVER AND TIDAL WATERS

Delete and substitute the following:

SOUNDING METHODS

The methods generally used in sounding operations in measuring underwater depths are considered either as the manual or mechanical method.

The manual method of sounding includes the use of a sounding pole, graduated to feet and tenths of a foot, which is applicable to depths of water not exceeding 10 ft. For greater depths, a hand or lead line is used consisting of a weight attached to a sash cord, or a solid braided rope with a phosphor bronze wire center, tagged or marked at 5-ft intervals. In soundings taken with a hand line, allowance should be made for shrinking and stretching of the line. The size of the weight required depends on the velocity of the current and depth of the water.

The sounding wheel and the supersonic depth recorder are included in the mechanical sounding category.

The sounding wheel is usually 10 ft in circumference, with graduations in feet and tenths of a foot on one side of the wheel. A small radial dial indicates the number of revolutions made by the wheel, and a radial arm is also provided which can be set in any position independent of the operation of the wheel. The wheel is fastened to the sounding boat, or sled if soundings are taken through ice. The sounding lead is lowered to the water surface and the radial arm is set at 0.0 graduation on the wheel. The lead is then lowered to the bottom and the depth is read from the dial on the wheel.

The supersonic depth recorder consists of two units; a portable depth recorder containing electronic circuits which generate impulses at the rate of 300 per min that accurately measure under water depths, and a chart mechanism which records the depths as a permanent record. This unit resembles a large portable radio and is carried in the sounding boat. The second unit, usually referred to as a fish, consists of either an aluminum or mahogany housing, streamlined to reduce current resistance. This unit contains two magneto-striction type oscillators. One oscillator transmits the supersonic wave, and the other oscillator receives the reflected wave or echo which is recorded on the chart in the recorder as the under water depths are measured. The "fish" is fastened to the side of the sounding boat and submerged below the water surface at various depths, depending on the draft and speed of the boat. The soundings are measured at the rate of approximately five impulses per second, and are recorded on the chart to give a continuous profile. While the soundings are recorded automatically, it is necessary to locate the sounding points. Where extremely soft bottoms are encountered, the recordings may appear shadowy; at times the top of the soft bottom may be indicated, and at other times the bottom of the soft bottom may be indicated. When this condition is encountered, the supersonic soundings should be supplemented at frequent intervals with hand line soundings, using a mushroom type lead.

Complete description of the equipment and operation of the supersonic depth recorder is covered in the December 1949 issue of Railway Engineering and Maintenance magazine.

The procedure in sounding operations is generally as follows:

1. The elevations of water surfaces varying from time to time, a water gage referred to the datum of the survey should be established to keep automatically a gage height record with respect to time, or gage heights should be recorded at frequent regular intervals by an observer. Soundings and gage heights timed simultaneously will permit reduction of the soundings to correspond to the same water surface curve.

2. The establishment of a base line or a broken traverse line along the bank or shore for the location of range lines and transit stations.

3. When sounding operation is over comparatively narrow waterways, range lines may be established perpendicular to the waterway at intervals along the base line or broken traverse line with a flag placed on each bank, or two flags may be placed on the same bank as the base line for the guidance of the sounding boat.

4. Soundings are taken from a boat with the location of soundings determined by:

a. Moving the sounding boat at a uniform rate of speed along the sounding range in sluggish current to give transverse location by speed multiplied by time.

b. Moving the sounding boat at random speed along the sounding range and foresighting the sounding position from a transitman located at a favorable point on the base line when a flag is waved to indicate the point of sounding.

c. Simultaneously sighting the sounding position by two transitmen located at two different favorable points on the base line or traverse line.

d. Measuring the amount of piano wire paid out from a distance wheel or taping machine equipped with a register in cases of narrow rivers or adjacent to shore lines where soundings may be located on the range lines.

e. Using two sextants from the sounding boat, or buoys set on range lines where they can be used with shore points, or towers built on shore for long distance sighting in cases of very wide rivers, outer harbors, estuaries, bays, gulfs, or far off shore of lakes and sea coasts.

5. Soundings may also be taken from light cable foot bridges.

6. The distance between soundings along the range lines is determined by the purpose of the hydrographic survey and according to the underwater configuration.

7. The weight of the lead used in soundings is determined by the depth of water and velocity of the current. In slack water or light current a 3 to 5-lb weight will suffice. In swift current and water over 20 ft deep, it may be necessary to use a lead weighing from 12 to 20 lb. The lead weight should be streamlined and pivoted so as to offer the least resistance to the current.

A. B. Stone (chairman, subcommittee 1–C), G. K. Davis, H. S. Davis, J. A. Droege, Jr., Oscar Fischer, C. J. Henry, A. L. Sams, W. D. Simpson, G. L. Staley, P. V. Thelander, J. G. Sutherland.

Your committee recommends the following:

Pages 25–9 and 25–10

LANDS SUBJECT TO SERVITUDE OF NAVIGATION AS AFFECTING PROTECTION OF ROADBEDS BUILT OR TO BE BUILT ON PROPOSED DAM POOL AREAS

Reapprove without change.

Pages 25–11 to 25–13, incl.

PUBLIC IMPROVEMENT PROJECTS—THEIR COSTS AND BENEFITS

Reapprove with the following changes and deletions:

In third line, under "Forward", "including" to be changed to "included."

In the last paragraph under "Forward", "to adequately define" change to "to define adequately."

First paragraph under "Scope", change the word "costs" to "cost".

Change *"3. Annual Costs,"* to *"3. Annual Cost."*

Under "Annual Cost" add line reading "(h) Losses resulting from the project."

Under Definition, change the sidehead "Costs" to "Cost". First line, change "estimate of costs" to "estimates of cost". Fourth line, change "estimate" to "estimates". Also on fourth line insert "and losses" to read "costs and losses".

Delete the last paragraph under BENEFITS, reading, "intangible benefits should be carefully appraised and stated separately from tangible benefits."

Delete last sentence under Definition, reading, "Tangible and measurable benefits should be distinguished from intangible benefits which may not be susceptible of definite measurement."

C. J. Henry (chairman, subcommittee 1-D), J. A. Droege, Jr., N. E. Ekrem, R. L. Groover, B. M. Howard, S. L. Mapes, J. L. Vogel, V. R. Walling.

Your committee recommends the following:

Page 25-13

CLEARANCES FOR STRUCTURES OVER NAVIGABLE WATERWAYS

Reapprove without change.

Page 25-13

ALLOCATION OF EXPENSE FOR THE CONSTRUCTION, MAINTENANCE AND OPERATION OF BRIDGES OVER NAVIGABLE WATERWAYS

Reapprove with the following change:

Insert the word "Alteration," in the title, after the word "Construction."

Report of Committee 20—Contract Forms

G. W. Patterson, *Chairman,*
J. P. Aaron
E. H. Barnhart
G. H. Beasley
H. F. Brockett
A. B. Costic
G. K. Davis
A. D. Duffie
E. M. Hastings, Jr.
C. B. Niehaus, *Secretary,*
C. J. Henry
J. R. E. Hiltz
L. J. Hughes
J. S. Lillie
C. E. McCarty
W. L. Mogle
W. G. Nusz
L. A. Olson
J. L. Perrier
W. D. Kirkpatrick, *Vice-Chairman,*
E. E. Phipps
Bruce Shaffner
B. M. Stephens
W. R. Swatosh
J. L. Way
I. V. Wiley
Clarence Young
Committee

To The American Railway Engineering Association:

Your committee reports on the following subjects:

1. Revision of Manual.

   Progress report including recommended revisions .... page 531

2. Form of agreement covering subsurface rights to mine under railway carrier property.

   No report.

3. Form of agreement covering subsurface rights to mine under railway non-carrier property.

   No report.

4. Form of agreement for development of oil, gas and sulfur deposits on railway lands.

   No report.

5. Insurance provisions recommended for various forms of agreements.

   No report.

The Committee on Contract Forms,
G. W. Patterson, *Chairman.*

AREA Bulletin 504, November 1952.

Report on Assignment 1

Revision of Manual

For the purpose of reviewing the entire section of the Manual devoted to contract forms, seven sub-committees were organized and each was assigned a few of the forms (related insofar as possible) for review. Reports of the sub-committees are as follows:

Assignment 1–A

CONSTRUCTION AGREEMENTS

E. H. Barnhart (chairman, subcommittee 1–A), W. G. Nusz, L. A. Olson, G. W. Patterson, J. L. Perrier, Bruce Shaffner, B. M. Stephens, W. R. Swatosh, Clarence Young.

Your committee offers the following recommendations with respect to the Manual, for adoption:

Page 20-1—Form of Construction Contract

Reapprove without change.

Page 20-10.1—Form of Bond

Reapprove without change.

Page 20-11—Form of Cost—Plus Percentage Construction Contract

Reapprove without change.

Page 20-137—Form of Construction Contract for Minor Projects

Reapprove without change.

Page 20-147—Form of Agreement to Permit Subsurface Exploration by State or Other Governmental Agencies on Railway Right-Of-Way

Reapprove without change.

Report on Assignment 1-B

AGREEMENTS COVERING PASSENGER AND FREIGHT FACILITIES

C. E. McCarty (chairman, subcommittee 1-B), H. F. Brockett, G. K. Davis, C. J. Henry, J. S. Lillie, W. R. Swatosh.

Your committee has reviewed that portion of the Manual in Chapter 20 on Agreements covering passenger and freight facilities and makes the following recommendations:

Page 20-21—Form of Agreement for the Organization and Operation of a Joint Passenger Terminal Project—Parts 1 and 2

Reapprove without change.

Page 20-46.1—Form of Agreement for Cab Stand and BaggageTransfer Privileges

Withdraw and substitute the revised form shown in Exhibit A.

Page 20-47—Form of Agreement for Joint Use of Passenger Station Facilities

Reapprove with the following change: Eliminate the word "mutually" in the Now, Therefore, clause.

Page 20-53—Form of Agreement for Joint Use of Freight Terminal Facilities

Reapprove without change.

Report on Assignment 1-C

ELECTRICAL AGREEMENTS

E. M. Hastings, Jr. (chairman, subcommittee 1-c), A. B. Costic, W. L. Mogle, W. G. Nusz, J. L. Way.

Your committee offers the following recommendations with respect to the Manual material:

Page 20–61—Form of Agreement for Interlocking

Withdraw the present Manual material and substitute the revised form presented as Exhibit B.

Page 20–91—Form of Agreement for Purchase of Electrical Energy for Traction and Other Purposes

Reapprove without change.

Page 20–101—Form of Agreement for Purchase of Electrical Energy for Other Than Traction Purposes

Withdraw the material now in the Manual and substitute revised form presented as Exhibit C.

Page 20–109—Form of Agreement for Joint Use of Poles on Railway Lands

Delete the word "mutually" from second line of "Now Therefore" clause. Otherwise reapprove the form as it now appears in the Manual.

Page 20–113—Form of Agreement for Wire or Cable Line Crossing

Revision of this form is at present a matter of study by a special AAR committee, headed by W. R. Swatosh of AREA Committee 20, working in cooperation with representatives of the Rural Electrification Administration. It is possible this Special Committee may make some progress to report next year. In the meantime, it is the recommendation of Committee 20 that the present form be temporarily reaffirmed.

Report on Assignment 1–D

TRACK AGREEMENTS

J. L. Perrier (chairman, subcommittee 1–D), E. H. Barnhart, G. H. Beasley, L. J. Hughes, W. L. Mogle, I. V. Wiley.

Pages 20–67 to 20–72, incl.—Form of Agreement for Trackage Rights

Reapprove with the following changes:

Page 20–67—At the end of the dotted lines in the first Whereas clause add ", and".

In the second Whereas clause delete the word "and" at the beginning of the clause and change the period at the end of the clause to a semicolon (;).

Change the Now, Therefore, clause to read:

"Now, Therefore, in consideration of the mutual covenants herein stipulated to be kept by the parties hereto, it is agreed as follows:"

Page 20–68—Change the heading of Art. 7 from "Rental" to "Payments".

In the first line of Art. 7 change the words "agrees to" to "shall".

Page 20–69—In Art. 7 change part (f) to read as follows:

"(f) All bills shall be payable monthly, thirty days after rendition. Bills shall include wages at the current rate paid by the "A" Company for each class of labor furnished, including vacation allowance, Public Liability and Property Damage Insurance, Workmen's Compensation Insurance, Unemployment Compensation Insurance, payments pursuant to Social Security and Retirement Laws, or similar laws, State and Federal, applicable to the work undertaken by the "A" Company, and .... percent on labor costs for supervision and administration. Materials shall be billed at cost plus transportation and .... percent for handling, supervision and administration. From all credits for scrap or second-hand material there shall be deducted .... percent."

Page 20–70—In Art. 17 the second line of the second paragraph add after the word "employees" the following ", tools and equipment" and add the same after the word "employees" in the last line of the same paragraph.

Pages 20–73 to 20–75, incl.—Form of Agreement for Industry Track

Reapprove with the following changes:

Page 20–73—In the Whereas clause change the colon to a semicolon after the words "and made a part hereof".

Change the Now, Therefore clause to read:

"Now, Therefore, in consideration of the mutual covenants herein stipulated to be kept by the parties hereto, it is agreed as follows:

Page 20–74—2. Construction

Change to read:

The construction of said sidetrack, including roadbed, trestles, bridges, and all other appurtenances in connection therewith, shall be performed and the cost thereof borne as follows: ....

3. Maintenance

Change the first line to read:

Said sidetrack shall be maintained (including removal of ice, snow, weeds and debris) and renewed.

7. Clearances

In the first line change the words "agrees not to" to "shall not".

8. Liability

Change to read as follows:

It is understood that the movement of railway locomotives involves some risk of fire, and the Industry shall assume all responsibility for, and shall indemnify the Railway Company against loss or damage to property of the Industry or to property upon its premises, regardless of the Railway Company's negligence, arising from fire caused by locomotives operated by the Railway Company on said side track, or in its vicinity for the purpose of serving the industry, except to the premises of the Railway Company and to rolling stock belonging to the Railway Company or to others, and to shipments in the course of transportation.

In the second paragraph change the words: "also agrees to" to "shall" and put a period after the words "on or about said side track" and delete the balance of the paragraph which is the first two lines of page 20–75.

Page 20–75—In the clause beginning "In Witness Whereof", insert a comma before the words "the day and year".

Pages 20–81 to 20–86, incl.—Form of Agreement for Crossing of Railways at Grade

Reapprove with the following changes:

Page 20–81—At the end of the dotted lines in the first Whereas clause add ", and"

In the second Whereas clause change the words "a blueprint" to "the plan" and change the semicolon to a comma.

In the third Whereas clause change the period to a semicolon.

Change the Now, Therefore clause to read as follows:

"Now, Therefore, in consideration of the mutual covenants herein stipulated to be kept by the parties hereto, it is agreed as follows:"

Page 20–82—3. Construction

Change "agrees to" to "shall".

In the second line add a comma after "Exhibit A" and substitute "conforming" for the words "and according".

In the fourth line change "agrees to" to "shall".

In the last line change the words "to carry" to "shall carry".

4. Apportionment of Cost

Change the first line of the sentence following the dotted lines to read:

"The cost of maintaining and renewing said crossing shall include the expense".

5. Extensions and Changes

(a) In the third line change the dotted blank to "A".

(c) In the second line make the word "crossings" singular.

Page 20–83—6. Maintenance and Renewal

In the first line change the words "shall" to "will", and delete "shall" in second line and change "remove" to "removes".

Page 20–84, Change "11. Precedence" to "9. Precedence"

Change "12. Ownership" to "10. Ownership"

Delete Art. 13. Payment of Bills, and substitute the following:

11. Payments

All bills shall be payable monthly, thirty days after rendition. Bills shall include wages at the current rate paid by the .... Company for each class of labor furnished, including vacation allowance, Public Liability and Property Damage Insurance, Workmen's Compensation Insurance, Unemployment Compensation Insurance, payments pursuant to Social Security and Retirement laws, or similar laws, State and Federal, applicable to the work undertaken by the..............Company, and........ percent on labor costs for supervision and administration. Materials shall be billed at cost plus transportation and........percent for handling, supervision and administration. From all credits for scrap or second-hand material there shall be deducted......... percent.

Page 20–85—Delete Art. 14. Added Percentages

Art. 15 becomes Art. 12

Art. 16 becomes Art. 13

Art. 17 becomes Art. 14

Art. 18 becomes Art. 15

Pages 20–87 to 20–88, incl.—Form of License for Private Road Crossing

Reapprove with the following changes:

Page 20–87—Change that part of the preamble beginning with "The Railway Company" and ending with "and made a part hereof" to read:

WITNESSETH:

WHEREAS, the Railway Company owns and operates certain right-of-way and tracks situated near .... County, ..., and

WHEREAS, the Licensee desires the privilege of constructing, maintaining and using a private road crossing .... (Here insert character of structure, whether grade, over or under) .... the right-of-way and .... the tracks of the Railway Company, and

WHEREAS, the Railway Company grants unto the Licensee the license and privilege of constructing, maintaining and using said crossing substantially as shown on the plan dated ...., 19 ....., Exhibit "A", attached hereto and made a part hereof;

NOW, THEREFORE, in consideration of the mutual covenants herein stipulated to be kept by the parties hereto, it is agreed as follows:

Page 20-88—In the "IN WITNESS WHEREOF" clause delete the comma following the word "hereto".

Pages 20-89 to 20-90, incl.—Form of Agreement for Purchase of Water

Reapprove with the following changes:

Page 20-89—In the fifth line of the preamble add the word "the" before the words "Water Company".

Change the WITNESSETH clause to read:

"In consideration of the mutual covenants herein stipulated to be kept by the parties hereto, it is agreed as follows:"

Art. 3. Interruption of Supply

Delete the words "breaks in water pipe failure of pumping apparatus or any other causes beyond its control," and substitute therefore the following: "failures in its water supply system beyond its control."

Pages 20-119 and 20-120—Form of Agreement for Placing Snow or Sand Fences Off the Railway Company's Property

Reapprove with the following changes:

Page 20-119—Place a colon after the word "WITNESSETH"

In the second WHEREAS clause change the comma to a semicolon at the end of the clause.

In the second line of the NOW, THEREFORE, clause delete the word "mutually".

Page 20-120—3. Consideration

In the first line change the words "agrees to" to "shall".

Pages 20-121 and 20-122—Form of Agreement for Furnishing Water From Railway Water Systems to Employees and Others

Reapprove with the following changes:

Page 20-121—Change the comma to a semicolon at the end of the second WHEREAS clause.

Delete the word "mutually" in the second line of the NOW, THEREFORE clause.

1. Construction

In the first line delete "agrees to" and substitute "will".

In the second line add "dated .... 19 ....," between the words "plan" and "hereto" and place a comma after the word "attached".

Delete the word "and" in the 3rd line and place a comma at the end of the dotted fourth line.

In the fifth line delete the word "hereby" and substitute the word "will" for the word "to".

In the eleventh line delete "and agreed".

2. Maintenance

Substitute "will" for "agrees to".

Page 20-122—3. Payment for Construction

Substitute "shall" for "agrees to".

4. Payment for Water

Substitute "shall" for "agrees to".

10. Idemnification

Substitute "shall" for "agrees to".

Pages 20–122.1 to 20–122.4, incl.—Form of Agreement for Operation of Commissary and Boarding Outfits

Reapprove with the following changes:

Page 20–122.1—Change the "Now, Therefore" clause to read:

"Now, Therefore, in consideration of the mutual covenants herein stipulated to be kept by the parties hereto, it is agreed as follows:"

Page 20–122.3—Insert "Railway" before the word "Company" in the heading of Art. 15.

17. Track Cars

Start the first sentence with the words "That nothing".

18. Statement to Railway Company

In the 4th line delete "agrees that it will thereupon" and substitute "shall".

Page 20–122.4—19. Railway Company's Control.

Insert the word "That" at the beginning of the first sentence and change "The" to "the".

Page 20–122.4—Change the "In Witness Whereof" clause to read:

"In Witness Whereof, the parties hereto have caused this agreement to be executed in ...., the day and year first above written."

Report on Assignment 1–E

FLOOD CONTROL AGREEMENT FORMS

W. D. Kirkpatrick (chairman, subcommittee 1–E), H. F. Brockett, A. D. Duffie, C. J. Henry, Bruce Shaffner, B. M. Stephens, Clarence Young.

The committee has reviewed the three flood control agreement forms assigned and has made minor revisions thereto for the sake of uniformity with other Manual agreements.

Pages 20–143 to 20–145, incl.—Form of Agreement for Construction of Stop Log or Other Structures for Flood Control

Reapprove with the following revisions:

Page 20–143—First line of preamble after "by" add "and".

Third line of preamble insert "Railway" before "Company".

Delete "That" after "Witnesseth".

First Whereas clause, Line 3, insert "Railway" before "Company".

Second line of second Whereas clause insert "Railway" before "Company".

Last line of second Whereas clause insert "Railway" before "Company".

Last line of last Whereas clause insert "Railway" before "Company".

Page 20–143—Subhead the sections as follows:

	1. Grant	
	2. Plans	
Page 20–144	3. Safety	
	4. Track Support	
	5. Cost	(New Number)

6. Laws (New Number)
7. Indemnity (New Number)
8. Permits (New Number)
9. Insurance (New Number)
10. Clean-up (New Number)
11. Independent Contractor (New Number)

Page 20-143—1. Grant

Line 1, insert "Railway" before "Company".

Page 20-144—3. Safety

Line 3, delete "railroad of the Company" and substitute "Railway Company's facilities."

Lines 5 and 6, insert "Railway" before "Company"

Page 20-144—4. Track Support

Number second paragraph and remainder of Section "5. Cost" and renumber succeeding paragraphs accordingly.

Lines 1, 2 and 4 of Section 4 insert "Railway" before "Company".

Line 4 delete "hereby agrees to" and substitute "shall"

Page 20-144—5. (New)—Cost

Line 1 change "further agrees" to "shall" and in line 13 change "hereby agrees" to "shall".

Lines 1, 3, 8, 9, 11, 14 insert "Railway" before "Company"

Page 20-144—6. (New)—Laws

Line 1, delete "further agrees to" and substitute "shall"; Insert "Railway" before "Company"

Line 2, after "also" delete "to" and substitute "shall".

Line 5, insert "Railway" before "Company".

Page 20-144—7 (New)—Indemnity

Line 1, insert "Railway" before "Company".

Page 20-145—9. (New)—Insurance

Lines 1, 4, 5, 10, 18, 19, 20, 21, 23, insert "Railway" before "Company".

Page 20-145—10. Clean-Up

Line 2, insert "Railway" before "Company".

Page 20-145—11. Independent Contractor

Line 1, insert "Railway" before "Company".

Page 20-145—In Witness Whereof Clause, line 2, delete "effective".

Page 20-145—In execution line insert "Railway" before "Company".

Pages 20-149 to 20-152, incl.—Form of Agreement for Railway Force Account Work on Flood Control Projects

The committee reapproves with the following revisions:

Page 20-149—Line 2 of preamble, delete quotation marks before and after "Government".

Page 20-149—Line 5 of preamble delete "Railway" and substitute "the Railway Company".

Page 20-149—Line 6 of first Whereas clause, delete semicolon before "and" and substitute a comma.

Page 20-149—Line 1 of second Whereas clause change "Railway" to "the Railway Company".

Line 3 of second Whereas clause delete semicolon before "and" and substitute a comma.

Page 20–149—Line 1 of third WHEREAS clause, change "Railway" to "the Railway Company".

Line 2 of third WHEREAS clause, delete the semicolon before "and" and substitute a comma.

Page 20–149—Line 1 of last WHEREAS clause change "Railway" to "the Railway Company", delete "for the consideration hereinafter stated".

Page 20–149—Line 4 of last WHEREAS clause substitute a semicolon for period after "Exhibit A".

Page 20–149—Now therefore clause should read, "NOW THEREFORE, in consideration of the mutual covenants stipulated to be kept by the parties hereto it is agreed as follows:"

Page 20–149—1. Scope of Work
Line 3, change "Railway" to the "the Railway Company".

Page 20–150—Line 1, change "Railway" to "the Railway Company".

Page 20–150—2. Prosecution of Work
Line 1, change "Railway" to "The Railway Company".

Page 20–150—3. Payment for Work
Lines 1, 2, 6, 11, 13, 14, 17, change "Railway" to "the Railway Company".
Lines 18, 20, change "Railway's" to "the Railway Company's"
Line 27, change "Railway" to "the Railway Company".
Page 20–151—Line 2, change "Railway" to "the Railway Company".
Line 3, change "Railway's" to "the Railway Company's".
Lines 6, 7, 9, 11, 12, change "Railway" to "the Railway Company".
Page 20–151—4. Changes During Construction
Line 2, change "Railway" to "the Railway Company".
Page 20–151—5. Disputes and Arbitration
Line 3, change "Railway" to "the Railway Company".
Page 20–151—6. Licenses and Permits
Line 1, change "Railway" to "The Railway Company".
Page 20–151—7. Insurance
Lines 1 and 5, change "Railway" to "the Railway Company".
Page 20–152—Lines 2, 4, 6, change "Railway" to "the Railway Company".
Page 20–152—8. Final Inspection
Line 1, change "Railway" to "The Railway Company".
Line 4, change "Railway to "the Railway Company".
Page 20–152—9. Right of Way
Lines 1, 2, 3, change "Railway" to "the Railway Company".
Page 20–152—Execution line, insert "Railway" before "Company".

Pages 20–153 to 20–156, incl.—Form of Agreement for Division of Work, Maintenance and Operation of Flood Protection Projects

The committee reapproves with the following revisions:
Page 20–153—Change the last word in title from "PROJECTS" to "WORKS".
Page 20–153—Line 4 of preamble change "Railway" to "the Railway Company".
Page 20–153—First WHEREAS clause.
Line 5, change the semicolon to a comma.
Page 20–153—Second WHEREAS clause.
Line 1, change "Railway" to "the Railway Company".
Line 3, change the semicolon to a comma.

Page 20–153—Third WHEREAS clause.
Line 2, change "Railway" to "the Railway Company".
Line 2, change the semicolon to a comma.

Page 20–153—Fourth WHEREAS clause.
Line 2, change "Railway's" to "the Railway Company's".
Line 3, change the semicolon to a comma.

Page 20–153—Fifth WHEREAS clause.
Line 3, change the semicolon to a comma.

Page 20–153—Sixth WHEREAS clause.
Line 1, change "Railway" to "the Railway Company".
Lines 1 and 2, delete "or its agents, for the consideration hereinafter stated to be paid by Government to Railway".
Lines 3, 5, change "Railway" to "the Railway Company".
Line 5, change "Railway's" to "the Railway Company's".
Line 8, change period at end of line to a semicolon.

Page 20–153—Change NOW THEREFORE clause to read "NOW, THEREFORE, in consideration of the mutual covenants stipulated to be kept by the parties hereto it is agreed as follows":

Page 20–153—1. Grant of Easement
Line 1, change "Railway" to "The Railway Company".
Lines 3, 4, 7 change "Railway" to "the Railway Company".

Page 20–154—Line 3 change last "Railway" to "the Railway Company".
Line 3 change the word "at" to "as".

Page 20–154—2. Right of Entry
Line 1, change "Railway" to "The Railway Company".
Lines 2, 5, change "Railway's" to "the Railway Company's".
Line 7, change "Railway" to "the Railway Company".
Page 20–154—4. Work to be Performed By Railway at Government's Expense
Heading change "Railway" to "the Railway Company".
Lines 1, 3, 5, change "Railway" to "the Railway Company".
Page 20–154—5. Work to be Performed by Public Authority at Its Expense
Line 2, change "Railway's" to "the Railway Company's."
Lines 3, 4, 6, 8, 9, change "Railway" to "the Railway Company".
Page 20–154—6. Prosecution of Work
Lines 1, 3, change "Railway" to "the Railway Company".
Page 20–155—Line 3, change "Railway" to "the Railway Company".
Page 20–155—7. Payment for Work.
Lines 1, 2, 4, 5, 6, 10, change "Railway" to "the Railway Company".
Line 5, after "Workman's Compensation Insurance" insert "or Employer's Liability Insurance and Federal Employer's Liability".
Page 20–155—8. Insurance
Lines 1, 3, 14, 15, 20, change "Railway" to "the Railway Company".
Page 20–156—9. Railway Indemnified by Public Authority.
Heading and Lines 1, 5 change "Railway" to "the Railway Company".
Page 20–156—10. Notification of Railway by Public Authority.
Heading and Lines 2, 9, change "Railway" to "the Railway Company".
Lines 3, 6, change "Railway's" to "the Railway Company's".
Page 20–156—11. Interference with Railway Operations
Heading and Line 5, change "Railway' to "the Railway Company".

Line 2, change "Railway's" to "the Railway Company's".

Page 20–156—The Witness Whereof clause

Line 1, change "Agreement" to "agreement".

Report on Assignment 1–F

REVISION OF MISCELLANEOUS AGREEMENTS FORMS

G. W. Patterson (chairman, subcommittee 1–F), G. H. Beasley, A. D. Duffie, W. D. Kirkpatrick, J. L. Way.

Pages 20–105 to 20–107, incl.—Form of Agreement for the Use of Railway Property By High Pressure Pipe Lines With Special Reference to Pipe Lines Carrying Inflammable Oils and Gas

Reapprove without change.

Pages 20–117 and 20–118—Form of License for Pipes, Conduits, Drains, Hopper Pits and Other Structures on Railway Property

Reapprove the following minor changes:

Indent the word Witnesseth to line up with Whereas below.

In second Whereas clause, add comma after "construction"; also change to semicolon after "Set forth".

In Now Therefore clause, delete "mutually" preceding "agreed".

Rewrite Art. 3 to read as follows:

The Licensee shall at its sole cost and expense, and in a manner satisfactory to the .... of the Railway Company, construct, maintain, use and finally remove the above described facility. The Licensee shall not do any work which may interfere with the operation of the railway without written permission from the .... of the Railway Company. The Railway Company may perform without notice any work, on or adjacent to the facility, which it considers necessary for the safe operation of the railway, and the Licensee shall reimburse the Railway Company for the costs of such work plus the addition of .... percent on labor and .... percent on materials required.

Change Art. 4 by deleting "or any rights other than license".

Pages 20–133 to 20–135, incl.—Form of Agreement for Unloading Liquefied Petroleum Gases and Other Liquefied Gases

Reapprove with the following minor changes:

In last line of record Whereas clause, add words "to permit" between "and" and "said".

Page 20–133—1. Grant

Place "to the Industry" between "grants" and "the" and delete the same words following "permission". Delete comma following "facilities".

Page 20–134—7. Liability

Delete comma following "whomsoever" in fourth line.

Page 20–134—8. Consideration

Change last two lines to read "year, payable annually in advance. The first payment shall be made on or before the .... day of .... 19 ....".

Page 20–135—10. Duration and Consideration

Change to read:

This agreement shall continue in effect until terminated by .... days' written notice from either party to the other, and shall inure to the benefit of and be binding upon the parties hereto, their heirs, executors, administrators, successors and assigns.

Report on Assignment 1-G

AGREEMENTS COVERING LAND

W. R. Swatosh (chairman, subcommittee 1-G), J. P. Aaron, J. R. E. Hiltz, J. S. Lillie, C. B. Niehaus, E. E. Phipps, I. V. Wiley.

The committee, in conformance with assignment, reviewed the Form of Lease For Industrial Site, Form of Option For Purchase of Land, Form of Conveyance of Title Granting the Right to Construct and Maintain Buildings Over Railway Property, and Form of Agreement For Commercial Signs on Railway Property.

In the main, the revisions in these forms consist of editorial changes in the text thereof, and in the Whereas and Now, Therefore clauses.

With the changes made it is the considered opinion of the committee that the forms as revised will be comprehensive in scope and in harmony, as to text and form, with other Manual agreements.

Pages 20-77 to 20-80, incl.—Form of Lease for Industrial Site

Reapprove with the following changes:

Art. 1—Ahead of the word "Company" insert the word "Railway".

Art. 11—Delete the word "Lessor" in the last line, and insert the words "Railway Company".

Art. 13—Delete, in the first line, the words "agrees" and "to" and insert the word "shall" in lieu of the word "agrees".

Art. 23—Delete, in the first line, the words "agrees to" and insert the word "shall".

Page 20-123—Form of Option for Purchase of Land

Reapprove with the following changes:

Delete the one sentence second paragraph and substitute with new two sentence paragraph reading "The Railway Company will pay for examination of titles. Interest, taxes, water rents, rents and insurance are to be prorated as of the date of delivery of the deed."

Pages 20-125 to 20-128, incl.—Form of Conveyance of Title Granting the Right to Construct and Maintain Buildings Over Railway Property

Reapprove without change.

Pages 20-129 to 20-131, incl.—Form of Agreement for Commercial Signs on Railway Property

Reapprove with the following changes:

Delete all the language between preamble of the agreement and Art. 1 and substitute with:

Witnesseth:

Whereas, the Licensee desires to construct, maintain and use a commercial sign upon the property of the Railway Company situated at .... and substantially as shown on the plan and in the specifications hereto attached, designated as .... dated .... and made a part hereof, and

WHEREAS, the Railway Company is agreeable to said construction, maintenance and use;

NOW, THEREFORE, in consideration of the mutual covenants herein stipulated to be kept by the parties hereto, it is agreed as follows:

Art. 4—Following the word "expense" in first line insert the word "and".

Art. 5—Delete in first line "The Licensee further covenants and agrees that if and", and change the existing word "in" to upper case.

Art. 6—Delete in second and third lines "if requested by the .... of the Railway Company,". In lines eight and nine delete words "covenants and agrees to" and insert the word "shall".

Art. 9—In first line following word "Licensee" insert the word "shall" and change word "assumes" to the singular.

Exhibit A

FORM OF AGREEMENT FOR CAB STAND AND BAGGAGE TRANSFER PRIVILEGES

THIS AGREEMENT, made this .... day of ...., 19 ...., by and between ...., a corporation organized and existing under the laws of the State of ...., hereinafter called the Railway Company, and ...., a corporation organized and existing under the laws of the State of ...., hereinafter called the Cab Company.

WITNESSETH:

WHEREAS, the Cab Company desires sole and exclusive privileges of maintaining a public cab stand and baggage transfer on Railway Company premises and for soliciting passengers and baggage on Railway Company grounds and platforms, including the right to check baggage through from residence and hotels to destination, and

WHEREAS, the Railway Company, so far as it lawfully may, is agreeable to do so subject to its rules and regulations.

NOW, THEREFORE, in consideration of the mutual covenants herein stipulated to be kept by the parties hereto, it is agreed as follows:

1. Grant

The Railway Company grants to the Cab Company, so far as it lawfully may, the sole and exclusive privilege of maintaining a public cab stand and baggage transfer on its premises at ...., and of soliciting passengers and baggage on the grounds and platforms at said location, including the right to check baggage through from residences and hotels to destination, subject to the rules and regulations of the Railway Company.

2. Parking Space

The Railway Company will permit the Cab Company to park upon railway property a sufficient number of cabs for transportation of passengers and others at a point, or points, to be designated from time to time by the Railway Company, but nothing herein contained shall make it obligatory upon the Railway Company to furnish such parking space. The Cab Company shall mark off space allotted by the Railway Company, and provide appropriate signs for indicating cab stands and such other service furnished to the public.

3. Transfer Cabs

The Cab Company shall provide for regular service at said location suitable cabs and conveyances for passengers and baggage to fully accommodate all reasonable demands of patrons of the Railway Company, and shall at all times keep them in proper repair.

4. Transfer—Station to Station

The Cab Company shall provide suitable cabs and conveyances for transferring passengers and baggage from said location to other stations, for account of the Railway Company, at rates approved by the Railway Company as provided for in Sec. 6, prior to the effective date of this agreement.

5. Agents and Employees

The agents and employees of the Cab Company shall not be considered agents or employees of the Railway Company, and shall at all times conduct themselves in an orderly and respectful manner when soliciting business from patrons or passengers of the Railway Company.

6. Transfer Rates

The Cab Company, from time to time, or when requested by the Railway Company, shall submit to the Railway Company a schedule of its rates for transfer of passengers and baggage and the Cab Company, its agents or employees, shall not collect or charge patrons or passengers of the Railway Company rates in excess of the schedule approved by the Railway Company, regular rates of recognized cab companies in the same zone, or fares prescribed by law.

7. Hotel Solicitation

The Cab Company, its agents or employees, shall not act as solicitors for any hotel, restaurant, lodging house or any business, or in any way endeavor to prejudice any patron or passenger of the Railway Company for or against any hotel, restaurant, lodging house or business, nor shall they, or any of them, distribute or circulate any form of advertising whatsoever in behalf of any hotel, restaurant, lodging house or business.

8. Baggage Records

The Cab Company shall keep a record of the disposition of all baggage received from the Railway Company for delivery, and all such baggage shall be considered in good condition unless a "bad order" receipt is accepted by the Railway Company.

9. Claims

Except as herein specified the Cab Company shall handle all claims for loss or damage, direct with the claimants, and shall assume all costs thereof.

10. Waybills

The Cab Company shall waybill all baggage collected by it for delivery to the Railway Company and shall obtain from the Railway Company a receipt for all such baggage delivered to it.

11. Loss and Damage

The Cab Company shall be responsible for all loss and damage to baggage collected by it which has not been receipted for by the Railway Company. On baggage billed through from residence, or hotel, to destination, in the event of loss or damage, when the responsibility for such loss or damage cannot be ascertained, and it is not already hereinbefore provided for, the Cab Company shall contribute to any payment made, cost, expense or injury suffered by the Railway Company or any other carrier, on account of such loss or damage, in the proportion that the charge of the transfer of such piece of baggage bears to the total revenue received by the Railway Company and other carrier, from the transportation of said baggage and passengers accompanying same.

12. Liability

The Cab Company shall indemnify the Railway Company, and save it harmless from all loss, claims, damages, costs, or causes of action of whatsoever nature, arising from or growing out of injury to or death of any person or persons, or damage to or destruction of property of any person whomsoever in connection with the maintenance and use by the Cab Company of the property of the Railway as granted under the provisions of this agreement.

13. Consideration

The Cab Company shall pay to the Railway Company monthly, in advance, for said privileges, the sum of .... Dollars ($............), such payment to be made at the principal offices of the Railway Company or at such other point the Railway Company may, from time to time, direct.

14. Independent Contractor

The Railway Company reserves no control whatsoever over the employment, discharge, compensation of or services rendered by the Cab Company's employees, and it is the intention of the parties to this agreement that the Cab Company shall be and remain an independent Cab Company, and that nothing in this agreement contained shall be considered as inconsistent with that status. The Cab Company shall pay all contributions measured by the wages of its employees required to be made under the State and Federal Unemployment Compensation Insurance, Social Security or Retirement laws, applicable to the work performed hereunder by the Cab Company and it accepts exclusive liability for said contributions; the Cab Company shall indemnify and save harmless the Railway Company, its successors and assigns, from any and all liability arising therefrom.

15. Term

This agreement shall become effective as of the .... day of ...., 19 ...., and shall continue from month to month until terminated as follows:

(a) By either party giving the other .... days written notice prior to first day of any calendar month, it being the intention that either party will have a full calendar month's notice.

(b) By the Railway Company, if the Cab Company should at any time fail, in the judgment of the Railway Company, to fully perform any or all of its obligations under this agreement, giving the Cab Company, or its agent on the premises, ... days written notice. The Cab Company, upon receiving such notice, shall remove its vehicles and property from the premises and discontinue use of Railway Company's property.

(c) By the Railway Company, if the Cab Company is in arrears in its rental payments more than three months, unless deferred payments are arranged by mutual agreement between the Railway Company and the Cab Company.

(d) By the Railway Company when the Cab Company sublets, without the consent of the Railway Company, any of the privileges hereby granted to the Cab Company.

(e) By the Railway Company if the Cab Company shall make an assignment for the benefit of its creditors, or be adjudicated bankrupt, or any legal proceedings shall be instituted for the appointment of a receiver therefor or to have it adjudicated bankrupt.

16. Obligations—Termination

It is mutually agreed that in the event of the termination of this agreement in accordance with the foregoing clauses of Sec. 15, nothing shall be construed to relieve the Cab Company of any of its obligations in sections 9 and 10, which may have occurred prior to the termination of this agreement.

17. Assignment

The Cab Company shall not, without the written consent of the Railway Company, assign or sublet any of the privileges herein granted.

In Witness Whereof, the parties hereto have executed this agreement, in

............................, the day and year first above written.

.... Company

Witness: .... By ....

.... Company

Witness: .... By ....

Exhibit B

FORM OF AGREEMENT FOR INTERLOCKING

THIS AGREEMENT, made this .... day of ...., 19 ...., by and between ...., a corporation organized and existing under the laws of the State of ...., hereinafter called the .... Company, and .... a corporation organized and existing under the laws of the State of ...., hereinafter called the .... Company.

Witnesseth:

Whereas, ...

(Note: Insert brief description of conditions, including location of existing facilities; enumerate any existing agreements giving dates, interested parties and purposes.)

...., and

Whereas, the parties hereto mutually desire to construct, maintain and operate an interlocking at said location, the type and arrangement of the interlocking to be substantially as shown on plan marked "Exhibit A," dated ...., 19...., further identified by the signatures of .... (proper officers) .... of the .... Company and the .... Company, attached hereto and made a part hereof, and

Whereas, the parties hereto desire to define the ownership of facilities, and their rights and obligations with respect to the proposed interlocking;

NOW, THEREFORE, in consideration of the premises and of the mutual covenants herein stipulated to be kept by the parties hereto, it is agreed as follows:

1. Definition

The term "interlocking" as used herein shall be held and taken to include the interlocking station, power plant, buildings, housings, machinery, appliances and appurtenances necessary for operation of the interlocking within the limits as shown on "Exhibit A," but shall not include ties, rails, insulated joints, other track materials or special items as provided in Art. 6 hereof.

2. Construction

(a) Subject to approval of proper public authorities, the .... Company shall construct the interlocking substantially as shown on "Exhibit A," shall begin the construction within .... days after the date of such approval, and shall carry the work forward to a prompt completion.

(b) Each of the parties hereto shall, at its own expense, reconstruct and realine its tracks to conform to the arrangement of tracks as shown on "Exhibit A," excepting that ....

(Define responsibility for construction and maintenance of any rail crossings, jointly owned turnouts, etc., to accommodate existing tracks)

*(c) Each of the parties hereto shall have the right to construct additional tracks

* This paragraph to be used only if applicable or mutually agreed upon.

at this location. The construction, maintenance, repair and renewal of all .... (crossing frogs, switches, etc.) .... and other junction appurtenances for future tracks of either party hereto shall be under the sole charge and control of the .... Company. All costs and expense of such future construction, maintenance, repair and renewal shall be borne by the parties hereto as follows:

....

....

3. Apportionment of Cost

(a) The cost of construction, maintenance and renewal of said interlocking, as shown on "Exhibit A," shall be borne by the parties hereto in the proportion that the number of AAR units assigned to each party, shall bear to the total number of units installed.

(Note: Insert the principles to be followed in assigning units to each party in "Exhibit C".)

Table of signal and interlocking units based on Association of American Railroads Signal Section Table of Signal and Interlocking Units, "Exhibit B," dated ...., 19 ...., and unit distribution, "Exhibit C," ...., 19 ...., and identified by the signatures of .... (proper officers) .... of the .... Company and the .... Company, are attached hereto and made a part hereof.

(b) In the event that by mutual agreement of the parties hereto any change shall be made during construction of the interlocking, "Exhibit C" shall be revised in accordance with AAR Signal Section Table of Signal and Interlocking Units and the cost of constructing, maintaining and renewing the interlocking shall be borne by the parties hereto on the basis of such revised "Exhibit C."

(c) Each party hereto shall participate in the ownership of said interlocking in the ratio which the payments made by it for construction of said interlocking, including changes chargeable to capital account, bear to the total cost of construction thereof.

(d) The cost of maintaining and renewing the interlocking shall include repairs of damage due to fire, action of the elements, strikes or other contingencies.

(e) Each party hereto shall, at its option, carry insurance on its equity in the interlocking.

(f) Each party hereto shall report its interest in the interlocking as may be required for taxation purposes.

(g) The cost of operating the interlocking, including wages of employees operating same, their expenses, if any, and cost of their supplies, heating, lighting, and cleaning the interlocking station, shall be borne by the parties hereto as follows:

....

....

....

(h) That portion of the cost of wages of signal forces, and other expenses included in ICC Account 404, Signal and Interlocker Operation, shall be divided between and borne by the parties hereto on the same basis as the cost of maintaining the interlocking.

(i) The cost of removing any existing safety appliances or devices shall be divided in the same manner as the maintenance and renewal expense of said appliances or devices has heretofore been divided.

(j) If either of the parties hereto shall require communication or other special service in connection with operating the interlocking, resulting in additional wages or other expense, the party requiring such service shall bear the additional cost thereof. In case both of the parties hereto shall require such special service the additional cost thereof shall be borne as follows:

....

....

4. Changes

Each of the parties hereto shall have the right to require changes in the interlocking, provided they shall not impair its efficiency. Such changes, arising from changes made in any existing track or tracks, or made to cover any future track or tracks or other facilities which either party hereto may have the right to construct, or which may be required by reason of any changes made in the standard appliances or practices of either party hereto, or which may be ordered by a lawfully constituted public authority, shall be made by maintaining company, or by other agreement, and the cost of such changes, including the cost of flagmen or other additional employees made necessary by the changes, shall be borne by the party hereto for which the changes are made. When changes are made, a revised "Exhibit C" shall be prepared in accordance with current issue of "Exhibit B."

5. Control of Interlocking

(a) *Maintenance*

(1) The maintenance and renewal of the interlocking shall be under the sole charge and control of the .... Company, and it

shall employ qualified persons to maintain and renew the same. The non-maintaining company shall have the right to request the maintaining company to remove such persons for good and sufficient reason.

(2) Each of the parties hereto, through its authorized employees and representatives, shall have the right at all times to inspect the interlocking, also the accounts covering its construction, maintenance, renewal and operation. In the event that the non-maintaining company shall notify the maintaining company, in writing, of repairs and renewals that may be necessary for the safe and proper operation of the interlocking, and if the maintaining company neglects to make the necessary repairs and renewals, then the complaining company shall have the right to make such repairs and renewals, and the maintaining company shall, upon presentation of proper bills, and within the time provided in Section 8 hereof, pay its proportion of the amount so expended.

(3) Each of the parties hereto shall, at its own expense, keep all pipe lines, switches, derails, and their connections, in or along its own tracks free from ice, snow, dirt, vegetation or other obstructions which may interfere with proper working of the interlocking. In case either party fails to do so, the other party may enter upon the premises of the party at fault and remove such ice, snow, dirt, vegetation or other obstruction. The party at fault shall reimburse the party doing such work for all expense incurred thereby.

(b) *Operating*

(1) The operating of the interlocking shall be under the sole charge and control of the .... Company, and it shall employ qualified persons to operate the same. The non-maintaining company shall have the right to request the maintaining company to remove such persons for good and sufficient reason.

(2) Either party hereto may use the employees operating the interlocking in its communication or other special service, provided it shall give the other party at least ten days prior written notice of such intention, and provided further that the use of such employees does not interfere with the prompt handling of the interlocking.

(3) If for any reason it becomes necessary to take the interlocking out of service temporarily, the operating company shall provide and control the necessary additional employees, and the expense of such additional employees shall be borne by the company necessitating the service.

6. Material and Labor Supplied

Each of the parties hereto shall at its own expense furnish and install its own derails, switch points, switch rods, special switch and derail ties and timbers, all track insulations, poles, cross arms and fixtures, except as otherwise provided, and shall maintain and renew them thereafter. Each party hereto shall do all the grading and track work necessary to prepare its tracks for the installation of the interlocking, shall provide and maintain proper drainage, and shall bear the cost and expense of raising and adjusting pipe carrier and mechanism foundations, and the renewal of any other appliances required or made necessary by its resurfacing, reballasting or rail renewal within the limits of the interlocking.

Each party hereto shall have the right to carry its respective signal control circuits through the interlocking at its own expense, provided however, that work within home signal limits shall be performed by the forces of the party maintaining the interlocking, or under its supervision, at expense of the party for whose benefit the work is done.

7. Precedence

In the use of the interlocking, passenger, mail and express trains shall have precedence over freight trains and light engines; and freight trains shall have precedence over light engines. When of like class, trains and engines shall have precedence in the order of their arrival.

8. Payment of Bills

All payments hereunder shall be made within thirty days after rendition of proper bills.

The .... Company shall render bills covering the cost of constructing the interlocking, such expense to be billed in one statement unless otherwise agreed upon by the parties hereto.

Itemized bills covering the maintenance, operation and renewal of the interlocking shall be rendered monthly by the .... Company.

Such bills as are based upon payroll cost of labor, and stock prices of material shall include a fair arbitrary charge to cover supervision, inspection, handling, transportation, accounting and similar undistributed items of expense. Such a fair arbitrary charge shall be in accordance with the recommendations of the General Managers' Association of ...., in effect from time to time, or in the absence of any such recommendations, shall be agreed to by the parties, or determined by arbitration as hereinafter provided.

Should dispute arise as to the correctness of any items included in bills rendered under this agreement, the party against which such bills are rendered shall pay all items included in the bills, and the correctness of disputed items shall be determined and proper adjustment allowed in future bills.

9. Liability

For the sole purpose of determining the manner of contribution between the parties hereto where either may suffer loss or damage or be liable for loss or damage to property or injury to or death of persons (all hereinafter called "damage"), caused by or attributable to the construction, maintenance, renewal, operation and operating the interlocking as herein provided for, it is agreed that employees of either party hereto when engaged in performing service or doing work as provided for in Arts. 4, 5 (a) (3) and 6 hereof shall be construed as the sole employees of the party hereto required to ultimately pay for such service and work; employees of either party hereto when engaged in performing service or doing work as mentioned in Arts. 2, 5 (a) (1) and (2), and 5 (b) (1), (2) and (3) hereof shall be construed as the joint employees of parties involved, provided, however, that such joint employees when performing services solely for the benefit of one of the parties hereto shall be construed as the sole employees of the party hereto for whom at the time such services are being performed; and that said contribution shall be determined and paid as follows:

(a) Each party hereto shall assume, bear and pay, and shall indemnify, protect and save harmless the other from, all damage attributable to the fault or negligence of its sole employee or employees, whether or not concurring with that of a joint employee or employees, excepting only as provided in Par. (b) of this Article.

(b) Each party hereto shall assume, bear and pay all damage to its property, to property under its control or in its custody, and to its sole employees and persons in or upon its engines, trains, or cars, attributable to failure properly to construct, maintain or renew the interlocking, or when attributable to the fault or negligence of its sole employees combined with the fault or negligence of the sole employees of the other party hereto, or solely to the fault of one or more joint employees, or one or more joint employees and the sole employees of either party hereto, or unknown or concealed causes; all other damage, when so attributable, shall be assumed, borne and paid by the parties hereto in the same ratio as the costs of maintaining and renewing the interlocking were divided between them during the period in which the damage occurred.

In case of death or injury due to fault or negligence as defined above, occurring to employees upon the property covered by the terms of this agreement, in which case under any law, state or federal, compensation is required to be paid, such compensation shall be distributed between the parties hereto as in case of liability provided in this Article.

In every case of death or injury occurring, without fault or negligence as defined above, to a sole employee, the party employing such employee shall be solely responsible for any compensation required by law to be paid by reason of such death or injury.

In every case of death or injury occurring, without fault or negligence as defined above, to a joint employee as hereinbefore defined, the compensation required by law to be paid on account thereof shall be paid solely by the party hereto for whom service is being performed at the time of such death or injury. In the event that both parties are being served at the time such death or injury is caused, all consequent payments resulting therefrom shall be borne by the parties hereto in the proportion shown in "Exhibit C."

If and when compensation is required to be paid in installments over a period of years, the future payments shall be distributed between the parties hereto in the same ratio as the first payment. No party shall be released from the payment of its share of such installments for which it may become liable by the cancellation or termination of this agreement.

10. Arbitration

In case any question arises under this agreement or concerning the subject matter thereof, upon which the parties hereto cannot agree, such question shall be settled by a sole, disinterested arbitrator, to be selected jointly by the parties to this agreement, and if they fail to select such arbitrator within .... days after demand for arbitration is made by either party hereto, then such arbitrator shall be appointed by the judge of the .... Court of .... Where signal practices are involved, the Arbitrator shall be one thoroughly conversant with signal practices and requirements.

The expense of arbitration shall be apportioned between the parties hereto, or wholly borne by either party, as determined by the Arbitrator.

11. Cancellation of Conflicting Agreements

The agreement dated ...., 19 ...., between the parties hereto or their predecessors is hereby terminated. Except as herein modified, any and all other agreements between the parties hereto or their predecessors shall continue in full force and effect.

12. Duration and Succession

This agreement shall take effect on the .... day of ...., 19 ..... and shall continue in force during the existence and operation of the interlocking or until terminated by the mutual agreement of the parties hereto.

The provisions of this agreement shall be binding upon and inure to the benefit of the parties hereto, their successors, lessees and assigns.

IN WITNESS WHEREOF, the parties hereto have executed this agreement in .... the day and year first above written.

Attest: .... Company

.... By ....
Secretary

Attest: .... Company

.... By ....
Secretary

Exhibit C

FORM OF AGREEMENT FOR PURCHASE OF ELECTRICAL ENERGY FOR OTHER THAN TRACTION PURPOSES

THIS AGREEMENT, made this .... day of ...., 19 ...., by and between ...., a corporation organized and existing under the laws of the State of ...., hereinafter called the Railway Company, and ...., a corporation organized and existing under the laws of the State of ...., hereinafter called the Power Company.

WITNESSETH:

WHEREAS, the Railway Company desires to purchase and take from the Power Company during the term hereof, energy estimated to be initially about .... kilowatts of Billing Demand for electric operation of certain portions of the Railway Company's system as herein set forth, and

WHEREAS, the Power Company desires to sell and deliver energy to the............ .... Railway Company.

NOW THEREFORE, in consideration of the mutual covenants and agreements herein stipulated to be kept by the parties hereto, it is agreed as follows:

1. Form of Energy

The electrical energy to be supplied under this agreement shall be in the form of .... phase alternating current of .... cycles and .... volts, and shall be measured on the .... side of the Power Company's transformers; or direct current of .... volts.

2. Point of Delivery

The electrical energy furnished hereunder shall be delivered at a point (or points) on the Railway Company's property to be mutually agreed upon and hereinafter referred to as the "Delivery Point."

3. Limits of Fluctuation

The Power Company agrees, subject to the ordinary fluctuations incidental to the usual practice in generation and transmission of electrical energy, that it will maintain uniform frequency and voltage at the delivery point. Under normal operating conditions the permissible degree of variation of frequency for alternating current of .... cycles shall be .... cycles above or below normal, and for alternating or direct current of .... volts the permissible degree of variation shall be .... volts above or below normal.

4. Character of Load

The Railway Company shall have the right to use the electrical energy furnished hereunder for its power and lighting requirements and for any other purposes mutually agreed upon incidental to the operation of its railroad and its allied interests.

5. Capacity

The Power Company agrees to have available at all times a capacity of equipment sufficient to furnish continuous supply of electrical energy up to the limit of the maximum demand of the Railway Company.

6. Rates

The Railway Company agrees to pay monthly to the Power Company upon rendition of bills for electric service rendered hereunder, an amount based on the Power Company's rate schedule .... (See Note 1)

(If suitable rates are not established, the following form of Rate Schedule is suggested:)

(a) Demand Charge: A demand charge of .... dollars per month per kw (or kva) of maximum demand as determined in Paragraph "d" hereunder. *(The demand charge may also be set up on a sliding scale schedule if found more desirable.)*

(b) Energy Charge: In addition to the demand charge, energy charge of .... mills per kw-hr. *(The energy charge may also be set up on a sliding scale if found more desirable.)*

(c) Discounts: Bills shall be payable by the Railway Company monthly for service rendered hereunder and shall be subject to a prompt payment discount of .... percent if paid within .... days after the date of bill, and any other discounts which may be provided.

(d) Contract kw (or kva): The contract kw (or kva) under this schedule shall be the .... minutes demand of the combined lighting and power load determined by suitable demand meters. The average of the three highest demands so established (no two of which shall be on the same calendar day) and measured during a month shall be used as the billing maximum demand for that month. The minimum demand for which the Railway Company shall pay under this schedule shall be .... kw (or kva).

(e) Power Factor: *(If demand charge is based on kva of maximum demand, no power factor clause is necessary. If on a kw basis, either of the following clauses (1) or (2) may be included.)*

(1) The Railway Company agrees to maintain, insofar as practicable, during the periods of maximum demand, a power factor of .... percent. Should the power factor be greater or less than this value during such periods, the maximum demand shall be corrected accordingly.

(2) The Railway Company agrees to maintain, insofar as practicable, an average power factor of .... percent throughout the entire

month. Should the average power factor be greater or less than this value, the maximum demand shall be corrected accordingly.

(f) Change in Energy Charge Due to Fuel Cost: It is further agreed that the prices to be paid to the Power Company for steam-generated electrical energy consumed by the Railway Company are based upon cost of .... cents per .... Btu of fuel delivered f.o.b. alongside generating station. If at any time during the continuance of this agreement the cost of fuel as aforesaid is increased or decreased, the Railway Company shall pay to the Power Company, after such increase or decrease, an additional or lesser amount for the electric energy consumed hereunder equal to .... mills per kw-hr for each .... cents of such increased or decreased fuel cost.

7. Supplying Electrical Energy to Any Consumer

In the event the Power Company supplies electrical energy to any consumer under conditions substantially similar to and at rates lower than those herein provided, the Power Company agrees to charge the Railway Company such lower rates in lieu of the rates provided for herein.

8. Prevention of Use

In the event the Railway Company is prevented at any time, by reason of strike, riot, insurrection, civil or military authority, fire, explosion, act of God, or any other cause beyond its control, from making use of the electrical energy to be supplied hereunder in whole or in part, or the Power Company is unable to supply such electrical energy, then the minimum demand charge to the Railway Company shall be reduced in proportion to the inability of the parties to perform their respective obligations hereunder.

During the time or times when because of strikes, floods, fires, destruction of property, unavoidable accident, or from other cause beyond the control of the obligated party, the Power Company shall be unable to make delivery of electric power or energy to the Railway Company, or the Railway Company shall be unable to use power or energy furnished by the Power Company, as hereinbefore agreed, the Railway Company may procure any electric power or energy required to maintain its electrical operations from other parties than the Power Company.

9. Meters

All meters shall be furnished and maintained by the Power Company and shall be tested by approved methods by the Power Company at its own expense during the months of .... and ...., and the Power Company shall, where necessary, adjust or replace defective meters. The Power Company shall give to the Railway Company at least .... days' notice when each test is to be made and representatives of both parties may be present thereat. If, upon test, a meter is found to be inaccurate, it shall be promptly restored to an accurate condition or a new meter shall be substituted; should any meter be found to register in excess of .... percent, either above or below normal, the correction in the readings of such meter shall be made for one-half of the inaccuracy found, provided the error is less than ten percent, and if the error is more than ten percent, the electrical energy consumed shall be estimated by agreement between the parties, but no such correction shall be made in excess of thirty days prior to the date of the test, and in no case prior to the date of the last prior test. (See Note 2)

10. Rules and Regulations

(a) Terminal Facilities: The Power Company shall at its own cost and expense extend its service line to the terminal or delivery points established as hereinbefore provided for delivery of power hereunder and for this purpose the Railway Company shall provide the right-of-way on, over or under its premises necessary for service line in reaching said delivery points.

It is agreed that no service line or electrical apparatus of the Power Company installed under this agreement and located on, over or under the property of the Railway Company, shall be used by or for any person, firm or corporation other than the Railway Company, except with the permission of the Railway Company given in writing and specifying the authorized additional use or construction facilities.

(b) Company Installation: All apparatus and appliances necessary to make and maintain proper connections to the circuits of the Railway Company at the delivery points designated shall be provided, maintained and kept in repair by the Power Company. All apparatus and appliances thus provided by the Power Company shall remain the property of the Power Company and change thereof may be effected at its option, except that the type of demand meter shall not be changed other than by mutual agreement. The Railway Company shall not do any work upon any apparatus or meter belonging to the Power Company.

The Power Company shall install and maintain its meters in such manner that authorized representatives of the Railway Company may read them at such time as may be desirable.

11. Location of System Lines

The certain portions of the Railway Company's system where energy will be used in the operation thereof, comprise ....
....,
all of which lines are located as shown on map dated ....,
designated ....,
marked "EXHIBIT A", which is attached hereto and made a part hereof, and for such other purposes as herein provided.

12. Liability

The Railway Company agrees to indemnify and save harmless the Power Company from all cost, expense or liability for damages, which may arise or result from the use, care or handling of the energy delivered hereunder after the same shall have been delivered to the Railway Company at the points of delivery specified herein, or from the presence upon the premises of the Railway Company of any appliances of the Power Company, except that the Power Company shall be responsible for all claims of its own employees, agents or servants.

The Power Company agrees to indemnify and save harmless the Railway Company from all cost, expense or liability for damages which may arise or result from the use, care or handling of the energy delivered hereunder before the same shall have been delivered to the Railway Company at the points of delivery specified herein, or from the presence upon the premises of the Power Company of any appliances of the Railway Company, except that the Railway Company shall be responsible for all claims of its own employees, agents or servants.

13. Interference with Apparatus

The Railway Company shall use reasonable care to prevent anyone other than the authorized employees of the Power Company from interfering with meters or other appliances of the Power Company.

14. Arbitration

In case any question arises under this agreement or concerning the subject-matter thereof, upon which the parties hereto cannot agree, such question shall be settled by a sole, disinterested arbitrator, to be selected jointly by the parties to this agreement, and if they fail to select such arbitrator within .... days after demand for arbitration is made by either party hereto, then such arbitrator shall be appointed by the judge of the .... Court of ....

The expense of arbitration shall be apportioned between the parties hereto, or wholly borne by either party, as determined by the arbitrator.

15. Access to Premises

The Power Company shall have the right of access to the premises of the Railway Company at all reasonable times during the period of this agreement for the purpose of reading meters and inspecting and repairing the Power Company's equipment, and, on the termination of this agreement, for the purpose of removing its property.

16. Termination of Agreement as Applied to Any Point of Service by Loss of the Railway Company's Plant

In event of the abandonment, loss or destruction of the Railway Company's plant at any point of service, the Railway Company may, upon written notice to the Power Company, terminate this agreement with respect to such service as such abandonment, loss or destruction renders useless to the Railway Company.

17. Regulation by Public Utility Regulatory Bodies

The rate, rules and regulations under which said electric service is furnished hereunder are subject to revision to conform to such changes as may be lawfully prescribed by the .... In the event that the rate is revised and that the revised rate is not acceptable to the Railway Company, the Railway Company shall have the right to terminate this agreement on .... days' written notice to the Power Company.

The Power Company shall notify the Railway Company in writing of any contemplated change in the rates hereunder at least thirty days prior to any notice to the regulatory body having jurisdiction.

18. Term

This agreement shall take effect as of the .... day of .... 19 ...., and shall continue until the .... day of ...., 19 ...., and thereafter until terminated by written notice given by either party to the other at least .... days prior to the date of termination.

19. Successors

This agreement and each provision herein contained is hereby made binding upon the legal representatives, successors and assigns of each party hereto.

IN WITNESS WHEREOF, the parties hereto have executed this agreement in ...., the day and year first above written.

Attest: .... Company

By ....

Attest: .... Company

By ....

NOTE: (1) When selecting rate schedule the following points should be given consideration:

(a) If the rate schedule provides for billed demand either on a yearly or a monthly basis, check to determine which would probably be more favorable.

(b) Check to determine whether the rate schedule is such that a high demand established in one month is billed for succeeding months.

(c) Check to determine whether the rate schedules have any special provisions, such as per diem demand charge, to enable the customer to reduce his bill and not be unduly penalized for a high demand established during one month.

(d) Check the rate schedules to determine whether the demand interval is 5, 15, or 30 min, or longer. Select as long a demand interval as possible.
As an alternate to continuous use of a demand meter the demand may be determined and agreed upon based upon connected load or other acceptable method.

(e) Check to determine whether it is economical and practicable to shut down any of the equipment during the period when the peak demand will occur. If so, it may be possible to apply an automatic demand limitator to one or more machines.

(f) Check to determine whether a penalty is imposed for a low power factor or a bonus offered for a high power factor, and if so, whether or not corrective equipment or synchronous motor drive can be economically applied. Where power factor corrective equipment is applied the average power factor may be higher than that during the period of maximum demand.

(g) Check to determine if Night Rider is applicable, as certain work might be changed to night or off-peak operation to reduce energy cost or billing demand.

(h) Check to determine whether discount is offered for metering at primary voltage.

(2) If there is no regulatory body having jurisdiction over the accuracy of the meters, a maximum variation of one percent above or below should be agreed upon.

Report of Committee 6—Buildings

J. B. Schaub, *Chairman,*
F. H. Alcott
C. M. Angel
W. F. Armstrong
G. A. Belden
C. E. Booth
H. M. Booth
R. R. Cahal
T. S. Carter, Jr.
E. Christiansen
C. E. Close
G. V. Coffey
J S. Cooper
L. H. Corning
C. O. Coverly
L. B. Curtiss
C. E. Defendorf
A. G Dorland
V. E. Elshoff
D. W. Converse, *Secretary,*
T. J. Engle
R. L. Fletcher
C. S. Graves
J. W. Gwyn
W. G. Harding
J. W. Hayes
R. V. Hazer
J. P. Hendrickson
K. E. Hornung
B. J. Johnson, Jr.
Earl Kimmel
M. L. Koehler
S. E. Kvenberg
L. H. Laffoley
N. C. LeClaire
E. M. Loebs
H. C. Lorenz
I. A. Moore
O. W. Stephens, *Vice-Chairman,*
G. A. Morison
B. M. Murdoch
R. A. Nelson
W. C. Oest
D. E. Perrine
C. L. Robinson
J. J. Schnebelen
J. T. Schoener
E. W. Scripture, Jr.
E. R. Shultz
J. E. South
S. G. Urban
W. E. Webb
J. W. Westwood
O. G. Wilbur
T. S. Williams

Committee

To the American Railway Engineering Association:

Your Committee reports on the following subjects:

1. Revision of Manual.
   Progress report, including recommended Manual revisions .... page 560
2. Specifications for railway buildings.
   Specification for application of asbestos-cement roofing shingles, submitted for approval and later inclusion in the Manual .... page 601
3. Shop facilities for diesel locomotives.
   Progress in study, but no report.
4. Servicing facilities for diesel locomotives collaborating with Committees 13 and 14.
   No report.
5. Pile Foundations for railway buildings, collaborating with Committees 7 and 8.
   Final report on specification for later inclusion in the Manual .... page 603
6. Modernization of station buildings.
   Bibliography, submitted as information .... page 605
7. Modernization of freight houses.
   Progress in study, but no report.
8. New materials for buildings.
   Progress in study, but no report.
9. Air conditioning.
   Progress report covering small air-conditioning installations, submitted as information .... page 610
10. Means of Conserving Labor and Materials.
   No report.

The Committee on Buildings,
J. B. Schaub, *Chairman.*

AREA Bulletin 504, November 1952.

Report on Assignment 1

Revision of Manual

O. W. Stephens (chairman, subcommittee), F. H. Alcott, C. M. Angel, G. A. Belden, R. R. Cahal, C. E. Close, D. W. Converse, C. O. Coverley, C. E. Defendorf, R. L. Fletcher, C. S. Graves, J. W. Hayes, R. V. Hazer, N. C. LeClaire, H. C. Lorenz, R. A. Nelson, J. E. South, O. G. Wilbur.

Your committee offers the following recommendations with respect to the material in its chapter in the Manual:

Pages 6–1 to 6–4, incl.—GENERAL CONDITIONS

Reapprove without change.

Pages 6–5 to 6–7, incl.—EXCAVATION, FILLING AND BACKFILLING

Reapprove with the following revision:
Delete Art. 14, pages 6–6 and 6–7, Pile Foundations.

Pages 6–7 to 6–10.1, incl.—SEWERS AND DRAINAGE

Reapprove without change.

Page 6–10.1—CONCRETE

Reapprove without change.

Pages 6–10.2 to 6–14, incl.—BRICKWORK

Reapprove with the following revisions:
Insert the following as Art. 2.

2. Brick

All bricks used, if of clay or shale, shall preferable be side-cut. All bricks used shall at least conform to the requirements shown in the following table:

Required Strength of Brick

Part of Structure	*Compressive Strength Pounds per Square Inch Brick Tested Flatwise*		*Modulus of Rupture*	
	Individual Minimum	*Average 5 Specimens*	*Individual Minimum*	*Average 5 Tests*
Walls	5000 lb	Not less than 6000 lb	450 lb	600 lb or over
Foundation	3500 lb	Not less than 4000 lb	400 lb	500 lb or over

Renumber present Arts. 2 to 12, incl., as Arts. 3 to 13 incl.
Insert the following as Arts. 14 and 15:

14. Reinforcing Steel

Reinforcing steel shall conform to the standard specifications for billet steel concrete reinforcing bars of the AREA.

15. Integral Waterproofing

No waterproofing materials shall be added to the mortar except by permission of the engineer.

Renumber present Arts. 13 to 16 incl., as Arts. 16 to 19 incl.

Delete Art. 17, page 6–13, Flue Linings.

Delete Art. 18, page 6–13, Fire Brick Linings.

Insert the following as Arts. 20, 21, 22, 23 and 24, and renumber balance of articles.

20. Proportioning and Mixing of Mortar

a. All mortar used shall be mixed by volume in the proportion of 1 part of portland cement, ½ part of slaked quick lime putty or of soaked hydrated lime putty, and 3 parts of sand. No lime putty shall be used which has not been slaked or soaked at least 12 hr before being mixed into the mortar. All mortar shall be mixed with the minimum amount of water consistent with maximum density and workable plasticity.

b. The method of measuring mortar materials shall be such that the specified proportions thereof can be controlled and accurately maintained at all times.

c. All mixing of mortar shall be done in a mechanically operated batch mixer of the drum type for a period of at least 3 min after all materials for a batch are in the drum. The drum must be completely emptied before the succeeding batch of materials is placed therein. Continuous mortar mixers and hand mixing will not be allowed.

d. The use of retempered mortar will not be permitted.

21. Brick Laying

a. Wetting Bricks

All bricks, immediately before being laid, shall be sprinkled in the stock pile, or elsewhere as may be suitable, for not less than 5 min, or for such additional time or wetted in such other manner as the engineer may decide is necessary to supply the bricks with sufficient moisture to effect a proper bond between the bricks and mortar.

b. Mortar Beds and Other Joints

All bricks shall be laid on a full, flat bed of mortar with all head and side or collar joints completely filled by shoving or by slushing. Splitting or furrowing of mortar beds will not be permitted.

c. Placing Reinforcement

Before mortar is placed under, over or around a bar, such a bar shall be in correct position and shall be held without movement until the next course of bricks is laid. The minimum thickness of mortar joints, as related to bar size, shall be as shown in the following table:

Bar Size	*Minimum Mortar Joint Thickness*
⅜ in or less	½ in
½ in	⅝ in
⅝ in	13/16 in
¾ in	1 in
1 in	1¼ in

d. Condition of Equipment

All equipment used for mixing or transporting mortar and bricks shall be clean and free from set mortar, dirt or other injurious foreign substances.

e. Laying Brick Masonry in Foundations

Before laying bricks in a foundation, a layer of not less than 1 in of mortar shall be spread over the surface of the soil. Immediately thereafter the first course of bricks shall be laid.

f. Joining Work

When fresh masonry is to join with masonry that is partially or entirely set, the exposed joining surface of the set masonry shall be cleaned, roughened and wetted so as to effect the best possible bond with the new work. All loose bricks and mortar shall be removed.

g. Disturbance of Completed Work

When any portion of the brickwork has been completed, such work shall remain undisturbed until thoroughly set, except in the case where work left off at the end of a day is recommenced on the following morning, or as soon thereafter as practicable.

h. Finishing of Work

All brickwork shall be finished in a workmanlike manner with a thickness of joints and manner of striking or tooling indicated on the drawings or as described in the specifications. All work shall be built true to the dimensions and to the grade shown on the drawings.

i. Cleaning and Tuck Pointing

All exterior brick masonry shall be thoroughly cleaned and tuck pointed. If so specified, a 5 percent solution of muriatic acid shall be used for cleaning down, but this must be followed by copious baths of clean water.

22. Laying Bricks in Freezing Weather

a. Protection of Bricks

All bricks delivered for use in freezing weather shall be fully protected immediately upon delivery by a weather-tight covering such as will prevent the accumulation of water, snow or ice on the bricks. Loose board covering will not be permitted.

b. Heating of sand

All sand shall be heated in such a manner as will remove all frost, ice or excess moisture. The methods and equipment used shall be of such character as will prevent the burning or scorching of the sand.

c. Heating of Bricks

All frosted bricks shall be defrosted by heating to a temperature of approximately 180 deg F.

d. Heating of Water

During freezing weather, or when so directed by the engineer, all water used shall be heated to a temperature of approximately 180 deg F.

e. Slaking or Soaking of Lime

All slaking of quick lime or soaking of hydrated lime shall be done at a temperature of at least 60 deg F and this temperature shall be maintained until the lime is incorporated into the mortar.

f. Protection of Mortar Against Freezing

After the mortar is mixed, it shall be maintained at such temperature as will prevent its freezing. Mortar on the boards shall be kept from freezing at all times, and if necessary the contractor shall use metal mortar boards equipped with banjo-type oil or gas torches. No anti-freeze liquid, salt or other substance shall be used in mortar except by permission of the engineer.

g. Enclosures and Artificial Heat

All work under construction shall be protected against freezing for a period of 48 hr by means of enclosures, artificial heat, or by such other protective methods as will meet the approval of the engineer. In general, the methods now commonly accepted and used for the protection of reinforced concrete construction in freezing weather shall be used.

23. Bricklaying in Hot Weather

All finished or partly completed work shall be covered or wetted in such manner as will prevent too rapid drying of the masonry.

24. Compression Tests

a. Brick Masonry

At least 3 compression test specimens, each nominally 8 in square and 16 in high, shall be made and tested before actual construction is commenced. These test specimens shall be built up of unselected bricks from the stock pile and laid in the same mortar mixture and in the same manner proposed to be used on the job. The specimens shall be moist cured for 27 days, exposed to the atmosphere of the laboratory for 1 day, and then tested in a vertical position. The average compression strength of such test specimens shall not fall below the requirements of Art. 2 according to the allowable unit stress to be used.

In preparing compression test specimen, care shall be taken that the top and bottom bearing areas are exactly parallel and that the mortar joints do not exceed ¾ in. The method of capping and testing shall be that presented in the current ASTM Specifications designation C 67.

b. Mortar Cubes

Mortar test cubes shall be 2 in by 2 in by 2 in and shall be tested in accordance with the current ASTM Specifications, designation C 150. Such cubes shall develop a compressive strength of at least 900 psi at 7 days and 2000 psi at 28 days. At least 3 cubes shall be made and tested for each lot of 50,000 bricks.

Pages 6–14 to 6–16, incl.—STONE MASONRY AND CUT STONE WORK

Reapprove without change.

Pages 6–17 to 6–19, incl.—CLAY HOLLOW TILE

Reapprove without change.

Pages 6–19 to 6–21, incl.—ARCHITECTURAL TERRA COTTA

Reapprove without change.

Pages 6–22 to 6–24, incl.—CONCRETE ARCHITECTURAL STONE

Reapprove without change.

Pages 6–24 to 6–27, incl.—CONCRETE ROOFING TILE

Reapprove without change.

Pages 6–27 and 6–28—CLAY ROOFING TILE

Reapprove without change.

Pages 6–28 and 6–29—SLATE ROOFING

Reapprove without change.

Pages 6–29 to 6–43, incl.—BUILT-UP ROOFING

Reapprove without change.

Pages 6–43 to 6–47, incl.—SHEET METAL WORK

Reapprove without change.

Pages 6–47 to 6–66.2, incl.—STRUCTURAL STEEL AND IRON

Pages 6–74 to 6–74.10, incl.—WELDED STRUCTURAL STEEL

Delete both of these existing sections and substitute therefore the material appearing herewith in Exhibit "A".

Pages 6–67 to 6–74, incl.—ORNAMENTAL AND MISCELLANEOUS METAL WORK

Reapprove without change.

Pages 6–74.11 and 6–74.12—SPECIFICATIONS FOR COPPER TUBING

Reapprove without change.

Pages 6–74.12 to 6–79, incl.—CARPENTRY AND MILLWORK

Pages 6–198 to 6–200, incl.—WOOD SCREENS

Delete both of these sections and substitute therefore the specifications appearing herewith in Exhibit "B".

Pages 6–80 to 6–83, incl.—LATHING AND PLASTERING

Reapprove without change.

Pages 6–83 to 6–86, incl.—MARBLE AND TILE WORK

Reapprove without change.

Pages 6–86 to 6–91, incl.—PAINTING AND GLAZING

Reapprove without change.

Pages 6–91 and 6–92—HARDWARE

Reapprove without change.

Pages 6–93 to 6–97, incl.—PLUMBING

Reapprove without change.

Pages 6–97 to 6–104.1, incl.—HEATING—HOT WATER AND STEAM SYSTEMS

Reapprove without change.

Pages 6–104.1 to 6–112, incl.—HOT AIR HEATING AND HOT BLAST HEATING SYSTEM

Delete the entire Specifications for Hot Air Heating and the Specifications for Hot Blast Heating System and substitute therefore the specifications for Warm Air and Blast Heating appearing herewith in Exhibit "C".

Pages 6–112.1 to 6–112.7, incl.—VENTILATION OF RAILWAY SHOP BUILDINGS

Reapprove without change.

Pages 6–112.7 and 6–113—OIL BURNING EQUIPMENT

Reapprove without change.

Pages 6–113 to 6–115, incl.—ELECTRIC LIGHT WIRING

Reapprove with the following revisions:

Art. 6—Wires. Pars. 1 and 2 to be revised to read as follows:

Except for fixtures and pendant cords, the minimum size of wire shall be No. 14 AWG. All branch circuit wires shall be of such size as not to produce a drop in potential of more than 3 percent, and the entire system shall be calculated so as not to produce a drop in potential of more than 5 percent.

Wire of No. 6 AWG and larger shall be stranded and may be either single or double braid, according to local requirements. No. 8 AWG wire may be either solid or stranded.

Art. 9—Service Switches and Cabinets. Revise to read as follows:

Service switches shall be essentially of the safety type installed separately and easily accessible.

Branch circuit cabinets shall be provided with a minimum of 10 percent of circuits for future expansion but not less than one. When a lock is required, it shall be of the cylinder type and provided with three keys.

Art. 11—Fuses. Change to "11. Circuit Protection," and revise to read as follows:

Main and feeder circuits shall be provided with circuit breakers or fuses of the enclosed type which shall plainly indicate the amperes and volts for which they are rated. Branch lighting circuits shall be provided with .... circuit breakers or screw plug cutouts, and where circuits are to be controlled from cabinet with screw plug cutouts, approved detachable toggle switches with insulated dead front covering, or equal, shall be installed.

Art. 12—Wiring Systems. Change voltage figures to, "115 to 230 v."

Revise fourth sentence to read: The total load shall not exceed the branch circuit rating, and shall not exceed 80 percent of the rating where in normal operation the load will continue for long periods.

Pages 6–116 to 6–127, incl.—BRICK PAVEMENTS AND FLOORS

Reapprove without change.

Pages 6–127 to 6–133, incl.—CONCRETE PAVEMENTS AND FOUNDATIONS

Delete the Specifications for Concrete Pavements and Foundations and substitute therefore the Specifications for Concrete Pavements appearing herewith in Exhibit "D".

Pags 6–133 to 6–135, incl.—WOOD BLOCK FLOORING AND PAVING

Reapprove without change.

Pages 6–136 to 6–140, incl.—ASPHALTIC CONCRETE PAVEMENTS

Reapprove without change.

Pages 6–140 to 6–143, incl.—HOT ASPHALT MASTIC FLOORS

Reapprove without change.

Pages 6–149 to 6–151, incl.—MACADAM PAVEMENTS

Reapprove without change.

Pages 6–151 to 6–153, incl.—ASPHALT MACADAM PAVEMENTS

Reapprove without change.

Pages 6–153 to 6–153.6, incl.—CEMENT GROUTED MACADAM PLATFORMS, FLOORS, PAVEMENTS AND PAVEMENT BASES.

Reapprove with the following revisions.

Change title to read:

CEMENT GROUTED PLATFORMS, FLOORS, PAVEMENTS AND PAVEMENT BASES

2. Description—Revise to read:

Cement grouted platforms, floors, pavements and pavement bases shall consist of a coarse aggregate bound together by portland cement and sand grout. It shall be constructed by placing on a prepared subgrade a layer of coarse aggregate over which is poured a grout of such fluidity that it immediately flows through and completely fills the voids in the coarse aggregate.

4. Materials—Revise first paragraph to read:

Portland cement, fine and coarse aggregate and water shall comply with the specifications for concrete as given in Chapter 8 of the Manual, except as hereinafter provided. Air-entrained grout containing 3 to 5 percent by volume of entrained air shall be used.

7. Forms—Delete the last sentence.

8. Joints—Delete entire article and substitute the following:

If pavement is constructed of more than one longitudinal strip, and in pavements with integral curb and gutter, transverse joints shall be continuous in a straight line through all pavement strips, gutter and curb.

Manhole and catch basin covers, column bases, and all other fixed objects shall be separated from the concrete by joint filler not less than ½ in thick.

a. Expansion and Contraction Joints

Expansion joints shall be as shown in Fig. 1(a) unless otherwise specified or shown on the drawings. The pre-molded joint filler shall be cut to conform to the cross section of the pavement and in lengths equal to the width of the pavement strip, except that strip equal in length to half the width of the pavement strip may be used when laced or clipped together in a satisfactory manner. A suitable bulkhead shall be used to hold the joint filler and dowels in positions during the depositing of concrete.

Expansion joints at intersections shall be located as shown on the drawings or as directed by the engineer.

Contraction joints shall be as shown in Figs. 1(b) and 1(c), unless otherwise specified or shown on the drawings. Suitable supports shall be provided to hold the dowels (when used) in place while pouring concrete. For paving inside buildings, contraction joints should be spaced 15 to 20 ft in each direction.

b. Longitudinal Joint and Construction Joints

These joints shall be as shown in Fig. 1(d) unless otherwise specified or shown on the drawings.

The longitudinal joints shall be not further apart than 13 ft and the construction joints located at end of a pour, if this point does not coincide with location of expansion joint.

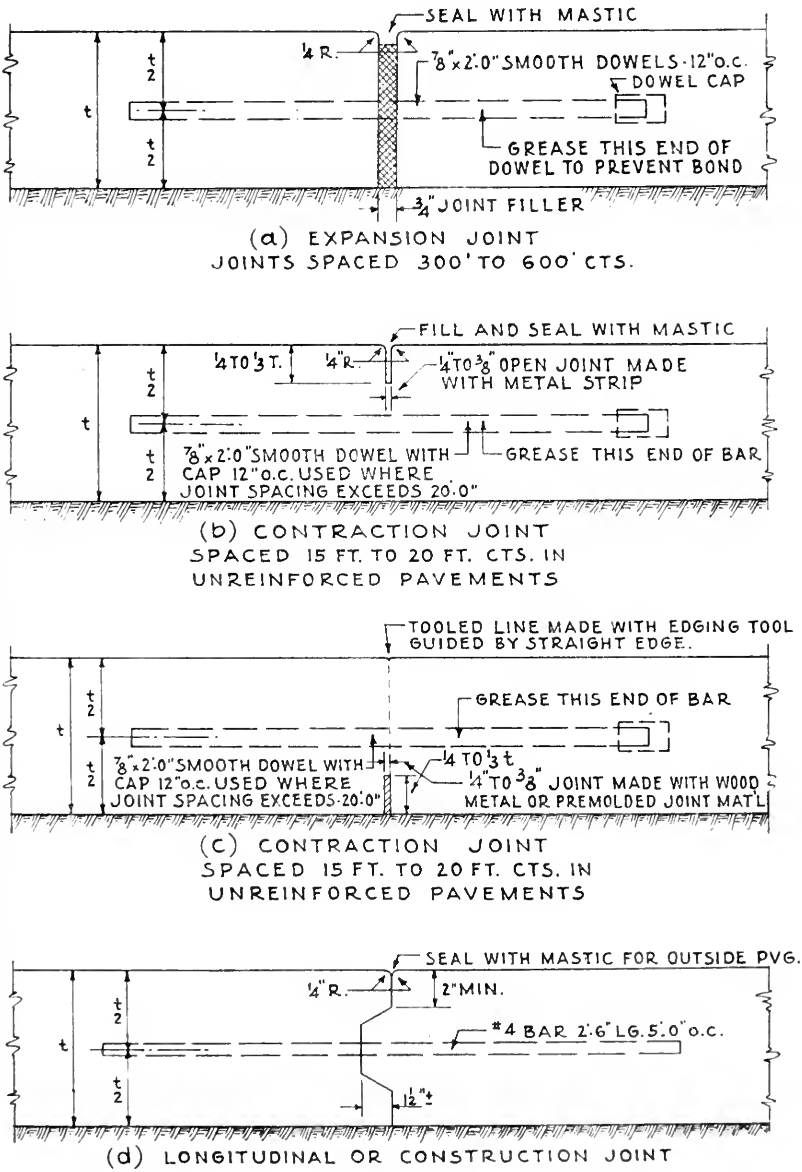


FIGURE - 1
TYPICAL PAVEMENT JOINT DETAILS

The joint shall be made by use of suitable forms which will hold the dowels (when used) in position when concrete is poured.

If the pavement is more than three lanes wide, the dowel rods shall be omitted from every second or third joint so as to divide the pavement into units of not more than three lanes wide. The pavement adjacent to the undoweled joints shall be designed in the same manner as other free edges of the pavement.

c. Joints in Cement Grouted Pavement Base

In cement grouted pavement bases, for other than concrete wearing surface, expansion and contraction joints may be omitted at the discretion of the engineer.

16. Curing—Change to "Curing and Protection."

Delete the entire article and substitute the following:

The curing and protection shall comply with the specifications for Concrete Pavements and Floors, Part 9, this Chapter.

17. Delete entire article, including title, and substitute the following:

17. Prohibition of Traffic

The contractor shall provide and maintain substantial barricades across the pavement, with suitable warning signs day and night, to prevent traffic upon the pavement until otherwise directed by the engineer.

Add new article as follows:

18. Adjusting Existing Structures

Manholes and catchbasin covers, valve boxes, and similar existing structures within the area to be paved shall be adjusted by the contractor to come flush with the surface of the pavement.

Addenda 1—No change.

Addenda 2—Omit all but last two paragraphs which should be revised as follows:

Thickness of Cement Grouted Pavements and Floors

In the absence of special design, the following pavement thicknesses are recommended:

Four and one-half inches for passenger platforms, truckways, and shop floors built on soil where wheel loads will not exceed 2000 lb. When built on compacted cinders or ballast, 4 in will suffice.

Six and one-half inches for shop yard driveways built on soil where wheel loads will not exceed 4000 lb. When built on compacted cinders or ballast, 6 in will suffice.

Pages 6–153.6 to 6–157, incl.—SPRINKLER SYSTEM

Reapprove without change.

Pages 6–157 to 6–165, incl.—HYDRAULIC ELEVATORS—BAGGAGE AND FREIGHT

Reapprove without change.

Pages 6–165 to 6–171, incl.—ELECTRICALLY-OPERATED FREIGHT OR BAGGAGE ELEVATORS

Reapprove without change.

Pages 6–171 to 6–198, incl.—CHIMNEYS

Delete the entire section and substitute therefor the specifications appearing herewith in Exhibit "E".

Pages 6–200 to 6–202, incl.—METAL SCREENS

Reapprove without change.

Pages 6–205 to 6–208.1, incl.—ROOFINGS

Reapprove without change.

Pages 6–209 and 6–210—FLOORS FOR RAILWAY BUILDINGS

Reapprove without change.

Pages 6–211 to 6–213, incl.—PAINTS FOR RAILWAY BUILDINGS

Reapprove without change.

Pages 6–214 to 6–216, incl.—PASSENGER STATIONS

Reapprove without change.

Page 6–216.1—LOCATION AND DESIGN OF SIGN FOR PASSENGER STATIONS

Reapprove without change.

Pages 6–217 to 6–221, incl.—FREIGHT HOUSES

Reapprove without change.

Pages 6–221 to 6–223, incl.—ICE HOUSES AND ICING STATIONS

Reapprove without change.

Pages 6–223 and 6–224—REST HOUSES

Reapprove without change.

Page 6–225—SECTION TOOL HOUSES

Delete.

Pages 6–226 to 6–228, incl.—ENGINEHOUSES

Reapprove without change.

Pages 6–229 and 6–230—LOCOMOTIVE CINDER PITS

Reapprove without change.

Pages 6–230 to 6–233, incl.—STOREHOUSES FOR SHOPS AND LOCOMOTIVE TERMINALS

Reapprove without change.

Pages 6–233 and 6–234—OIL HOUSES

Reapprove without change.

Page 6–234—LUMBER SHED

Reapprove without change.

Pages 6–235 to 6–237, incl.—LOCOMOTIVE COALING STATIONS

Reapprove without change.

Pages 6–238 to 6–241, incl.—SPECIFICATIONS FOR MECHANICAL TYPE COALING STATIONS

Reapprove without change.

Pages 6–242 to 6–250, incl.—LOCOMOTIVE SANDING FACILITIES

Reapprove without change.

Pages 6–251 to 6–255, incl.—DROP PITS, JACKS AND TABLES

Reapprove without change.

Page 6–256—PASSENGER CAR SHOPS

Reapprove without change.

Pages 6–256 and 6–257—FREIGHT CAR REPAIR SHOPS

Reapprove without change.

Pages 6–258 and 6–259—CAR PAINT SHOPS

Reapprove without change.

Pages 6–260 and 6–261—DETERMINATION OF THE DESTRUCTIBLE VALUE OF STRUCTURES WHICH CAN BE COLLECTED IN CASE OF FIRE

Delete and substitute therefor the material appearing in Exhibit "F".

Pages 6–261 to 6–262, incl.—DIFFERENT TYPES OF PAINT AND THEIR ECONOMICAL SELECTION

Reapprove without change.

Pages 6–265 to 6–268, incl.—PLATFORM SURFACES

Reapprove with following revisions:

Art. 2—Wood. In the first sentence, substitute the word "extensively" for the words "the most generally" and delete the word "material".

Delete the second paragraph and substitute the following two paragraphs:

Preservative treatment to assure long life under alternately dry and wet conditions of service is recommended for practically all species of wood. Soft or nondense species will provide satisfactory wearing surfaces for light traffic. Species of relatively high density are the most suitable for heavy-duty wearing surfaces.

If the grain of a species of wood to be used for a platform surface has a tendency to splinter from heavy wear, the risk of such splintering can be reduced noticeably by laying all flat grain pieces so that the convex side of each piece as to growth ring curvature will be the wearing surface. Also, paint retention usually is very noticeably better on the convex side of flat grain lumber than on the concave side.

Art. 3—Brick. In the first sentence, substitute the word "sometimes" for the word "extensively."

Change the second paragraph to read:

The brick may also be laid on a well rolled and smooth base of sand, cinders, gravel, crushed stone or slag.

Art. 4—Concrete. Delete the seventh paragraph beginning "Two-course construction . . ."

Delete the tenth paragraph beginning "If the topping . . ." and insert the following:

Two-course construction may be advantageous wherever foot and truck traffic is heavy, when there are impact loads or other conditions requiring superior durability, and where rigid requirements of slope and elevation are to be met. The base is poured in the same manner as one-course work, and is roughly screeded about 1 in below the desired finished surface. On an unhardened base, the topping should be applied within

45 min after the base is in place. For a hardened base the surface should be roughened to improve bonding, should be thoroughly wetted just prior to placing the finish, and a thin coat of neat cement paste should be broomed into the surface for a short distance ahead of the topping. The topping should be composed of 1 part cement, 1 part fine aggregate, and from 1½ to 2 parts coarse aggregate by volume. The coarse aggregate should be graded from 3/16 to ⅜ in. Silica, granite, carborundum chips and trap rock are most suitable for the coarse aggregate. Sands containing stone dust, clay or silt are particularly objectionable. Cement or a mixture of cement and sand should not be sprinkled on the surface to absorb moisture or to stiffen the mix.

Delete the last paragraph beginning "A new concrete surface . . ." and substitute the following:

A new concrete surface may be placed over an old concrete floor; however, the new slab is likely to develop cracks at the same points as those already existing in the underlying floor. Shrinkage joints in the new platform may not be effective unless the new slab is isolated from the old by a layer of tar paper or sand. An alternate method of construction is to thoroughly clean the old floor, saturate it with water for several hours, pour the slab and form the joints so that they coincide with the joints in the old floor.

Art..5—Bituminous. Delete the entire article and substitute the following:

Wearing surfaces of bituminous materials may be natural asphalts, emulsified or cut-back asphalt. Some types of emulsified asphalt may be mixed with portland cement. Asphalt on mill-type or laminated wood floors gives a good wearing surface. Hot type mastics should be used where water tightness or acid resistance is necessary. These may be laid over concrete or on firm wooden bases. See Asphalt Mastic Floors, Part 9, this Chapter.

Manufacturers' specifications should be followed and care should be taken to see that the correct type for various conditions, such as indoor or outdoor traffic, whether light or heavy, cold storage rooms, etc., is used.

Art. 7—Steel and Iron Plates. Delete the entire article and substitute the following:

Bare steel plates may be applied over wooden or concrete platforms and are especially useful for platforms subjected to the wear of metallic wheels, such as wheel storage platforms. Plates may also be welded to steel framing members and to each other to form a battle deck type of floor construction. These plates commonly vary from ⅜ to ¾ in. in thickness and are frequently rolled with raised patterns to give a more non-skid surface. Plates should not be less than ⅜ in thick on freight platforms where self-propelled trucks are employed, and their embedment in a mastic cushion is desirable. Fastenings may be countersunk screws.

Steel gratings are sometimes used instead of solid plates because the former are stronger and stiffer for the same weight of steel per square foot. One type of grating serves as a topping or armor for concrete floors. In this case, the openings in the grating are filled to a depth of about ¼ in above their tops with grout or with some mastic or plastic material.

Cast iron plates are also used as a covering for wooden or concrete floors and can be laid upon sleepers between which is placed a compacted sand fill. In the latter example, each plate may be large enough, say 6 ft by 3 ft by 1 in, to be held in place by its own weight. The edges of the plates can be scalloped to assist in maintaining the proper alinement. Cast iron plates are more resistant to corrosion than steel.

Pages 6–269 to 6–273, incl.—YARD LUMBER SPECIFICATIONS FOR RAILWAY BUILDINGS

Reapprove without change.

Exhibit A

STRUCTURAL STEEL

All contracts entered into and work performed under this section shall conform to the Specification for The Design, Fabrication and Erection of Structural Steel Buildings of the American Institute of Steel Construction, current edition.

APPENDIX

1. Reduction of Live Load

Where uniform live loads per square foot are used for the roof and floors of a building, the roof slabs, joists, beams, girders and columns supporting them and all floor slabs, joists and beams shall be designed for full dead and full live loads. In structures designed for storage purposes, floor girders, columns, piers, walls and foundations shall be designed for full dead and full live loads. In the design of all other structures, floor girders shall be designed for full dead and 85 percent of live loads, and all columns, piers, walls and foundations supporting floors shall be designed for full dead load and the percentages of the live loads given in the following table:

	Number of Floors in Building														
Floor No.	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
15	85														
14	80	85													
13	75	80	85												
12	70	75	80	85											
11	65	70	75	80	85										
10	60	65	70	75	80	85									
9	55	60	65	70	75	80	85								
8	50	55	60	65	70	75	80	85							
7	50	50	55	60	65	70	75	80	85						
6	50	50	50	55	60	65	70	75	80	85					
5	50	50	50	50	55	60	65	70	75	80	85				
4	50	50	50	50	50	55	60	65	70	75	80	85			
3	50	50	50	50	50	50	55	60	65	70	75	80	85		
2	50	50	50	50	50	50	50	55	60	65	70	75	80	85	
1	50	50	50	50	50	50	50	50	55	60	65	70	75	80	85

The percentage of live load on walls, piers and columns of buildings more than 15 stories in height shall be taken in the same ratio as the above mentioned table.

2. Weights of Materials of Construction

The unit weights of some materials will vary according to locality, and the weights of some will vary because of a difference in quality. The following values may be used as averages for ordinary conditions:

	Pounds
Book tile, 2 in thick, per square foot	12
Book tile, 3 in thick, per square foot	14
Beam tile (when not included with arch tile), per square foot	12
Brick masonry, pressed or paving, per cubic foot	140
Brick masonry, hard common, per cubic foot	120

	Pounds
Brick masonry, hollow, per cubic foot	90
Cast iron, bar 1 in sq, per linear foot	3.125
Cast iron, per cubic inch	0.26
Cinder concrete, per cubic foot	96
Cinder fill (without sand and cement), per cubic foot	72
Floors, marble, tutti colori, and similar, per square foot	12
Floor flat arch (average of set), 8 in thick, per square foot	28
Floor flat arch (average of set), 10 in thick, per square foot	32
Floor flat arch (average of set), 12 in thick, per square foot	36
Floor flat arch (average of set), 14 in thick, per square foot	40
Floor flat arch (average of set), 16 in thick, per square foot	46
Floor segmental arch tile (average of set), 6 in thick at crown, per square foot	28
Granite, per cubic foot	160
Gypsum partition blocks, 3 in thick, per square foot	10
Gypsum partition blocks, 4 in thick, per square foot	12
Gypsum partition blocks, 5 in thick, per square foot	14
Gypsum partition blocks, 6 in thick, per square foot	16
Marble, per cubic foot	175
Mortar and plaster, per cubic foot	120
Mortar for tile arch floors, per square foot	3
Oaks, maple, per foot board measure	5
Ornamental terra cotta, backed and filled with common brick, per cubic foot	120
Partition tile, 3 in thick, per square foot	14
Partition tile, 4 in thick, per square foot	15
Partition tile, 6 in thick, per square foot	22
Partition tile, 8 in thick, per square foot	28
Partition tile, 10 in thick, per square foot	32
Plaster on brick, concrete, tile or gypsum	5
Plaster on lath, per square foot	7
Roofing, composition, per square foot	5
Roofing gravel, per square foot	10
Roofing slate, per square foot	10
Roofing tile, per square foot	10
Roofing, shingle, per square foot	3
Sandstone or limestone rubble, per cubic foot	140
Sandstone or limestone cut facing, per cubic foot	150
Sheet metal roofing, cornice, etc. per square foot	3
Suspended ceiling complete, per square foot	10
Steel bar, 1 in square, per linear foot	3.4
Steel plate, 1 in thick, per square foot	40.8
Stone concrete, per cubic foot	144
Windows, (glass, frames and sash), per square foot	5
White pine, spruce, hemlock, per foot board measure	3
Yellow pine, fir, per foot board measure	4

The following items may vary considerably in weight but the values given may be used for preliminary computations or when the quantities are small:

	Pounds
Concrete stair construction, per square foot	150
Iron stair construction, per square foot	50
Partition, 4 in tile plastered, per square foot	25
Same in hotels, per square foot of floor	35
Same in office buildings, per square foot of floor	25
Reinforcement of concrete, per cubic foot	6
Sidewalk lights in concrete, per square foot	30
Steel joists, per square foot of floor	6
Steel girders, per square foot of floor	4
Total weight of reinforced concrete, per cubic foot	150
Wood stair construction, per square foot	20

3. Live Loads (Minimum—See Art. 4.)

Structure	Loads in Pounds Per Square Foot
Baggage rooms	150
Carpenter shops	150
Coaling platforms	Special
Commissaries	300
Cotton loading platforms	150
Express buildings	150
Fire escapes	100
Freight houses	300
Freight platforms	300
Garages—passenger cars	75
trucks and busses	Special
Hospitals	60
Hotels—guests' rooms	60
Lobbies	100
Halls	100
Assembly rooms	100
Storerooms	150
Ice manufacturing plants	150
Ice crusher houses	150
Ice storage	Special
Icing platforms	150
Laundries	150
Locker rooms	60
Machine shop—light work	100
Mail rooms	100
Offices and office buildings. General office space	60
Business machine equipment	Special
Paint shop	100
Passenger platforms	100
Planing mills	150
Power houses	Special
Reading rooms	60
Residences	40
Restaurants	60
Roofs	25
Scale houses	50
Scrap docks	300
Sidewalks	100
Signal towers	100
Stairways (all)	100
Station foot bridges	100
Stock pens	100
Stock runways	100
Storehouses—	
Bananas—on racks	50
Beverages	350
Cement	450
Cotton	250
Flour	300
Fruits	350
Glass	350
Grain	300

Structure	*Loads in Pounds Per Square Foot*
Groceries and canned goods	350
Hay—baled	225
Hardware	300
Oil	250
Paint	250
Railway	500
Salt	300
Soda ash	200
Vegetables	350
Telegraph offices	100
Ticket offices	60
Tool equipment buildings	100
Trainmen's rooms	60
Transfer Platforms	300
Waiting rooms	100
Wash rooms	50
Water treating plants	100

4. Special Loads

In addition to the live load which is assumed to be uniformly distributed over the floor, provision shall be made for any special loads such as elevators, machinery, material handling equipment, water in tanks, coal in bins, space for storage of special material, etc.

5. Wind Load

Wind load shall be specified by the engineer to suit local conditions and for the type of building.

6. Snow Load

Snow load shall be specified by the engineer to suit local conditions. This load shall be considered a constant load on the horizontal projection of roofs from flat roof up to roof slope of 45 deg, omitting snow load on roofs steeper than 45 deg slope.

7. Allowable Working Stress for Columns

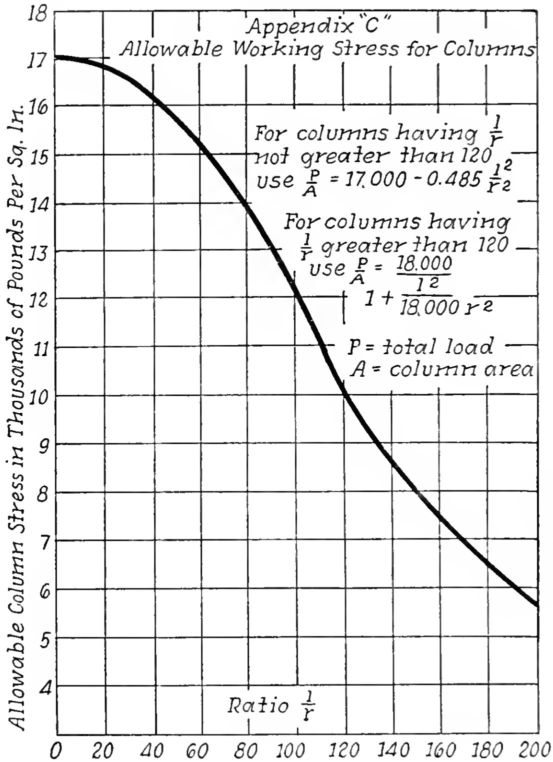


Exhibit B

CARPENTRY AND MILLWORK

1. General

Carpentry and millwork shall include all framing and woodwork which form part of the completed building. Unless otherwise noted, sizes called for in the specifications or on the drawings shall be nominal dressed sizes conforming to American Lumber Standards (AREA Manual, Chapter 7). The sizes of all timber and lumber shall conform to the sizes shown on the drawings or specified herein and where sizes are not so indicated the contractor shall request the engineer to furnish this information before beginning the work affected. All lumber throughout the work shall be graded .and classified:

a. Structural (stress-grade) timber, in accordance with grading rules and classification of timber and lumber appearing in Chapter 7 of the AREA Manual.

b. All other lumber shall conform to current specifications for yard lumber as outlined in the section on Yard Lumber Specifications for Railway Buildings, Chapter 6, of the AREA Manual.

2. Inspection

All lumber shall be subject to inspection on delivery at the site. Rejected lumber shall be promptly removed from the site by the contractor.

3. Species and Grades

The lumber used in the various parts of the building shall be of the species and shall conform to the grades as set forth in the specifications. Species and grades shall be included in specifications for the various items of the work or a list of the items with species and grades of lumber for each item shall be made a part of or an addendum to the specifications.

4. Seasoning

All framing lumber sheathing and timbers shall be thoroughly air seasoned before being used, and all finishing lumber, flooring, ceiling, siding, and millwork shall be kiln dried to a moisture content consistent with the conditions of service. After delivery at the site, all kiln dried lumber shall be protected from the weather and other damage until the final completion and acceptance of the building.

5. Treated Lumber

Where called for on the drawings or in the specifications, lumber treated with a preservative shall be used and such lumber shall be termed "Treated Lumber". Unless otherwise provided in this specification, the railway company will furnish all treated lumber, precut and preframed prior to treatment, and the contractor shall provide for unloading and erecting such lumber in his proposal, quality of workmanship to be same as for other carpentry work under this specification. All field holes and cuts shall have two coats of approved preservative applied after framing.

6. Termite Shields

Before sills and joists are set on the foundation piers or walls, the top of these piers or walls shall be covered with metal termite shields as shown on the plans.

7. Framing

All framing throughout shall be of the dimensions shown on the drawings and shall be placed as indicated. The framing shall be done in a neat, workmanlike manner to give close joints and shall be securely fastened. Studding shall be doubled at all openings and opposite each cross partition, and all corners and angles shall be made solid and well braced, and all bracket supporters tripled. All studs shall be in one piece from sill to plate. Horizontal block bridging of the same dimensions as the studding shall be inserted at intervals of 4 ft in height and at the level of all floors. Where partitions come over voids they shall be trussed as detailed, or according to instructions from the engineer. The contractor shall provide and set all hangers, straps, shoes and bolts required in trussing partitions. Horizontal joist supports shall be carefully notched into studding and well nailed. Wall plates on top of studs shall be doubled with the joints broken; all joints shall come over studs.

8. Joists

Joists shall be of the dimensions shown on the drawings, and spaced as indicated. Through partitions carried from the ground floor up shall have a joist nailed securely against the studs at each floor. All trimmer joists and all joists around wells or openings shall be doubled unless otherwise shown. Where their span is greater than 8 ft, joists shall be stiffened with cross bridging between each joist, spaced not over 6 ft. Ceiling joists shall be firmly fastened to the rafters.

9. Partitions

The top plates of all bearing partitions shall be doubled. The studs of bearing partitions running perpendicular to the line of joists shall extend through the floor to the girder below, or to the top plates of the supporting partition. The studs of partitions running parallel to the line of joists shall be framed over double joists as described under "Joists", except that the studs of upper-story bearing partitions, if not continuous from the lower story, shall extend through the floor to the top plates of partitions below. Where nonbearing partitions run parallel to ceiling joists, a lathing member wide enough to provide nailing surface for ceiling lath shall be placed above the partition plates.

10. Roof Framing

Roofs shall be framed and built in accordance with the detail drawings, accurately fitted and securely fastened. Chords of trusses shall be in one piece unless otherwise detailed, and shall be set level and plumb and securely braced longitudinally, and in the planes of the top chords. Trusses shall be framed with a camber as directed by the engineer. Wall plates shall be in long lengths with lapped joints halved, and well spiked at all angles. Rafters and purlins shall be set at the centers shown on the drawings. They shall be carefully cut and set, and have a solid bearing over wall plates, beams and at ridge pieces, and be well anchored at all bearings, and properly trimmed for chimneys or other openings. Sprocket or lookout pieces not less than 2 in. in thickness shall be carefully cut to form curves where shown, and well nailed to rafters. Sheathing boards shall be of uniform width, nailed twice at every bearing to avoid warping and injury to the roof covering; all joints to come on rafters.

11. Sheathing and Siding

Sheathing may be wood or treated fiber board as specified. Fiber board sheathing shall be a minimum of ¾ in thickness. Sheets shall be installed with joints on studs. The fiber board shall be surface treated both sides with asphalt to provide waterproof surfaces. Wood sheathing, when called for by the drawings, shall be placed diagonally or horizontally as detailed, and double nailed at each bearing. Horizontal sheathed walls shall be braced with a diagonal brace (preferably 45 deg) at each corner and at each story. Where diagonal sheathing is used, the boards shall be applied at approximately 45 deg and the direction of the sheathing shall be changed on each side, adjoining at a corner. Sheathing boards shall be of a uniform width.

Drop siding, shiplap and weather boards shall be placed truly horizontal with tight square butt joints, closely and accurately fitted against all casings, sills, water table and corner trim. All siding shall be drawn tight, secret nailed if called for, and when complete, shall be tight against wind and rain. Nails used in attaching siding over fiber board sheathing shall be long enough to obtain firm anchorage in studs or other framing.

12. Flooring

Rough flooring shall be of the dimensions shown on the drawings (tongued and grooved if called for) evenly laid, in long lengths and securely nailed throughout, all joints to come on joists, except where end-matched subflooring is used. Finish flooring shall be kiln dried, dressed and matched, and of the dimensions shown on the drawings, with no two joints together, and shall be secret nailed with wire or cut floor nails as directed by the engineer. An expansion space of 1/16 in per ft of width and length, or a minimum of ¾ in shall be provided at each wall. It shall be smoothed by hand or machine to the final finish. No floor boards, unless end matched, except in closets, shall be less than 2 ft in length. Finish floors shall not be laid until the plastering is finished. Where maple flooring is called for as the finish flooring in warehouses and shops, it shall be of the dimensions shown and shall be square edged and end matched, and, unless otherwise directed shall be face nailed with wire floor nails. Flooring shall be tightly driven up and nailed so that the joints are closed.

13. Building and Sheathing Papers, etc.

Where called for on the drawings, storm sheathing and subflooring shall be covered with one layer of waterproof building paper, weighing not less than 5 lb per 100 sq ft. Paper shall be lapped at least 2 in at all joints, and carried underneath all corner boards, casing, etc., making a windtight finish throughout.

14. Furring and Grounds

Unless otherwise specified or shown on the drawings, interior surfaces of stone, brick or concrete walls which are to be plastered shall be furred with 1-in by 2-in furring strips placed 16 in on centers and securely nailed. Furring on masonry walls shall provide a plumb surface for lathing, and shall be nailed to wood bricks or inserts built into the walls by the mason. Grounds ¾ in thick shall be provided around all openings and along base, and shall be in true planes.

15. Window and Door Frames

Window and door frames shall conform to details and shall be substantially built using kiln-dried lumber and securely framed into sills and heads. Frames shall be given one priming coat of paint before delivery at the site and shall be braced and protected until the building is completed. Frames shall be set plumb and true, heads level, and shall be securely attached to rough framing. Where wall construction is masonry, rough bucks shall be set in the wall with metal anchors attached with screws. Frames with transoms and mullions shall be made in one frame with transom bar and mullion mortized in. All frames shall be of proper size to receive sash and doors, and shall be weather-tight. Frames for double-hung windows shall have sash pulleys or spring balances built in as specified under Part 12—Hardware, this chapter. Where called for, frames shall be built to receive fixed thermal glass units. The frame shall be designed for setting of the glass units in accordance with the manufacturer's specifications. Where called for on the drawings, window frames shall be built to receive storm sash and door frames to receive storm doors. Frames shall be built to receive screens where specified. Plank frames for masonry walls shall have a break strip built into the wall and nailed to frame around head and jambs.

16. Wood Screens

Window, transom and door screens shall be made of kiln-dried dressed lumber as specified and built according to details. Frame stiles and rails to be of thickness and such widths to match window, transom and door frames. Corners and joints to be rigid and substantial. Suitable screen moulding shall be applied after screen is attached. Wire cloth shall be 16-mesh copper bronze unless otherwise specified. A special sun-ray shade screen may be used on those exposures where it is desirable to reduce thermal build-up in rooms because of sun light. Copper-bronze wire cloth shall be given one coat of clear lacquer. All removable screens shall be provided with a duplicate set of non-corrodible metal number tags, one applied to each screen and one applied to the corresponding opening.

17. Stairs

Stairs shall be strongly and rigidly built in locations shown, and as detailed. Rough work for all stairs shall be self-supporting without the aid of angle posts. Treads shall have moulded nosings, be plowed into risers, and risers into the underside of treads, and both housed into the wall stringer and tightly wedged and glued. Unless otherwise specified or shown on the drawings, treads shall be 1¼ in thick and risers 1 in thick, and both of hardwood, and shall be in one piece. All newels, balusters and handrails shall be as detailed. Landings and platforms shall be finished to match treads, and all finish on stairways shall match general finish throughout the building. Cellar and porch stairs on minor buildings may be open without risers where directed by the engineer. Outside steps shall be framed with proper waterfall.

18. Outside Finish and Trim

Outside finish and trim shall be neatly and accurately fitted. All necessary baseboards, watertable, corner trim, casings, fascias, frieze boards, cornice and mouldings, and everything necessary to make a complete finished piece of work, shall be furnished and erected.

19. Interior Finish

Interior trim, wainscoting, chair rail base, picture mouldings, etc., shall be kiln dried and conform to the details, be neatly and accurately fitted, joints mitred and secret nailed with fine finishing nails. If face nailed, all nails shall be set for puttying. Interior finish shall be free from hammer marks and shall be hand dressed and sandpapered where required. No splicing of the window or door trim will be permitted and joints of bases, chair rail and mouldings must be carefully matched.

20. Cabinets, Counters, etc.

All cabinets, counters, drawers, lockers, shelving, etc., called for on the drawings shall be provided in place and fitted up with all hardware as specified. These facilities shall be preassembled units or job-built as specified. Preassembled units shall be securely attached to the floors or framing and shall be fitted to other finish work in a workmanlike manner. Job-built cabinet work shall be made in a workmanlike manner and securely and rigidly built in place, supported by necessary brackets and cleats. All lumber for this work shall be kiln dried and of the species and quality specified.

21. Toilet Partitions

Where wood water closet partitions are called for on the drawings, they shall be provided with approved metal fittings and hardware, and doors in accordance with the details.

22. Sash

Wood sash, including storm sash, shall be accurately made to fit openings, dressed and sanded to a smooth finish, pinned and through tenoned with muntins, etc., as detailed. They shall be rabbeted for glass and moulded and shall be properly hung, hinged or pivoted as required. Sash shall be so made and installed as to provide for a watertight fit. Double-hung windows shall have the sash counterbalanced using spring balance suspension, or by counterweights of lead or cast iron hung on approved sash cord or sash chains of proper strength. Sash shall be fitted to operate easily, but shall not be so loose as to rattle. Casement windows shall be made watertight by grooving the bottom rails and providing rabbets at jambs, head and meeting stiles. Glass sizes, thicknesses, widths of rails and stiles will be as shown on the drawings. Where glass sizes only are given, widths or rails, stiles and muntins shall be in accordance with standard mill practice. Storm sash shall be provided with a non-corrodible number tag to correspond with the numbered opening.

23. Doors

Doors shall be of the sizes and types shown on the drawings, properly and neatly hung so as to fill openings, free from warp, and fully equipped with all hardware necessary for their operation. Sliding doors in warehouses and baggage rooms shall have suitable protection built to protect the doors when in an open position, shall have all necessary stops, shall be so hung that the doors cannot be lifted off the track from the outside, and shall be hung and fitted so that no lateral motion will exist. Heavy and special doors shall be built to details with frames mortized together, backing rigidly fastened, and fitted with sash where shown.

A special schedule of hinged doors, showing thicknesses, sizes, design, panelling, glazing, etc., will be furnished to supplement this specification where needed. Unless otherwise specified or called for on the drawings, all panelled doors shall be 1¾ in thick, except interior doors in minor buildings, which may be 1⅜ in thick. Stiles and rails shall be mortized and tenoned, and pinned or doweled. In either case, joints shall be solidly glued up. Doors shall be hung with the proper size and number of butts to prevent sagging. Double-acting doors and gates shall swing clear and fill openings. Hardwood carpet strips or thresholds shall be provided for all doors, unless otherwise shown on the drawings.

24. Miscellaneous Carpentry

The carpenter shall provide, in place, all miscellaneous woodwork not above specified, such as wood foundation blocks and posts, fencing, atticing, coal bins, walkways in attics, wood gutters, signs, notice boards, etc., and do all necessary cutting, fitting and patching, and special framing necessary for the proper installation of work of other trades. Upon completion of the work, the carpenter shall remove all temporary work, scrap lumber and debris, draw all projecting and temporary nails, and leaves the work in a complete, finished and orderly condition.

25. Detailed Shop Drawings

Detailed shop drawings for all millwork shall be submitted for approval before the millwork is performed.

26. General Conditions

All materials entering into the work and all methods used by the contractor shall be subject to the approval of the engineer and no part of the work will be considered as finally accepted until all of the work is completed and accepted.

The General Conditions as given in Part 1, this Chapter, shall be considered to apply with equal force to this specification.

Exhibit C

WARM AIR AND BLAST HEATING

1. General

The contractor shall furnish all labor, material, tools and equipment, except as otherwise noted, to entirely complete the heating work as specified and shown on plans.

2. Furnace

Furnish and install furnaces in manner and location shown on plans. The units shall consist of .... size furnaces, or approved equal, with fans and filters, oil burners, gas burners, stokers, grates for burning .... fuel, or steam or hot water coils; complete with necessary controls and operating equipment.

a. *Oil Burner*

The oil burners shall be No. ...., as manufactured by ...., or approved equal, capable of efficiently burning No. .... fuel oil at a rate which may be varied from .... gph to .... gph. Burners shall be equipped with positive electric spark ignition for fully automatic control with safety controls to meet the specifications of the National Board of Fire Underwriters and local building code.

..........-gal fuel oil tank bearing Underwriters' label shall be installed where shown on plans, complete with vent, fill and supply lines, and an indicating gage of the remote type.

b. *Gas Burner*

Gas burners shall be No. .... as manufactured by ...., or approved equal, with an output rating of .... btu per hr when burning natural, manufactured liquefied petroleum gas, complete with pilots and necessary controls.

c. *Stoker*

A stoker of the underfeed *worm ram* type with *variable* .... steps of coal feed with a maximum capacity of .... lbs of coal per hour shall be installed under the furnace in accordance with the manufacturer's direction by skilled mechanics. The stoker shall be a standard product of the manufacturer and shall be designed for the efficient combustion of low volatile slack No. .... coal. The stoker shall be completely automatic and shall be provided with a device for automatically maintaining a constant static pressure over the fire.

The hopper shall have a minimum capacity of .... lb of coal, and the retort shall be of the sectional type with an active combustion area of not less than .... sq ft.

d. *Heating Coils*

The steam or hot water coils shall be No. .... as manufactured by ...., or approved equal. Steam coils shall be of non-freeze construction.

e. *Fans*

The fans shall deliver .... cfm against external static resistance of .... water pressure with a .... hp motor at a maximum fan speed of .... rpm.

f. *Filters*

Filters shall be ....in thick, ... type, as manufactured by ...., or approved equal. Air velocity through filters shall not be over .... fpm.

3. Breeching

Breeching shall be .... diameter, or equivalent area, ... gage black steel with cleanout door and balancing damper. Breeching shall finish flush with inside of flue and be rigidly supported.

4. Asbestos Connections

Connections between supply and return ducts and the furnace or blower shall be made with 12-oz asbestos cloth not less than 6 in wide, metal 2 in apart and asbestos cloth not under tension.

5. Duct Work

All ducts shall be of sizes shown on plans. Gages of metal shall be as shown on plans, seams and reinforcement shall be in accordance with current Heating, Ventilating, Air Conditioning Guide, published by ASHVE.

6. Dampers

Dampers shall be the type and location shown on drawings. They shall have adjustable quadrant to show position of damper and be equipped with solid bearings. Where ducts are furred in, quadrants shall be ...., or approved equal, for screw-driver adjustment. Volume dampers shall be 1¼ times the width of the duct perpendicular to damper axis. Splitter dampers shall be the lengths shown.

7. Registers and Grilles

Supply and return grilles—ceiling diffusers and return grilles shall be of size and type shown on plans.

8. Insulation

All supply and return ducts in unheated spaces shall be insulated with one .... -in semi-rigid .... insulation, or approved equal.

9. Controls

A ...., or approved equal, room thermostat shall operate gas oil burner stoker steam valve in conjunction with a ...., or approved equal, combination furnace controller and protecting device.

10. Lubrication

All bearings shall be protected during installation to keep out foreign matter. The oil level in all bearings shall be determined when the oil and bearings are at operating temperature.

11. Cutting and Patching

All necessary patching required for the proper installation of the work shall be done in a neat workmanlike manner. No joists, beams, girders or columns shall be cut without first obtaining the written permission of the engineers.

12. Adjustment and Trial Run

After completion of the air distribution system, it shall be given a run of sufficient duration to assure proper operation of the equipment and delivery of specified quantities of air at outlets.

13. Instructions

All switches and other operating devices shall be clearly and neatly marked as to purpose. Operating instructions shall be typed or printed and permanently installed in a frame properly protected under glass or transparent plastic near the controls. An electrical control diagram shall be furnished so that the system can be traced by an electrician.

Exhibit D

CONCRETE PAVEMENTS

1. General

The contractor shall furnish all labor, materials, tools, and equipment necessary to entirely complete the work as herein specified and shown on the drawings.

2. Description

The pavement shall consist of a subgrade and one course of concrete of the thickness shown on the drawings, together with a curb and gutter as shown or indicated.

3. Grading and Subgrade

The grading shall be completed to the proper subgrade elevation to permit the specified thickness of pavement to be laid to bring the finished surface of the pavement to the established lines and grades.

The bottom of the excavation or top of the fill, when completed, shall be known as the subgrade.

All vegetable, perishable, unstable or unsuitable material shall be removed from the subgrade and replaced with suitable material.

Where a fill is required to bring the subgrade to the required elevation, it shall be made of material that will compact readily and develop a satisfactory water tightness and stability. Each layer of material shall extend the entire length and width of the embankment. Each layer shall be not more than 6 in thick when in loose condition, shall be uniform in cross section, and shall be thoroughly compacted before the next layer is started.

The subgrade shall be constructed to have, as nearly as practicable, a uniform density throughout its entire width.

Compaction may be obtained by use of any of the following equipment:

a. Three-wheel roller, self-propelled, weighing not less than 5 tons.

b. Tamping roller having a minimum weight of 90 lb per in of width, and each individual tamper shall impose a pressure of not less than 100 psi of its tamping face area. The width of the tamping roller shall be not less than 8 ft, and it shall be constructed in two or more sections in such a manner that each section is free to move independently, and shall be equipped with cleaner teeth at the rear.

c. Truck roller shall be equipped with pneumatic tires, and under working conditions shall be of such weight that the compression per inch of width of tire tread shall be not less than 225 lb. The tires on the front and rear axles shall be staggered so that they will come in contact with the entire area over which the roller travels.

d. Hand tamping, where required, shall be done with a tamp weighing not less than 50 lb, and whose face does not exceed 100 sq in. in area.

All depressions and ruts developing under traffic on the subgrade or in connection with rolling shall be filled with suitable material, compacted into place.

Existing rigid-type pavements, base courses or other hard compacted crust which comes within 6 in of the elevation of the finished subgrade shall be plowed or otherwise broken up and loosened. The loosened material shall be redistributed across the full width of the subgrade, adding suitable material when necessary, and compacted.

Special treatment may be required for certain subgrades such as sand, gumbo, adobe, and other materials, which cannot be satisfactorily prepared by the methods specified in the foregoing paragraphs.

After being prepared in the manner above specified, the subgrade shall be so maintained until the concrete pavement has been placed thereon.

Surplus excavated material shall be disposed of by the contractor. The contractor shall remove all obstructions such as trees, stones, blocks, etc.

4. Curbing

Concrete curbing shall be built according to details shown on drawings.

5. Concrete Materials and Workmanship

All cement and concrete materials and workmanship shall comply with the specifications for concrete as given in Chapter 8 of the Manual. Not more than 5 gal of water shall be used to each sack of cement. Air-entrained concrete containing 3 to 5 percent by volume of entrained air may be used.

6. Joint Filler

Joint filler shall be non-extrusive and consist of prepared strips of fiber matrix and bitumen, or a uniform mixture of fiber and bitumen, or a combination of both, containing not more than 25 percent by weight of inert material, having thickness of .... in and width equal to .... in greater than the thickness of the pavement at any point. The bitumen used in manufacture of the joint filler may be either tar or asphalt of a grade that will not become soft enough to flow in hot weather nor brittle in cold weather. Other non-extrusive joint fillers meeting the approval of the engineer may be used.

7. Forms

Forms shall comply with the specifications for concrete as given in Chapter 8 of the Manual. Unless impracticable, side forms for pavement shall be of metal. Metal forms shall be of stamped sections. They shall be straight, have a depth equivalent to the edge thickness of the work prescribed, and of sufficient strength and so secured as to resist, without springing or settlement, the pressure of the concrete when placed, and the impact and vibration of finishing equipment.

If side forms of wood are used, the form lumber shall be at least 2 in thick, straight and of a width equal to the edge thickness of the pavement. Wooden forms shall be nailed to stakes driven into the ground along the outside edge. The stakes shall be braced and placed at such intervals that grade and alinement of the form will be properly maintained during placing and finishing of the concrete.

8. Joints

If pavement is constructed of more than one longitudinal strip, and in pavements with integral curb and gutter, transverse joints shall be continuous in a straight line through all pavement strips, gutter and curb.

Manhole and catch basin covers, column bases, and all other fixed objects shall be separated from the concrete by joint filler not less than ½ in thick.

Where pavement forms the base for other than concrete wearing surface, expansion and contraction joints may be omitted at the discretion of the engineer.

9. Expansion and Contraction Joints

a. Expansion joints shall be as shown in Fig. 1 (a) unless otherwise specified or shown on the drawings. The premolded joint filler shall be cut to conform to the cross section of the pavement and in lengths equal to the width of the pavement strip, except

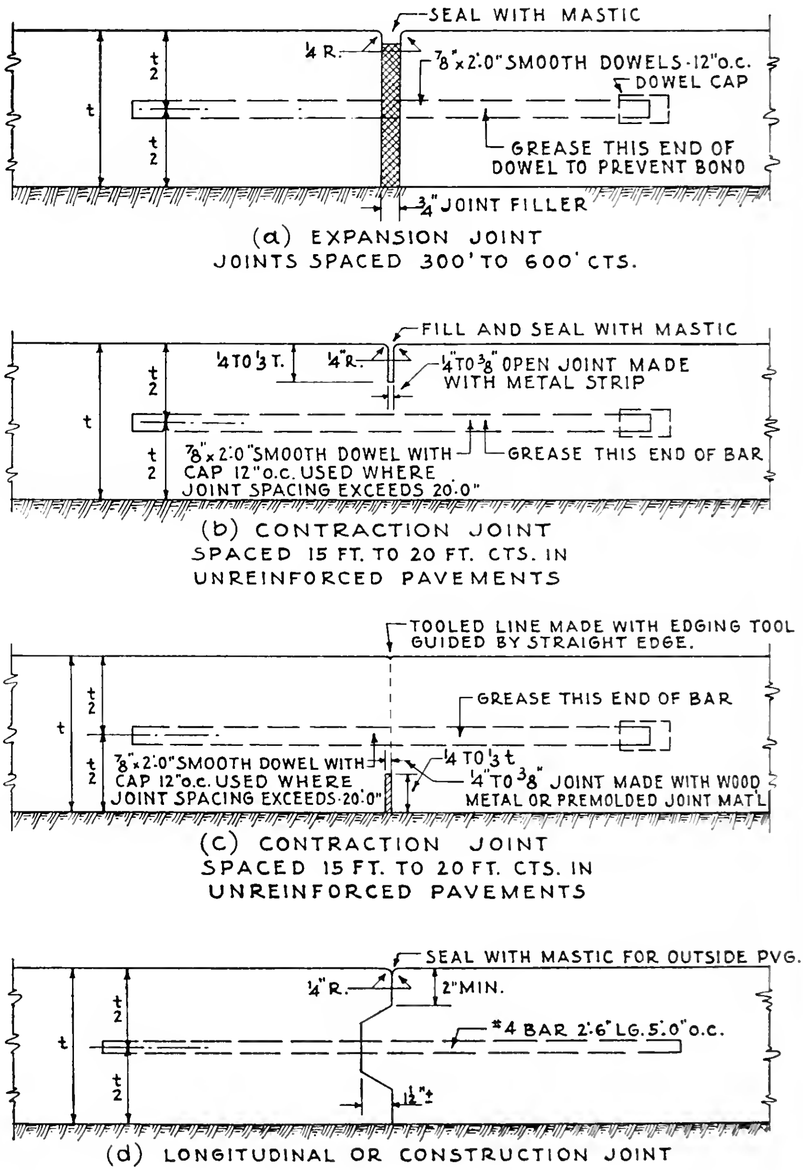


FIGURE-1

TYPICAL PAVEMENT JOINT DETAILS

that strips equal in length to half the width of the pavement strip may be used when laced or clipped together in a satisfactory manner. A suitable bulkhead shall be used to hold the joint filler and dowels in position during the depositing of concrete.

Expansion joints at intersections shall be located as shown on the drawings or as directed by the engineer.

b. Contraction joints shall be as shown in Fig. 1 (b) and Fig. 1 (c) unless otherwise specified or shown on the drawings. Suitable supports shall be provided to hold the dowels (when used) in place while pouring concrete. For paving inside buildings, contraction joints should be spaced 15 to 20 ft in each direction.

10. Longitudinal Joints and Construction Joints

These joints shall be as shown in Fig. 1 (d) unless otherwise specified or shown on the drawings.

The longitudinal joints shall be not further apart than 13 ft and the construction joints located at end of a pour, if this point does not coincide with location of expansion joint.

The joint shall be made by use of suitable forms which will hold the dowel (when used) in position when concrete is poured.

If the pavement is more than three lanes wide, the dowel rods shall be omitted from every second or third joint so as to divide the pavement into units of not more than three lanes wide. The pavement adjacent to the undoweled joint shall be designed in the same manner as other free edges of the pavement.

11. Placing Reinforcement

Steel fabric reinforcement, when called for on the drawings, shall be placed 2 in below the finished surface of the pavement, unless otherwise indicated. Fabric shall extend to within 2 in of sides and ends of slabs. All laps of fabric sections shall be not less than ¾ of the spacing of members in the direction lapped.

Steel bar reinforcement, when called for on the drawings, shall be placed 2 in below the finished surface of the pavement, unless otherwise indicated. Transverse bars shall extend to within 2 in of the margins of the pavement. Bar reinforcement shall be placed and securely supported in correct position before any concrete is laid. All intersections of longitudinal and transverse bars shall be securely wired or clipped together to resist displacement during concreting operations.

12. Placing Concrete

Concrete shall be placed only on a moist subgrade, but there shall be no pools of standing water. If the subgrade is dry, it shall be sprinkled with as much water as it will absorb readily. Concrete shall not be placed on frozen subgrade.

The mixed concrete shall be deposited rapidly on the subgrade to the required depth and for the entire width between longitudinal joints in successive batches, and in a continuous operation without the use of intermediate forms or bulkheads between joints. While being placed, the concrete shall be vigorously spaded, with suitable tools, to eliminate voids or honeycomb pockets. The concrete shall be especially well spaded and tamped against forms, bulkheads, curbs and gutters.

When the concrete is placed in two layers to permit the use of steel reinforcement, the first layer shall be roughly struck off with a template at the correct elevation to permit placing the reinforcement in the specified position. The concrete above the reinforcement shall be placed within 15 min after the first layer has been placed.

13. Finishing

a. Striking Off—Between intersections, the concrete shall be brought to the specified contour by means of a screed or template, fitted with handles and weighing not less than 15 lb per lin ft. This template may be of steel, or of wood shod with steel. It shall be shaped to the contour of the pavement and have sufficient strength to retain its shape under all working conditions.

The template shall rest on the side forms, curbs or gutters, and shall be drawn forward with a sawing motion. At transverse joints the template shall be drawn not closer than 3 ft toward the joint and shall then be lifted and set down at the joint and drawn backward away therefrom. Surplus concrete shall then be taken up with shovels. A slight excess of the material shall be kept in front of the cutting edge at all times.

b. Tamping—After the concrete has been struck off, the template shall be used as a tamp. In this operation one end of the template shall rest on the side support, while the other is lifted and dropped, advancing at such a rate that the whole pavement is struck at least once. The opposite end shall then be lifted and dropped and advanced in the same manner. In no case shall either end be advanced more than 1 ft ahead of the other.

c. Imperfections—Immediately thereafter, the surface shall be inspected for high or low spots and any needed corrections made by adding or removing concrete. Rough spots shall be gone over with a long-handled float and worked to proper contour and grade. The entire surface shall then be floated longitudinaly with a float board not less than 12 ft long and 8 in wide. This float board shall have convenient plow handles at each end. It shall be operated by two men, one at each end, each man standing on a bridge spanning the pavement. The lower surface of the float board shall be placed upon the surface of the concrete with the long dimension parallel to the center line of the pavement. The float shall then be drawn back and forth in slow strokes about 2 ft long, and advancing slowly from one side of the pavement to the other. The purpose of this operation is to produce a uniform even surface on the concrete, free from transverse waves. When the entire width of the pavement has been floated in this manner, from one position of the bridges, they shall be moved ahead so that the next section to be floated shall overlap the one previously floated from 3 ft to 4 ft.

Cement mortar gathered from the surface of the concrete already placed shall not be used in filling boot tracks or stony areas, but such imperfections shall be dug out and refilled with concrete to the depth of the reinforcing and worked smooth. No person shall then be allowed to walk over the area so completed.

d. Belting—After inspection, and as soon as excess moisture has disappeared, the pavement shall be belted by means of one application of a soft flexible belt. The belt shall be of canvas or canvas-rubber composition, two to four-ply, not less than 8 in nor more than 10 in wide, and at least 2 ft longer than the width of the area to be belted. The belt shall be moved forward with a combined transverse and longitudinal motion, the transverse stroke being short and rapid, the longitudinal advance being obtained with a sweeping motion. Care shall be taken that the belting operation does not work the crown out of the pavement. The belt shall be kept properly cleaned and oiled.

e. Edging—After belting has been completed and before the concrete has taken its initial set, the edges of the pavement and all transverse joints shall be carefully rounded with a finishing tool having a radius of ¼ in.

f. Mechanical Equipment—Where the width of the pavement is uniform and the contractor elects to use mechanical equipment operating on the side forms, an approved concrete spreader, and vibratory or non-vibratory finishing machine may be used, in place of hand operations specified in (a) Striking Off, and (b) Tamping.

g. Where the pavement forms a base for other than a direct concrete wearing surface, the base shall be finished in accordance with the requirements of the wearing surface to be used.

14. Curing and Protection

The surface of the newly laid pavement shall be wetted if it becomes dry before the curing material is applied. The water shall be applied as a fine spray so that it will not mar or injure the pavement surface.

The forms shall not be removed until the concrete has hardened sufficiently to prevent damage to the pavement edge, ordinarily about 12 hr after the concrete is placed. The top and edges of the concrete slab shall not be unprotected for a period of more than ½ hr at the time the forms are removed.

Curing shall be accomplished by one of the methods described hereinafter.

a. Wetted Burlap Method—The blankets shall be made from whole stock widths of new burlap, and shall be 2 ft longer than the width of the pavement. The blankets shall overlap 6 in. At least 2 layers of wetted burlap shall be placed on the finished surface immediately after the concrete has hardened sufficiently to prevent marring of the surface, and shall be kept saturated with water for a period of not less than 72 hr from the time applied. The blankets shall be placed so that they are in contact with the edges of the slab, and that portion of the material in contact with the edges shall be kept saturated with water. Blankets for re-use shall meet with the approval of the engineer.

b. Mat Curing Method—The pavement shall be covered with mats of cotton, sisal, jute or other approved material, with or without a waterproof covering. The mats used shall be of such composition and thickness that they will provide satisfactory curing and shall be at least equal in efficiency to the burlap covering specified in Par. (a). The mats shall be saturated with water and placed on the finished surface as soon as the concrete has hardened sufficiently to prevent marring of the surface, and shall remain in place for a period of not less than 72 hr. Mats without waterproofing covering shall be kept saturated with water; if for any reason mats with waterproof coverings fail to keep the concrete wet, additional water shall be applied, so that the concrete will be kept wet during the entire period the mat is on the surface. The blankets shall be placed so that the entire surface and both edges of the slab are completely covered.

c. Wetted Straw Method—The surface of the pavement shall be kept continuously wet as provided in Art. 14, Curing, first paragraph, for a period of approximately 4 hr. In lieu of applying water to wet the surface, wetted burlap may be used if kept continuously wet for the same period. The surface of the pavement shall then be covered with clean loose straw, applied at the rate of not less than 6 lb per sq yd, and shall be saturated with water as soon as placed and kept saturated for a period of not less than 72 hr from the time applied. The edges of the pavement shall be banked with not less than 12 in of straw, which shall be kept saturated with water during the curing period specified. If the straw covering becomes displaced, it shall be replaced immediately with the minimum thickness specified. Upon completion of the required curing, the straw shall be removed and disposed of, so that the right-of-way is left in a neat and presentable condition.

d. Impermeable Paper Method—The surface of the pavement shall be covered with impermeable paper blankets as soon as the concrete has hardened sufficiently to prevent marring the surface. The surface of the pavement shall be wetted immediately before the paper is placed. The blankets shall remain in place for a period of not less than 72 hr from the time applied. The blankets shall be lapped at least 12 in end to end, and these laps shall be securely weighted with a windrow of earth or other approved method to form a closed joint; the same requirements shall apply to the longitudinal laps where separate strips are used for curing the pavement edges, except that the lap shall be at least 9 in. The edges of the blanket shall be weighted securely with a continuous windrow of earth to provide contact with the edges of the pavement. Any torn places or holes in the paper shall be repaired immediately by patches cemented over the openings, using bituminous cement having a melting point of not less than 180 deg F. The blankets may be re-used, provided they are airtight and kept serviceable by proper repairs. Any unit which in the opinion of the engineer does not comply with this requirement shall be discarded. A longitudinal pleat shall be provided in the blanket to permit shrinkage where the width of the blanket is sufficient to cover the entire surface and both edges of the pavement slab; the pleat will not be required where separate strips are used for the pavement edges. Joints in the blanket shall be sewed or cemented together in such manner that they will not separate during use.

e. Membrane Curing—In lieu of wet curing, a colorless membrane curing compound, meeting with the approval of the engineer and applied in accordance with the manufacturer's directions may be used.

f. Wetted Sand Method—The surface of the pavement shall be kept continuously wet as provided in curing until 10 am on the day following the placing of the concrete. In lieu of applying water to wet the surface, wetted burlap may be used if kept continuously wet for the same period. The surface of the pavement shall then be covered with sand to a uniform thickness of 2 in. The sand covering shall be applied by 10 am on the day following the placing of the concrete, and shall be saturated with water as soon as placed and kept saturated for a period of not less than 72 hr from the time applied. The edges of the pavement shall be banked with not less than 4 in of sand, which shall be kept saturated with water during the curing period specified. If the sand covering becomes displaced, it shall be replaced immediately with the minimum thickness specified. Upon completion of the required curing, the sand shall be removed and disposed of so that the pavement and adjoining areas are left in a neat and presentable condition.

15. Prohibition of Traffic

The contractor shall provide and maintain substantial barricades across the pavement, with suitable warning signs day and night, to prevent traffic upon the pavement until otherwise directed by the engineer.

16. Adjusting Existing Structures

Manhole and catchbasin covers, valve boxes and similar existing structures within the area to be paved shall be adjusted by the contractor to come flush with the surface of the pavement.

17. General Conditions

All materials entering into the work and all methods used by the contractor shall be subject to the approval of the engineer, and no part of the work will be considered as finally accepted until all the work is completed and accepted.

The General Conditions as given in Part 1, this Chapter, shall be considered to apply with equal force to this specification.

Exhibit E

CHIMNEYS, FLUES AND VENTS

A. GENERAL

1. Definitions

Chimney. A vertical shaft enclosing one or more flues.

Interior Chimney. A chimney built within the walls of a building and having lateral support from the building.

Exterior Chimney. A chimney built outside the walls of a building but receiving lateral support from the exterior walls of the building.

Isolated Chimney. Any chimney other than an interior or exterior chimney. It is also that part of a chimney that projects above the walls of a building which gives it lateral support, but the chimney shall not be classified as isolated unless the length of the projecting part exceeds the length of the part receiving lateral support. For the purpose of this definition, guys or stays shall not be considered as lateral support.

Flue. An enclosed passageway in a chimney for removing products of combustion from solid, liquid or gas fuel.

Smoke Pipe. A pipe or breeching connecting a heating appliance and a flue.

Vent Pipe. As applied to heating, a pipe for removing products of combustion from gas appliances.

2. General Conditions

The general conditions shall comply with General Conditions, Part 1, this Chapter.

The engineer may require tests of all chimneys, smoke pipes and flues to insure gas, smoke and flame tightness.

Chimneys shall be so constructed as to permit necessary cleaning. Whenever a new flue is completed or an existing flue is altered, it shall be cleaned and left smooth on the inside.

3. Construction

Chimneys shall be constructed of masonry, reinforced concrete, metal or other noncombustible materials approved by the engineer.

Chimneys shall be constructed to resist all loads, including a horizontal wind pressure from any direction of 25 psi without exceeding the allowable stresses for the materials as provided in this specification or in Concrete, Part 4; Brickwork, Part 4; and Part 5—Iron and Steel, this Chapter.

4. Classification

Low Temperature. Chimneys for warm air and hot water heating plants, steam boilers operating as not over 50 psi gage pressure, steam boilers of not over 10 boiler hp regardless of operating pressure, and other low-heat appliances shall be classified as low temperature. Appliances considered as medium-heat appliances may be considered as low-heat appliances if not over 100 cu ft in size.

Medium Temperature. Chimneys for steam boilers of over 10 boiler hp operating at over 50 psi gage pressure, and other medium-heat appliances shall be classified as medium temperature.

5. Height of Chimneys

Low Temperature. Low-temperature chimneys shall extend to a height of not less than 3 ft above the roof at the point of intersection and not less than 2 ft above any roof within 10 ft of such a chimney, except that chimneys located on a roof having a slope of more than 15 deg may extend not less than 2 ft above the ridge.

Medium-Temperature Chimneys. Medium-temperature chimneys shall extend to a height of not less than 10 ft above any roof within a horizontal distance of 25 ft.

6. Flues

Sizes. The cross-sectional area of smoke flues shall be designed and proportioned to meet the conditions of temperatures within and without the flue, insulation quality of walls, weather exposure, shape and material of flue and other influences; for solid or liquid fuels they shall be not less than 70 sq in for warm air, hot water and low-pressure steam-heating appliances; not less than 40 sq in for ordinary stoves, ranges and room heaters; and not less than 28 sq in for small special stoves and heaters. The cross-sectional areas of flues and vents for gas-burning appliances shall be not less than 1 sq in per 7500 hourly Btu input and in no case shall this section be less than 3 in. in diameter.

Connections. Except for vents from gas appliances, nothing in this specification shall prohibit the joining of two or more pipes for a single flue connection, provided that smoke pipes and flues are of sufficient size to serve all the appliances thus connected, and that the several smoke pipes are constructed to comply with the severest requirements for any one of those connected. A vent from a gas appliance shall not be connected to a smoke pipe, but may be connected to another vent pipe or flue when such gas appliance is equipped with an automatic device to prevent the escape of unburned gas at the main burner or burners.

7. Flue Linings

Flue linings, where required in this specification, shall be of refractory materials which will withstand the action of flue gases and resist, without softening or cracking, the temperatures to which they will be subjected, but not less than 2000 deg F.

Type 1 Flue Linings. Type 1 flue linings shall have fire-resistive, refractory and insulating properties equivalent to flue linings of not less than 4½ in of fire brick laid in fire clay mortar. There shall be an air space of at least 2 in between such linings and the chimney wall, except that there shall be an air space of at least 4 in between such linings and a reinforced concrete chimney wall. The thickness of the independent lining shall not be considered as a part of the required thickness of the wall.

Type 2 Flue Linings. Type 2 flue linings shall have fire-resistive, refractory and insulating properties equivalent to solid fire clay masonry units not less than ¾ in thick laid in fire clay mortar.

Type 3 Flue Linings. Type 3 flue linings shall have fire-resistive, refractory and insulating properties equivalent to flue linings of fire clay units not less than ⅝ in thick, laid in fire clay mortar, or in portland cement or cement lime mortar.

8. Guarantee

For a period of 1 year after a metal or isolated masonry or reinforced concrete chimney has been accepted by the railroad company, the contractor shall repair free of charge any defect which may develop from a wind pressure due to a velocity of wind not exceeding 100 mph, the influence of the atmosphere, the chimney gases and temperature not exceeding design temperatures, and faulty materials or workmanship.

B. MASONRY CHIMNEYS

1. General

Materials. Chimneys shall be constructed of brick of a quality at least equal to that required by current ASTM Specifications, designation C62–44, Grade MW, for clay or shale brick, or of perforated radial brick of special design adapted to chimney construction where the average amount of perforations does not exceed 30 percent. Either of the above units shall be considered as solid masonry units and the determination of all stresses shall be based on gross areas. Where special perforated radial brick is employed it shall be assumed not to weigh in excess of 110 lb per cu ft. Masonry shall be laid in portland cement or cement lime mortar.

Chimney Caps. Every such chimney shall be properly capped with brick, terra cotta, stone, cast iron or other approved non-combustible, weatherproof material.

Supports. Such chimneys shall be wholly supported on approved masonry or self-supporting fireproof construction.

Corbeling. No such chimney shall be corbeled from a wall more than 6 in, nor shall such chimney be corbeled from a wall which is less than 12 in. in thickness unless it projects equally on each side of the wall; provided that in the second story of two-story dwellings corbeling of chimneys on the exterior of the enclosing walls may equal the wall thickness. In every case the corbeling shall not exceed 1 in projection for each course of brick projected.

Clearances. Combustible framing shall be trimmed away from all flues and chimneys and no combustible material shall be placed within 2 in of any chimney nor within 6 in of any outlet to such chimney. Spaces between chimneys and wood framing shall be firestopped with approved non-combustible material.

Cleanout. Every such chimney shall be provided with a cleanout equipped with a cast iron door and frame arranged to remain tightly closed when not in use.

Construction. No tension shall be allowed in the masonry of chimneys built of solid masonry units or perforated radial brick unless proper steel reinforcement shall be provided. Reinforced brick masonry may be used when approved by the engineer.

2. Low-Temperature Chimneys

Wall Thickness. Walls of low-temperature chimneys shall be not less than 7 in thick, except that chimneys containing no flue exceeding 150 sq in. in net area may have walls not less than 3½ in thick. Thickness of walls as herein required shall not include flue linings.

Lining. Low-temperature masonry flues not exceeding a net area of 700 sq in shall be lined with type 3 flue lining, extending to the top of the chimney from a point not less than 8 in below the intake. It is recommended that flue linings extend 4 in above the top or cap of the chimney. Low-temperature masonry chimney flues exceeding a net area of 700 sq in shall be lined with type 1 flue lining, extending from a point not less than 2 ft below the bottom of the breeching to the top of the chimney, or to a point not less than 30 ft above the top of the breeching. If the type 1 lining is not extended to the top of the chimney, the outer shell shall be corbeled in over the top to prevent the access of water and soot behind the lining.

3. Medium-Temperature Chimneys

Wall Thickness. Walls of medium-temperature chimneys shall not be less than 7 in thick.

Lining. Medium-temperature masonry chimney flues not exceeding a net area of 700 sq in shall be lined with type 2 flue lining. Flues exceeding a net area of 700 sq in shall be lined with type 1 flue lining extending from a point not less than 2 ft below the bottom of the breeching to the top of the chimney, or to a point not less than 30 ft above the top of the breeching. If the type 1 lining is not extended to the top of the chimney, the outer shell shall be corbeled over the top to prevent the access of water and soot behind the lining.

4. Isolated Chimneys

General. Chimneys not greater than 4 ft in least horizontal dimension nor greater than 100 ft in height may be of square or rectangular section. Chimneys of greater least horizontal dimension or of greater height shall be of circular section. An octagonal cross section may be used for the bottom section up to just above the entrance of the breeching. The outside of the chimney shall be battered above the top of the chimney foundation. This batter shall vary from $\frac{1}{8}$ in to $\frac{5}{16}$ in per ft, the batter increasing as the ratio of the height to the top diameter increases.

Unit Stresses

Brick masonry in tension	None
Brick masonry in compression, portland cement mortar	250
Brick masonry in compression, portland cement–lime mortar	200

The working stresses here given are for brickwork in which brick having a compressive strength of 4500 to 8000 psi are used. For masonry of brick having a greater or lesser compressive strength, these values should be changed.

Wall Thickness. No chimney shall have a wall thickness at the top of less than 8 in for chimneys from 7 ft to 10 ft in diameter; not less than 9 in for chimneys from 10 ft to 12 ft in diameter; and not less than 13 in for larger chimneys. At any section, the wall thickness in inches shall be not less than 1/9 of the height of the chimney in feet above the said section for brick with an average compressive strength greater than 8000 psi, nor less than 1/9 of the height in feet plus 4 in for brick having a compressive strength of 4500 to 8000 psi. The walls of the base section in inches shall not be less than 1/9 of the height in feet plus 7 in.

Wall Reinforcement. Chimneys shall be reinforced at every change in wall thickness with steel bands 3 in wide and $\frac{3}{8}$ in thick, built into the walls, but in no case shall the bands be spaced more than 20 ft apart.

Foundations. The foundation shall be designed to carry the chimney and all loads. It shall be so proportioned that the resultant of all forces will fall within such area that no uplift will occur at the bottom surface. In no case shall the width of the foundation slab be less than 1/10 of the height plus the inside diameter of the chimney at the top. The bottom of the foundations shall be approximately 1/25 of the chimney height below the ground, but not less than 4 ft deep. Where the foundation meets the chimney it shall be at least 9 in larger than the outside diameter of the chimney. Where piles are used, they should conform to the specifications of the AREA.

Excavations. All excavations and backfilling shall comply with Specifications for Excavation, Filling and Backfilling, Part 2, this Chapter.

Concrete. Concrete for foundations shall comply with Specifications for Concrete, Part 4, this Chapter.

Breeching Opening. The opening shall be lined on the reveals with refractory material. The masonry above the opening shall be supported by a steel beam set on bearing plates with a space at each end for expansion. Under the beam, a flat masonry arch shall be built to protect the beam from the effect of gases. Steel bands shall be provided above and below the opening.

Lightning Protection. A lightning protection system that will meet the requirements of the National Board of Fire Underwriters shall be installed on every isolated masonry chimney.

Lettering. When specified, letters of permanently colored kiln-burnt brick shall be built into the chimney shaft.

Ladder and Safety Cage. When specified, a ladder and safety cage shall be built, preferably on the outside of the chimney. The ladder shall consist of ¾ in square galvanized iron rungs, spaced approximately 15 in on center, securely anchored to the masonry. The safety cage shall consist of durable materials to meet requirements of local, state, and industrial codes.

Draft Gage. When specified, an approved gasometer bell-type pointer draft gage, together with all necessary attachments, pipings and fittings, shall be installed. The gage shall be located in a place visible to the operator when making adjustments to draft controls or dampers. Each pointer or reading shall be furnished with a stop cock close to the gage.

Pyrometer. When specified, an approved vertical, straight-stem, mercury-actuated dial pyrometer or, as may be determined by the engineer, a thermo-electric pyrometer, equipped with dial and recording attachment, shall be installed.

Lights and Markings. When specified, such lights and/or markings as required by the Civil Aeronautics Authority shall be installed.

C. REINFORCED CONCRETE CHIMNEYS

1. General

Design. Reinforced concrete chimneys shall be designed in accordance with the latest Building Code Requirements for Reinforced Concrete of the American Concrete Institute. The walls shall not be less than 4 in thick at the top and shall increase uniformly to a thickness at the bottom, which will be required to withstand the forces within the specified stresses. It is recommended that the effect of the thermal expansivity of aggregates on concrete be considered and that certain rocks with unusually low expansivities be avoided as well as those which change in volume a relatively large amount when exposed to high temperatures.

Clearances. See Masonry Chimneys, Part 19, this Chapter.

Cleanout. See Masonry Chimneys, Part 19, this Chapter.

2. Low-Temperature Chimneys

Lining. See Masonry Chimneys, Part 19, this Chapter.

3. Medium-Temperature Chimneys

Lining. See Masonry Chimneys, Part 19, this Chapter.

4. Isolated Chimneys

Foundations. The foundation shall be designed to carry the chimney and all loads. It shall be so proportioned that the resultant of all forces shall fall within the kern of a horizontal section through the base. Where piles are used, they shall conform to the specifications of the AREA.

Breeching Opening. The breeching opening shall have a concrete collar and buttress.

Excavation, lightning protection, lettering, ladder, draft gage, pyrometer, lights and markings. See Masonry Chimneys, Part 19, this Chapter.

D. METAL CHIMNEYS

1. Construction

Types of Construction. Metal chimneys shall be of riveted or welded construction.

Materials. Chimneys shall be constructed of steel or of wrought iron and shall conform to the current ASTM specifications, designations A–7 and A–42. All metal shall be galvanized or, preferably, painted.

Foundations. All chimneys erected outside or independent of a building shall be supported on an independent masonry or reinforced concrete foundation. For self-supporting chimneys, the foundation shall be so proportioned that the resultant of all forces will fall within such area that no uplift will occur on the bottom surface. Where piles are used, they shall conform to the requirements of the AREA.

Thickness of Metal. The thickness of the metal shall be adequate to resist all loads without exceeding the allowable unit stresses for the metal as provided in Structural Steel, Part 5, this Chapter, but shall not be less than the following minimum thickness:

Area of Chimney (square inches)	*Minimum Thickness of Metal*
Less than 155	12 gage
155 to 254	$\frac{3}{16}$ in
More than 254	$\frac{1}{4}$ in

Linings. Linings are not required for low and medium-temperature metal chimneys. However, if the temperatures of the flue gases rise for prolonged periods above the point at which the strength of the metal is impaired, that is, about 800 deg F for steel; or if the corrosive action of the combustion gases and condensation products is severe; or if it is desirable to improve the draft conditions by reducing the heat losses due to radiation, a lining is recommended. A type 1 lining should be capped with lead or some other material to prevent the access of soot, water and acids behinds the lining. A type 2 or 3 lining may be carried on shelf angles at 5 to 15-ft intervals.

Lightning Protection. Lightning conductors are not required. The steel shell shall be grounded in such manner as to meet the requirements of the National Board of Fire Underwriters.

Excavation. Excavation and backfilling shall comply with Specifications for Excavation, Filling and Backfilling, Part 2, this Chapter.

Concrete. Materials and workmanship for concrete shall comply with Specifications for Concrete, Part 4, this Chapter.

Fabrication. The plates forming the shell of the chimney shall be slightly conical so that the upper ring will always fit inside the section below. Vertical seams shall be so located as to break joints. For riveted construction, lap joints with scarfed corners shall be used. For welded construction, lap joints shall be used for circumferential seams, and butt joints for vertical seams.

Breeching Opening. The breeching opening shall be reinforced with angles around the edges to receive the breeching.

Painter's Collar. If specified, a painter's collar consisting of a structural steel shape shall be furnished and fastened to the chimney about 2 ft from the top.

Ladder and Safety Cage. If specified, an approved ladder shall be furnished and installed, preferably on the outside of the chimney. It shall consist of steel bars and safety rungs, and shall be attached to the chimney by means of anchors spaced not more than 8 ft center to center.

Draft Gage. See Draft Gage, Sec. B, Art. 4.

Pyrometer. See Pyrometer, Sec. B, Art. 4

2. Exterior Chimneys

Clearances. Every exterior chimney, or part thereof, erected on the exterior of a building shall have a clearance from the wall of not less than 24 in if the wall is of combustible construction, and not less than 4 in if it is of non-combustible construction; except that when the chimney is insulated with approved materials, the clearances herein prescribed may be reduced by one-third.

Location. No exterior chimney shall be located less than 24 in. in any direction from a wall opening, exit or fire escape, except that when the chimney is insulated, the specified clearance may be reduced to 16 in.

3. Interior Chimneys

Fire-Resistant Enclosure. Every interior chimney, or part thereof, erected within a building other than a one-story building, shall be enclosed, above the story in which the appliance served thereby is located, in walls of approved masonry or fire partitions, with a space on all sides between the stack and the enclosing wall sufficient to render the entire stack accessible for examination and repair. The enclosing walls shall be without openings, except doorways equipped with approved self-closing fire doors at various floor levels for inspection purposes. Metal chimney shall not be carried up inside of ventilating ducts unless such ducts are constructed as required for chimneys or flues, this specification, and such chimney or flues are used solely for venting the room or space in which the appliance served by the smokestack is located.

Thimbles. Where such chimney passes through a roof constructed of combustible materials, it shall be guarded by a galvanized iron ventilating thimble extending not less than 9 in below and 9 in above such roof construction. Such thimbles shall be of a size to provide a clearance on all sides of the chimney of not less than 18 in, provided that for chimneys of low-heat appliances the clearance may be reduced to not less than 6 in.

4. Isolated Chimneys

Flared Bottoms. Self-supporting chimneys over 100 ft high shall be flared out at the bottom. The diameter of the flare shall be determined by the type of foundation and the allowable unit stress, but shall not be less than 1½ times the chimney diameter, and the height of the flare shall not be less than 1/7 nor more than ¼ of the total height of the chimney above the foundation.

Guys and Stays. Guyed chimneys 100 ft or less in height shall be equipped with a minimum of one set of four guys attached to the chimney at the upper third point.

Guyed chimneys of a greater height shall be equipped with two sets of four guys each, one set attached to the chimney at a point three-quarters of the height of the chimney, and the other set at a point one-half of the height. Guys shall have a slope of from 45 to 60 deg with the horizontal. Each guy shall be designed to resist the entire wind load of the section to which it is attached. Stayed chimneys shall meet all of the requirements for guyed chimneys, except that there shall be half the number of stays as there are guys and each stay shall be designed for both tension and compression. Stays shall be placed 90 deg apart in plan.

E. FLUES AND VENTS FOR GAS APPLIANCES

1. Flue Connections Required

Every gas appliance shall be connected to an effective flue extending to the outer air and conforming to the provisions of Art. 2, Sec. E, if it is included in any of the following classifications, provided that such connections shall not be required for industrial appliances of such size or character that the absence of a connection does not constitute a hazard to the occupants:

a. Domestic appliances with input in excess of 50,000 Btu per hr, except domestic gas ranges.

b. Automatically controlled appliances with input rating in excess of 5000 Btu per hr, except single-faucet-type automatic instantaneous water heaters.

c. Automatically controlled appliances with input rating less than 5000 Btu per hour, unless equipped with an automatic device to prevent the escape of unburned gas at the burner or burners.

d. Each of several appliances, except domestic gas ranges, installed in the same room, which in the aggregate have an input rating as great as 30 Btu per hr per cu ft of room content.

e. Water heaters installed in bathrooms, bedrooms, or any occupied room normally kept closed.

f. Space heaters in sleeping quarters for use of transients.

g. All house heating steam and hot-water boilers and warm-air furnaces, including floor furnaces.

2. Types of Flues

Type A. Type A flues shall include chimneys complying with the requirements of this specification. Type A flues are required for: all incinerators; all appliances which may be converted readily to the use of solid or liquid fuel; all boilers and furnaces; and all other appliances except approved appliances which produce flue gas temperatures not in excess of 550 deg F at the outlet of the draft hood when burning gas at the manufacturer's input rating.

Type B. Type B vent piping shall include approved vent piping of noncombustible, corrosion-resistant material of adequate strength and heat insulating value, and having bell and spigot or other acceptable joints. Type B vent piping shall be used only with approved gas appliances that are not required by the preceding paragraph to be vented to type A flues. Approved gas appliances are listed in the "List of Inspected Gas, Oil, and Miscellaneous Appliances" of Underwriters' Laboratories, Inc. Type B vent piping should be installed with a clearance to combustible material or construction, whether plastered or unplastered, of not less than 1 in, provided that for vents of floor furnaces, water heaters or space heaters such clearance shall be not less than 3 in for a distance of not less than 3 ft from the outlet of the draft hood, measured along the center line of the vent piping. Type B vent should be protected from mechanical injury where it extends through walls, floors or roofs. Type B vent piping shall be made gas tight at the joints and shall not be used with solid or liquid fuel burning appliances.

Other Vent Piping. Vent pipes of sheet copper of not less than 24 U.S. gage or of galvanized iron of not less than 20 U.S. gage, or of other approved corrosion-resistant material, may be used for runs directly from the space in which the appliance is located through a roof or exterior wall to the outer air. Such vent pipes shall not pass through any attic or concealed space, nor through any floor or partition. Vent piping other than approved type B shall not pass through combustible walls or partitions unless they are guarded at the point of passage by double metal ventilated thimbles not less than 4 in larger in diameter than the pipe, with the annular space filled with approved non-combustible insulating material; or in lieu of such protection all combustible material in the wall or partition shall be cut away from the vent pipe a sufficient distance to provide the clearance required from such vent pipe to combustible material. Any material used to close such opening shall be non-combustible. Clearances from combustible material to gas appliance vent piping, other than approved type B vent piping, shall be as required for vent pipes in the National Board of Fire Underwriters' Building Code, Art. 12, Secs. 1201 to 1207, incl.

Exhibit F

DETERMINATION OF THE VALUE OF DAMAGE OR LOSS OF STRUCTURES WHICH CAN BE COLLECTED IN CASE OF FIRE

General

A fire insurance policy is a contract between the insurer and the insured indemnifying the insured against damage or loss by fire to the property covered by the policy. The amount of fire damage or loss collectible is dependent upon the provisions set forth in the policy. The policy should be specific in so far as location, description and specific items to be included are concerned. Special provisions or exceptions in relation to the property insured should be covered by endorsement.

Fire insurance policies are written either with or without a co-insurance clause. The term "co-insurance" is in general use and provides that the insured is required to carry insurance equal to a certain percentage of the sound or cash value of the risk or structure insured. In some locales the terms "average", "reduced rates", "contribution", and "reduced rate contribution" are used instead of "co-insurance". A great number of standard fire insurance policies are written with an 80 percent co-insurance clause. In some instances 90 percent is used. When policies are written without co-insurance, fire damage or loss is collectible on the basis of proven sound or cash value, or present worth, but not in excess of the face value of the policy covering the risk. Co-insurance should not be considered the same type of insurance coverage which introduces the term "deductible". This latter form of insurance applies only to those policies wherein it is defined that the insured will assume an initial declared percentage or amount of loss before the insurer is required to make good an amount equal to but not to exceed the face value of the policy.

The foregoing few remarks preface the subject to impress upon each and everyone the importance of purchased insurance and what it means to all in so far as it relates to collectible fire loss.

Appraisals

a. The methods of determining fire damage, or fire loss, are few. The most logical method to be followed in adjusting a fire damage or loss is to prepare a detailed statement or appraisal based on the prevailing cost of labor and material at the time of the fire to reproduce the damage or loss in kind. Many appraisals for losses in the average railroad structure are made using the net cost of labor and material on the basis of railroad company forces doing the work of reconstruction, plus a reasonable overhead for handling material, such as stores department charges, and a percentage chargeable to the net cost of labor to take care of supervision, vacations, Social Security and other incidentals.

It is advisable at times to have a contractor who is familiar with railroad building construction and requirements to prepare the appraisal. This is particularly true when the railroad does not have the costs of labor and material for reconstruction or replacement available, or when the structure is designed with unusual and special features. An appraisal by a contractor should be as complete as if the estimate was prepared as a contract proposal to do all work in connection with repairing or restoring the facility in kind to its original design and condition as of the date of fire. The following costs, to suggest a few, should be included: Supervision, overhead, profit, engineering, architect's fees, permits, premiums for fire, public liability and property damage insurance, premiums for bonds, temporary work and protection, cleaning up and removing refuse and debris, and railroad company force work. When a total loss occurs, the cost involved in clearing the site is not a collectible item.

b. Appraisals are also made on the basis of a unit price per square foot of floor area, or by the cubic foot method. There is always a possibility of inaccuracy in using either formula unless the appraiser or estimator has had broad experience in their application. He must use square foot or cubic foot prices which have been derived from building data similar in design, construction and apportionment to the structure which has been damaged or destroyed and for which the estimated reproduction cost is being prepared. For example, a warehouse four stories high having 1000 sq ft of area per floor, equipped with a freight elevator and provided with one toilet facility on each floor, would cost more per square foot or cubic foot than a warehouse four stories high having an area of 10,000 sq ft per floor and equipped with a similar type and capacity of elevator and a toilet facility having the same type of construction, finish and number of fixtures. Unit prices based on costs of structures having similar construction, size, and mechanical and electrical equipment may be used in appraisals on a square foot or cubic foot basis with some degree of accuracy, otherwise the appraisal will result in arguments and indecision between the insured and the adjusters representing the insurance companies.

c. A reasonably accurate estimate of reproduction, particularly in case of total loss, can be made by taking the net area of roof, walls, and floors, and pricing these areas based on the unit prices of materials and labor used in the various assemblies of construction. Special construction or finish such as balconies and stairways are generally priced separately. Lighting outlets, plumbing fixtures and elevators are estimated on a unit-price basis, dependent upon quality and number of units. Heating can be estimated at a unit price per square foot of radiation.

Appraisals which are questionable as to reasonable accuracy using the unit price per square foot of floor area, or a cubic-foot method, may be checked with little more effort by preparing an estimate on the above basis.

Depreciation

An accurate reproduction cost is important, but a reasonable depreciation to arrive at the amount collectible under the terms of the policy is of much more importance both to the insurer and insured. Reproduction cost should always be representative of what was actually damaged or destroyed by fire, and not on what construction or design is proposed or contemplated in replacements. Depreciation for insurance purposes reflects the loss in value of structures due to wear and tear, taking into consideration maintenance, rehabilitation, and use and occupancy during the life of the structure. For instance, a frame building which is painted at regularly scheduled periods, say three to five years, does not depreciate in the same degree as a similar structure where painting is neglected for indefinite periods. Again, the facilities in a passenger station consisting of waiting room, ticket office, rest rooms and toilet facilities which were a part of the structure when originally erected, may be renovated to meet the general modernization trend. The use and occupancy of a structure, such as a freight house or warehouse where heavy loads are handled on dollies, trailers and like equipment, requires constant maintenance of floors and, in many instances, full replacement in kind, or with improved construction, which by experience has proven less susceptible to wear and tear. Such improvements tend to appreciate the current sound or cash value of the structure and are reflected in the proper depreciation to apply. Age alone is not the factor by which depreciation for fire insurance purposes is determined, but is greatly affected by many conditions, some of which are cited above.

Report on Assignment 2

Specifications for Railway Buildings

S. E. Kvenberg (chairman, subcommittee), O. W. Stephens, F. H. Alcott, C. M. Angel, G. A. Belden, E. Christiansen, C. E. Close, L. H. Corning, L. B. Curtiss, R. L. Fletcher, H. C. Lorenz, B. M. Murdoch, J. T. Schoener, E. W. Scripture, Jr., J. E. South, O. G. Wilbur.

Your committee submits this specification for information, looking to subsequent inclusion in the Manual.

SPECIFICATION FOR APPLICATION OF ASBESTOS–CEMENT ROOFING SHINGLES

1. General

The contractor shall furnish all labor, material, tools and equipment needed to entirely complete the application of asbestos–cement roofing shingles of a color and type designated or approved by the architect or owner, including all valleys, flashing, eave starters, hip and ridge sections or ridge roll as specified or shown on drawings.

2. Types

a. *American Method (Individual Units).* Rectangular in shape, uniform in thickness, and laid with head cap. Can be laid where minimum roof pitch is 4-in rise per foot of horizontal run.

American Method (Multiple Units). Exposed part of shingle rectangular in shape, but unexposed area may be triangular or of other design according to manufacture. Uniform in shape and laid with head lap. Multiple units give appearance of single units when applied. Can be laid where minimum roof pitch is 4-in rise per foot of horizontal run.

b. *Dutch or Scotch Method.* Either rectangular or square in shape, uniform in thickness, and laid with head and side lap. Can be used where minimum roof pitch is 5-in rise per foot of horizontal run.

c. *French or Hexagon Method.* Uniform in thickness and laid with diagonal of shingle perpendicular to eave with apex sides lapped. Can be used where minimum roof pitch is 5-in rise per foot of horizontal run.

3. Materials

Shingles and supplementary shapes shall conform to current ASTM Specification, designation C–222.

4. Storage

To prevent discoloration or blooming, asbestos–cement shingles packed in bundles must be kept absolutely dry before application. They shall not be stacked over four bundles high and, if piled outside, they shall be stacked on raised planks to keep them off the ground, and covered with roofing felt, waterproof paper or a tarpaulin so that no water may reach them.

5. Preparation of Roof Deck

The roof decking shall be laid tight and be completely dry. Nail heads must be driven down and high spots and edges drawn down. All rubbish, nails, chips, and other foreign matter shall be removed before application is started. Wood cant strips of same thickness as the shingles shall be applied flush with the lower edge of eave to give proper pitch to shingles, and a nailing strip not over 2 in wide, and the same thickness as shingles, shall be applied on each side of the apex of the hip and ridge to provide a base for nailing hip and ridge covering.

6. Underlayment Sheet

Water-repellent asphalt-saturated felt, permeable to water vapor and weighing not less than 15 lb per 100 sq ft, shall be used as underlayment sheet. It shall be laid horizontally with 4-in lap and with 12-in lap on ridges, hips and valleys. Coal-tar saturated felt is not suitable or permissible for underlayment sheet.

7. Flashing

a. Vertical. All vertical flashing shall be of a corrosion-resistant metal, excluding aluminum. Base flashing shall be carried up along walls and chimneys not less than 4 in, and out over the roof deck not less than 4 in, with lower edge folded ½ in for rigidity. Exposed base flashing shall be secured with metal cleats 12 in on centers. Cap flashing shall overlap base flashing not less than 4 in, and individual pieces shall lap each other not less than 3 in. Cricket flashing shall be carried up under shingles not less than 6 in, and folded ½ in at the edge. Where cricket flashing laps base flashing, seams shall be soldered.

b. Valley. All valley flashing shall be a corrosion-resistant metal, excluding aluminum. It shall extend out on roof deck not less than 4 in beyond overlapping edge of shingles on both sides, with the edges turned back ½ in. It shall be attached to the roof deck with metal cleats 12 in on centers. Shingles shall be bedded down in a layer of asphalt long-fibered asbestos plastic cement for a distance of 6 in back from the edge where they end in the valley.

8. Nails and Fasteners

Nails shall have flat heads substantially larger than the diameter of the holes in the shingles, and the shank shall be not larger than 0.142 in. They shall be of such length as to penetrate not less than ¾ in into the deck lumber, and shall be of corrosion-resistant, nonstaining metal readily bendable, and in accordance with current ASTM Specification, designation C–222. On non-wood decks, special fasteners of an approved design shall be used.

9. Laying Shingles

The shingles shall lay smoothly and no attempt shall be made to stretch the courses. They shall be laid so that vertical lines are parallel with each other and at right angles to the eave. The shingles that verge along the hip and ridge nailing strip shall be cut to a close fit, after which a water-tight joint will be made with the best quality asphalt long-fiber asbestos plastic cement. Each piece of ridge roll or hip and ridge finishing piece shall then be securely nailed and cemented where they lap each other. No broken or cracked shingles shall be used, and any shingle showing breaks or cracks after application shall be removed and replaced. After completion of the work, the roof and ground surrounding the site shall be left clean of all roofing debris.

10. Guarantee

The roofing contractor shall furnish an unqualified guarantee, with good and sufficient bond covering the maintenance of the roof in a water-tight condition for a period .... years from date of completion.

11. General Conditions

All materials entering into the work and all methods used by the contractor shall be subject to the approval of the engineer in charge, and no part of the work will be considered as finally accepted until all the work is completed and accepted.

The General Conditions, as given in Part 1, this Chapter, shall be considered to apply with equal force to this specification.

Report on Assignment 5

Pile Foundations for Railway Buildings

Collaborating with Committees 7 and 8

L. B. Curtiss (chairman, subcommittee), R. R. Cahal, J. S. Cooper, L. H. Corning, M. L. Koehler, H. C. Lorenz, E. W. Scripture, Jr.

Your committee submits this specification as a final report for subsequent adoption and inclusion in the Manual.

SPECIFICATIONS FOR PILE FOUNDATIONS FOR RAILWAY BUILDINGS

1. General

The contractor shall furnish all labor, materials, tools and equipment, except as otherwise noted, necessary to entirely complete the pile foundation work specified or as shown on or implied by the drawings. For specifications for and the driving of concrete piles and steel piles, see AREA Manual, Chapter 8, Specifications for Pile Foundations.

2. Basis of Contract

The contractor shall be paid for furnishing, driving and cutting off piles at the unit price per foot provided in the contract for the aggregate lengths of the piles driven, measured from tip to cut-off. No payment shall be made for rejected piles.

3. Timber Piles

Timber piles shall conform to the Specifications for Wood Piles, AREA Manual, Chapter 7.

4. Preservative Treatment

Where plans provide for treated piles, seasoning and treatment shall conform to the specifications in AREA Manual, Chapter 17. The contractor shall secure approval from the engineer of the particular method of treatment to be employed.

5. Storage and Handling

Piles shall be handled and stored so that none will be damaged, and care shall be used to avoid dropping or bruising the piles. Treated piles shall be handled with rope slings and the use of sharp pointed tools is prohibited.

6. Driving

Each pile shall be located accurately as shown on the drawings, and driven without delay or interruption from start of driving to its final penetration. Bearing piles shall be driven to such penetration that each pile will, in the opinion of the engineer, have minimum safe capacity for the design load. In the event that the contractor elects to use water jets in connection with pile driving, the jets shall be withdrawn before the desired penetration is reached and the hammer only used for final penetration.

Remove each pile damaged in driving or if out of line so that some portion of the pile is not within the center line shown on drawings, and drive another pile in its place. If defective pile cannot be removed, drive another pile as close as possible to location shown on drawing.

Protect butt of pile with an approved cushion cap, and band piles showing indication of crack. The contractor may sharpen and head piles to fit driving cap. Piles may be sharpened to 5 in square point at tip if necessary to secure satisfactory driving penetration.

7. Equipment for Driving

The use of steam or air hammer, or gravity drop hammer, is permitted.

Minimum weight of ram of single-acting hammer shall be such as will develop at least 6000 ft lb of energy per blow. Steam boiler or air compressor capacity shall meet pile hammer manufacturer's recommendations and maintain uninterrupted operation of pile hammer at manufacturer's rated number of blows per minute. Take special care during last few blows so that ram of single-acting hammer makes its full upward movement in order that correct load bearing capacity may be properly determined.

Minimum weight of drop hammer shall be 2000 lb, minimum fall of drop hammer to be 15 ft free fall, maximum fall to be so regulated as to avoid injury to pile.

Leads shall be used for all pile driving. They shall have steel or steel-lined hammer guides arranged to allow free movement of the hammer, and shall be such as to hold and guide the pile for correct location and driving. Swing leads shall not be used except as may be directed by the engineer.

8. Bearing Capacity

The safe bearing capacity of piles shall be determined by the methods described under appropriate sections in the Specifications for Pile Foundations, AREA Manual, Chapter 8.

Test piles shall be driven if deemed advisable by the engineer. Payment for test piles will be made at the contract unit price for piles below cut-off.

9. Cut-Off

Each bearing pile shall be cut off to a level plane at the elevation shown on the drawings. Where treated piles are used, the cut-offs, unless encased in concrete, shall be protected by a method approved by engineer.

The cut-off butts shall become the property of the contractor and shall be removed from the site and disposed of by him.

10. General Conditions

All materials entering into the work and all methods used by the contractor shall be subject to the approval of the engineer, and no part of the work shall be considered as finally accepted until all the work is completed and accepted.

Report on Assignment 6

Modernization of Station Buildings

J. J. Schnebelen (chairman, subcommittee), H. M. Booth, J. S. Cooper, C. O. Coverly, C. E. Defendorf, R. V. Hazer, J. F. Hendrickson, M. L. Koehler, S. E. Kvenberg, W. C. Oest, J. T. Schoener, S. G. Urban.

This progress report is submitted as information, and consists of a bibliography on subjects pertaining to the modernization of station buildings, supplementing a previous progress report by the committee appearing in the AREA Proceedings, Vol. 52, 1951, pages 293–299.

BIBLIOGRAPHY

Modernized arrangement and appearance of Pennsylvania R. R. Station, Trenton, N. J.—Railway Age, 1938, June 4, p. 938.

Escalators—Moving stairs for stations—AREA Proc, Vol. 39, 1938, p. 222.

Rail and bus station—Brownsville, Tex., Mo. Pac. Ry.—Railway Age, 1938, June 25, p. 1056.

Parking facilities—Handling baggage between cabs and trains—Engr. News, 1938, Mar. 31, p. 479.

Large stations built or remodeled since 1923—AREA Proc., Vol. 39, 1938, p. 223.

Modernized station facilities for modern train service—AREA Proc., Vol. 39, 1938, p. 37. Railway Age, 1938, May 7, p. 803.

Small stations of low cost and unusual design—Railway Age, 1938, Apr. 16, p. 708.

Small stations modernized—CMStP&P—Railway Engineering and Maintenance, 1937, Apr., p. 280.

Lighting of platforms—Railway Gazette (London), 1938, Dec. 30, p. 1131.

Parcel handling by belt conveyors—Railway Gazette (London), 1938, Oct. 28, p. 728.

Platform shelter—steel—Los Angeles Union Station—Railway Age, 1939, May 6, p. 774.

Escalators and Moving Stairways—AREA Proc., Vol. 40, 1939, p. 250.

Moving stairways King's Cross Station—Railway Gazette (London) 1939, June 23, p. 1006.

Modernizing stations to meet changed conditions and requirements—American Railway Bridge & Building Assn. Proc., 1938, p. 61—Railway Age, 1939, Jan. 7, p. 27, July 22, p. 132.

Waiting rooms—Railway Gazette (London), 1939, July 14, p. 42.

Design to speed commuter traffic—Architectural Record, 1939, July, p. 30.

Modernizing old stations for appearance, comfort and convenience—American Railway Bridge & Building Assn., Proc., 1939, p. 181.

Modernizing waiting room and other facilities—Railway Age, 1939, p. 751.

Improvement and modernizing of terminal station, Minneapolis, Minn., CMStP&P—Business Week, 1939, Dec. 23, p. 24—American Railway Bridge & Building Assn., Proc., 1940—Railway Age, 1941, Jan. 11, p. 137.

Belt conveyor for handling mail and baggage between train and car ferry at Larne, Ireland—The Engineer (London), 1939, Nov. 24, p. 254.

Modernizing old stations—Union Pacific—Railway Engineering and Maintenance, 1939, Oct., p. 584; 1940, Jan., p. 38, Feb., p. 91.

Railroad design to speed commuter traffic—Architectural Record, 1939, July, p. 30.

New station—La Crosse, Wisc.—CB&Q—Architectural Forum, 1940, May, p. 323.

Floor construction of various materials for railway stations—MKT—Railway Engineering and Maintenance, 1940, Aug., 511 & 521.

Comparison of different platform materials—American Railway Bridge & Building Assn. Proc., 1939, p. 189.

Washing exterior of terminal station—Illinois Central—Railway Engineering and Maintenance, 1941, Aug., p. 541.

Escalators—Chicago Rapid-Transit subway—Journal, Western Society of Engineers, 1941, pp. 62, 67.

Escalators—London underground railways (80-ft rise)—Railway Gazette (London), 1941, July 4, p. 2.

Escalators—New York 6th Avenue subway—Transit, 1941, Feb., p. 52.

Stations on 6th Avenue subway—New York—Transit, 1941, Feb., p. 51.

Modernizing interior of station 50 years old—Rochester, Minn.—C&NW—Railway Age, 1941, Mar. 15, p. 458—Railway Engineering and Maintenance, 1941, Apr., p. 276.

Lighting by fluorescent light—American Railway Bridge & Building Assn. Proc., 1940, p. 117.

Modernizing old stations, large and small—Railway Age, 1940, Nov. 16 & 30, pp. 749, 830, 915; 1941, Jan. 11, p. 137, Mar. 1, p. 380, Mar. 15, p. 458—Railway Engineering and Maintenance, 1940, Dec., p. 882; 1941, June, pp. 406, 425, Nov., p. 797—American Railway Bridge & Building Assn. Proc., 1940 & 1941—New York Railroad Club Proc., 1940.

Station reconstruction and modernizing—Hudson, N. Y.—NYC—Railway Engineering and Maintenance, 1941, Jan., p. 30.

Modernized station 72 years old—Lafayette, Ind.—Wabash—Railway Age, 1941, Mar. 1, p. 380.

Relative merits of wood, tile, brick, concrete, etc., for small stations—Railway Engineering and Maintenance, 1941, May & Nov.

Paving for platforms, driveways and floors—American Railway Bridge and Building Assn Proc., 1941—Railway Engineering and Maintenance, 1941, Nov., p. 800.

Skylight roof over concourse—Montreal—CPR—Railway Age, 1941, Jan. 25, p. 216.

Modernizing and deferred maintenance—American Railway Bridge & Building Assn. Proc., 1941—Railway Engineering and Maintenance, 1941, Feb., p. 84.

Inspection, maintenance, heating and fire protection. Railway Age, 1940, p. 637—AREA Proc., Vol. 40, 1941, p. 106—American Railway Bridge and Building Assn. Proc., 1940, pp. 135, 165.

Comparison 1891—1941 type station—Architectural Record, 1941, Jan., p. 133.

Cleaning exposed masonry surfaces—American Railway Bridge & Building Assn. Proc., 1942—Railway Engineering and Maintenance, 1942, Nov., p. 830.

Design of railway structures—Railway Engineering and Maintenance, 1941, Nov., p. 809.

Platforms floors & driveways (wearing surfaces)—American Railway Bridge and Building Assn. Proc., 1942—Railway Engineering and Maintenance, 1942, Nov., p. 824. Modernizing of six stations—Missouri Pacific—Railway Age, 1942, Jan. 31, p. 299.

Defects in station design due to designers' unfamiliarity with railway station operation—Railway Age, 1942, Sept. 19, p. 454.

Modernizing small stations—American Railway Bridge & Building Assn. Proc., 1941—Railway Age, 1941, Oct. 25, p. 664—Railway Engineering and Maintenance, 1941, Nov., pp. 797, 809.

Small station of modern design—Erie—Railway Engineering and Maintenance, 1941, Oct., p. 681.

Original layout and modernization—Boston South Sta.—AREA Proc., Vol. 43, 1942, p. 153.

Modernized station 50 years old—CStPM&O—Railway Age, 1942, June 20, p. 1186.

Modern station design of the Southern Pacific—Railway Age, 1942, Aug. 22, p. 296.

Fluorescent lighting—Washington Union Station—Railway Age, 1942, July 25, p. 134.

Station of modern design—Las Vegas, Nev.—Union Pac.—Railway Age, 1942, Mar. 28, p. 670.

Station modernization—inside and out—C&NW—Railway Age, 1942, Apr. 11, p. 84.

Modernization of Minneapolis station—CMStP&P—AREA Proc., Vol. 43, 1942, p. 155.

Platform Shelters versus Large Train Sheds. AREA Proc., Vol. 43, 1942, p. 157.

Moving stairs and ramps (escalators)—AREA Proc., Vol. 43. 1942, p. 152.

Platforms of Seaboard new station at Raleigh—Railway Age, 1943, June 26, p. 1259.

Inspection and safety of elevators and escalators—Mechanical Engineer, 1943, June, p. 433.

Lighting passenger platforms for safety—Railway Age, 1943, June 12, p. 1167, June 26, p. 1249.

Modernizing present stations—AREA Proc., Vol. 44, 1943, pp. 223, 349, 681—Railway Age, 1942, Nov. 14, p. 780; 1943, Apr. 10, p. 711.

Loudspeaker train announcements at stations—Railway Gazette (London), 1943, Jan. 8, p. 54, and July 30, p. 121—Canadian Transportation, 1943, Feb., p. 53.

Mission style stations—MKT and IGN—Railway Age, 1943, Apr. 17, p. 785, May 1, p. 858.

Building types study on railroad stations—Architectural Record, 1943, Dec., p. 85.

Railroad station details—Architectural Record, 1943, Dec., p. 107.

New station—Burlington, Iowa—CB&Q—Architectural Record, 1943, Dec., p. 102.

Contracting for repair work—Railway Engineering and Maintenance, 1944, July, p. 309.

Modernizing St. Louis union station—TRRA of StL—Railway Age, 1944, Aug. 26, p. 330.

Modernizing Austin, Minn., station—CMStP&P—Architectural Record, 1943, Dec., p. 105.

New possibilities in building design and materials—Railway Engineering and Maintenance, 1944, Nov., p. 1045.

Modernizing of union station—St. Louis, Mo.—Railway Age, 1944, Aug. 26, p. 330.

Modernizing of station—Austin, Minn.—CMStP&P—Architectural Record, 1943, Dec., p. 105.

Stations as a neglected architectural opportunity—Architectural Record, 1943, Dec.

Design and modernization of stations—Railway Age, 1944, Mar. 11, p. 496; Sept. 6, p. 410—American Railway Bridge and Building Assn. Proc., 1943—Railway Engineering and Maintenance, 1943, Nov., p. 872; 1944, Jan., p. 46.

Two new stations—PRR—Architectural Forum, 1943, May.

New lighting system—LaSalle Street Station—Chicago, CRI&P—Railway Mechanical Engineer, 1944, May, p. 233.

Loud speakers on platforms of subway stations—Long Island R.R.—Railway Age, 1944, May 6, p. 871.

New rail and bus station—Burlington, Iowa—CB&Q—Architectural Record, 1944, Oct.—Bus Transportation, 1944, Dec.

Modernistic design—Midland—CNR—Canadian Transportation, 1944, Dec., p. 641.

New Station—Montreal, Que.—CNR—Railway Age, 1945, Mar. 31, p. 587; Sept. 22, p. 271—Railway Gazette (London), 1944, Sept. 22, p. 271, July 6, p. 15—Canadian Transportation, 1944, Sept., p. 467, Oct., p. 532, Nov., p. 586, 1945, May, p. 239.

Painting interior of Grand Central Station—New York—Railway Engineering and Maintenance, 1945, Sept., p. 874.

Colors for waiting rooms—Railway Engineering and Maintenance, 1945, July, p. 684.

Remodeling and modernizing station—DeWitt, Iowa—C&NW—Railway Engineering and Maintenance, 1945, Jan., p. 63.

New developments in interior painting—Railway Engineering and Maintenance, 1945, Nov., p. 1149.

Modernization of station buildings—AREA Proc., Vol. 44, 1943, p. 223.

Plastics in building work—Railway Engineering and Maintenance, 1945, Dec., p. 1290.

Lounge in women's rest room—Union Station—Chicago—Railway Engineering and Maintenance, 1946, Sept., p. 940.

Aluminum roof for union station—Cincinnati, Ohio—Engineering News—Record, 1946, Apr. 11, p. 515—Railway Age, 1946, June 1, p. 1109—Railway Engineering and Maintenance, 1946, June, p. 630.

New rail and bus station—Burlington, Iowa—CB&Q—Architectural Record, 1944, Oct.—Bus Transportation, 1944, Dec.

Illuminated signs in union station—Washington, D. C.—Railway Age, 1945, June 9, p. 1032.

Nursery in union station—Chicago—Railway Age, 1945, Mar. 17, p. 525.

Modernizing obsolete structures—Railway Engineering and Maintenance, 1945, Oct., p. 1000.

New developments in interior painting—Railway Engineering and Maintenance, 1945, Nov., p. 1149.

Plastics in building work—Railway Engineering and Maintenance, 1945, Dec., p. 1290.

Modernizing stations—Railway Age, 1945, Oct. 6, p. 553.

Color Dynamics—AREA Proc., Vol. 47, 1946, p. 114.

Innovations in small stations on the C&O—Railway Engineering and Maintenance, 1946, Aug., p. 842.

Stucco on old stations—Railway Engineering and Maintenance, 1946, Sept., p. 953.

What about our railroad stations—by J. C. Sherrick—American Railway Bridge and Building Assn. Proc., 1946, p. 15.

Modern architecture and materials for stations—Railway Age, 1946, Dec. 7, p. 952.

Modernizing Fort St. union station—Detroit, Mich.—Railway Age, 1946, Feb. 2, p. 290.

Aluminum roof for union station—Cincinnati, Ohio—Engineering News Record, 1946, Apr. 11, p. 515—Railway Age, 1946, June 1, p. 1109—Railway Engineering and Maintenance, 1946, June, p. 630.

Modernizing union station—Montgomery, Ala.—Railway Age, 1946, June 8, p. 1139.

Colors for painting stations—Railway Engineering and Maintenance, 1946, p. 524—AREA Proc., Vol. 47, 1946, p. 114.

Prefabricated design for small stations—Railway Age, 1946, Jan. 5, p. 61, June 15, p. 1183—Bus Transportation, 1946, June, p. 97.

Modernizing station for the Atlantic Coast Line—Railway Age, 1946, Mar. 23, p. 633.

Station Parking Facilities—AREA Proc., Vol. 48, 1947, p. 292.

Modernizing methods—Railway Age, 1946, Dec. 7, p. 952, Dec. 21, p. 1040; 1947, Jan. 4, p. 18, Feb. 15, p. 354, Apr. 19, p. 792, May 24, p. 1086—Railway Engineering and Maintenance, 1946, Nov., p. 1186; 1947, Apr., p. 385, May, p. 495, July, p. 678.

Radiant heating in new station of C&O—Railway Age, 1947, Sept. 6, p. 54—Railway Engineering and Maintenance, 1947, Sept., p. 868.

Modernizing Dearborn St. terminal—Chicago—Railway Age, 1947, July 19, p. 94.

Modernizing the Burlington Station—Dubuque, Iowa—Railway Engineering and Maintenance, 1947, July, p. 678.

Air conditioning bus terminals—Bus Transportation, 1947, May, p. 70 and 94, Aug. p. 50.

Station design and passenger handling—Railway Age, 1946, Nov. 16, pp. 836, 845.

Ticket office improvements—Railway Age, 1946, Nov. 16, p. 826.

Utilization of new types of materials in buildings—Railway Engineering and Maintenance, 1947, Nov., p. 1110.

Materials for interior walls—Railway Engineering and Maintenance, 1947, Apr. p. 401.

Modernizing small stations—Railway Engineering and Maintenance, 1947, May, p. 495.

Station and office building—Willmar, Minn.—GN—Great Northern Goat, Mag., 1948, Dec., p. 12.

Modern station—Ephrata, Wash.—GN—Great Northern Goat, Mag., 1948, Dec., p. 13.

Colors for interiors—Railway Engineering and Maintenance, 1948, Feb., p. 164.

Ticket office—Los Angeles, Calif.—Santa Fe—American Builder, 1947, June, p. 154.

New Erie passenger station—Akron, Ohio—Railway Age, 1947, Oct. 18, p. 123,

New Washington ticket office—B&O Magazine, 1948, July.

Lockers, source of additional revenue—Bus Transportation, 1947, Oct., p. 26, 100.

Railroad architecture in Europe—J. L. Martin—Architectural Record, 1948, Oct., pp. 104, 130.

Railroad building types-study-diagrams—Architectural Record, 1948, Oct., pp. 104, 122.

Revamping gives old station new look—Fort St. Union Depot, Detroit, Mich.—O. E. Hager—Railway Age, 1948, Aug. 28, pp. 125, 412.

Sanitary facilities and appurtenances—Railway Engineering and Maintenance, 1948, Nov., p. 1182.

Passenger and freight depot—Morris, Minn.—GN—Great Northern Goat, Mag., 1950, Feb., p. 7.

New streamlined station—Sioux Center, Iowa—GN—Great Northern Goat, Mag., 1950, Jan., p. 9.

Modernized station—Kerkhaven, Minn.—GN—Great Northern Goat, Mag., 1950, Mar., p. 7.

Modernized station—Robbinsdale, Minn.—GN—Great Northern Goat, Mag., 1950, April, p. 7—Railway Engineering and Maintenance, 1949, Aug., p. 769.

Modern motif is feature of new station at Akron, Ohio—Railway Age, 1950, June 10, p. 1130.
Systematic station modernization program—T&P—Railway Age, 1950, June 24, p. 1234.
Stations designed to fill the bill—Railway Age, 1949, Oct. 29, p. 750.
Stations please passengers—Railway Age, 1949, Nov. 19, p. 914.

Report on Assignment 9

Air Conditioning

J. W. Gwyn (chairman, subcommittee), C. M. Angel, W. F. Armstrong, C. E. Booth, D. W. Converse, J. F. Hendrickson, Earl Kimmel, J. T. Schoener, W. E. Webb, T. S. Williams.

Under this assignment the committee this year presents a report on Simplified Design of Small Air-Conditioning Installations Utilizing Package Air Conditioners, which is offered as information.

Simplified Design of Small Air-Conditioning Installations Utilizing Package Air Conditioners

The computations of an air-conditioning engineer often seem highly involved to an engineer of railroad buildings or to a railroad architect. Most frequently these computations deal with the amount of air conditioning required in a given cubical space. For the unusual application of a large installation, the rather involved computations of a specialist are essential, but many smaller railroad building air-conditioning installations can be designed intelligently on a simplified basis. The majority of railroad buildings undergoing air conditioning are used for office purposes and contain less than 45,000 cu ft. The air conditioning of such buildings should not necessarily require the services of an air-conditioning specialist.

Generally, this type of building can best be served by a mechanical "Package Air-Conditioning Unit". By a package unit is meant compressor, condenser, expansion valve, evaporator coil, and blower—all built into one cabinet and designed for coordinated operation. This machinery is rated in "tons" capacity, one ton representing an affinity for 12,000 Btu of heat per hour, and also about 1 hp to operate the compressor. Package units are generally built in 15, 10, 7½, 5, 3, 2, and 1½-ton sizes, with so-called "single room conditioners" in the 1-ton and ¾-ton sizes.

In the design of air conditioning for offices or public rooms, it may be estimated that each square foot of floor space will incur a 40 Btu heat regain per hour, making about 300 sq ft of area per ton of refrigeration. This figure applies to most of continental United States where summer design temperatures of 95 to 100 deg occur, and where a maximum difference of 15 deg between inside temperature and outside air temperature should be used.

The quantity, 40 Btu per sq ft, may be applied to two-story buildings, but qualification must always be made that there be a 3-in minimum thickness of insulation directly above the upper (or only) ceiling. It is also imperative that all windows (except those to the north) be equipped with either dark shades, venetian blinds, or (best) awnings. If a building can economically justify air conditioning, then measures to reduce the proportionately large solar heat regains from windows and roof can also be justified. Mention hardly need be made that unlined frame buildings, and especially unlined steel buildings, are unsuitable for air conditioning.

In the use of this method of figuring air-conditioning requirements, care must be taken to add any internal heat regains. Cooking processes, heaters, motors, or daytime lighting must be reduced to Btu's and added in such terms. If the electrical characteristics can be known on a kilowatt basis, then the heat emission rate of the equipment is 3400 Btu per kw-hr.

Another internal heat regain, the sensible and latent heat coming from a large crowd of people, generally merits evaluation by the air-conditioning engineer. The typical small railroad building, however, is not often crowded in the sense that a theater or school is crowded, and for simplified design the factor of room occupancy may often be neglected. If, by neglecting occupancy, a design provides an inadequate supply of conditioned air to an occasional closeted squad of smokers, the error probably can be corrected in one of several different ways without undue expense.

It is not customary to air condition toilet rooms, locker rooms, storage rooms, and most hallways, but whenever heating coils are incorporated in an air-conditioning package unit to provide year around air conditioning to a building or a group of rooms, it may nevertheless be wise to include in the air-conditioning system a toilet room or hallway. The cost of a separate piping or ductwork system to provide winter heating without air conditioning to an isolated room may often become an investment many times greater than the additional cost of extending the air conditioning to include the isolated room.

Buildings such as interlocking or communication towers, with large unprotected areas of glass exposed to the sun, usually require study by an air-conditioning engineer. A major factor in determining the heat regain in an installation such as this is the solar heat through glass at a given time of day, and with the sun at a given angle normal to the glass. Ways of overcoming solar radiation through large glass areas include the use of heat-resistant glass and the construction of a very wide roof overhang.

The location of an air-conditioning unit is preferably outside of the air-conditioned space; however, it is often difficult or impossible to so locate it. Each manufacturer may point with pride to the quiet operation of his conditioners, but the allowable noise level in railroad office space is low and motor hum has been found objectionable in dispatchers' and communications offices. Canvas duct connections have proven helpful in keeping mechanical noises from following ductwork. To locate the conditioner outside of the air-conditioned space involves ductwork which should be designed at an initial air speed of about 1000 ft per min through the supply duct, and at a final return air speed of about 500 ft per min.

The exact choice of location for the air-conditioning unit is related to existing water supply or cooling tower connections. The location of a sewer (or even better, a convenient means of utilizing the waste outflow from a condenser) is also a consideration in locating an air-conditioning unit. The location of the electric power supply, too, influences the location of an air-conditioning unit. In judging the electrical characteristics of a proposed alternating current supply, it is well to remember that three-phase current is much more economical than single phase.

To design ductwork it may be assumed there are 400 cfm of air per ton of refrigeration, and the proportion of outside air to recirculated air is variable, though sometimes taken as 25 percent of the total air. Some factors governing the proportion of outside air to recirculated air are: the outside relative humidity, quantity of dirt in the outside air, the occupancy of the building, and the presence of objectionable odors, such as smoke, within the building. An error in the designed quantity of fresh air is not an irreparable mistake as long as there is a fresh air-recirculated air damper to limit the supply of fresh air. If, however, the system is short of fresh air as evidenced by a constant objectionable odor, the slight opening of a window near a return air grille should introduce enough fresh air to improve conditions.

Air-conditioning units of the ¾-ton and 1-ton size, and some units of the 1½-ton size, have air-cooled condensers. These units require outside air to cool the refrigeration system as well as for ventilation. Some 1½-ton units, and all of the larger "package units", have water-cooled condensers. It is customary with the water-cooled units of 5-tons and under to waste the cooling water. The quantity of cooling water passing through the condenser in this case is limited, however, by the flow-control valve which passes only enough water to maintain approximately 100 deg at the outlet. At about 7½ tons of refrigeration, and in larger units, it becomes worthwhile to add a cooling tower to the system. With a cooling tower the condenser cooling water is recirculated after being sprayed through a slatted wooden structure in the presence of a current of outside air. Evaporative cooling of the warm cooling water thus takes place, although the cooling efficiency somewhat decreases with a rise in the relative humidity of the outside air.

The control of a package air-conditioning unit without special equipment is accomplished by a bulb thermostat in the air intake which cycles the compressor according to temperature requirements. Blower operation is constant. A graduated dial, effecting "off-cool-cold", generally gives accurate enough temperature adjustment when the unit is located within the air-conditioned space. However, a reverse snap-acting thermostat should be used to operate the compressor on the basis of room temperature in the conditioned space. In the operation of comfort cooling systems, the room temperature requirements vary with the outside temperature, whereas in winter air conditioning it is desirable to maintain a constant 72-deg temperature in office space. Customary comfort cooling design practice recommends an 85-deg room temperature with a 100-deg outdoor temperature (a temperature difference of 15 deg), yet with an 80-deg outdoor temperature, a room temperature of 75 deg is desirable if the inside relative humidity is not too high. Since no automatic resetting thermostat is yet available with a simplicity and low cost required for regular use with package air conditioners, the familiar fixed-setting thermostat furnishes automatic operation just as long as outside temperatures are constant.

Under present price levels, the cost of air conditioning with water-cooled package units can be expected to be between $500 and $700 per ton, depending on whether or not a cooling tower is used, the extent of ductwork (if any), the availability of existing utilities, and the prevailing labor costs. These unit prices do not apply to the "built-up" air-conditioning installations, which do a more precise job of air conditioning and which are consequently more expensive, nor do the prices apply to the air-cooled package units sometimes called "room air-conditioners", which generally cost less than the water-cooled units.

As a final word of advice to the designer of a package air-conditioning system, it is well to remember the importance of educating those who will be served by air conditioning. Great patience and tact will be necessary to broaden the thinking of those who insist that 72 deg is a healthful temperature which, moreover, must be maintained throughout the year. Also, difficult are the "cold-draft victims" who may have a truly just complaint for correction as an air distribution problem, or maybe just a dim outlook upon railroad officialdom. If it is possible to "sell" the good intentions of railroad management along with management's air-conditioning job to a disgruntled employee, a big step in improved labor relations has been taken, and the money spent for air conditioning has also purchased good will.

Contributions of Railroad Engineers to the Welfare of the Country Over the Last 100 Years*

By H. R. Clarke

Chief Engineer, Burlington Lines, Chicago

The Burlington has a line through the center of the Black Hills of South Dakota—Edgemont to Deadwood. There was another line, now abandoned, leaving this line at Englewood, not far from Deadwood, and ending at Spearfish, known as the Spearfish Canyon line. Both of these lines were practically mountain railroads, with heavy grades and sharp curves. Heavy and expensive work was involved in the construction of portions of the lines and both were scenic, particularly the Spearfish line.

When the late Daniel Willard came to the Burlington as operating vice president, he made an inspection trip over nearly the entire system. This included the lines in the Black Hills. One of the division officers in the party, who was very proud of the railroad, asked Mr. Willard on arrival at Spearfish what he thought of the railroad he had just come over. I am sure Mr. Willard's answer surprised him. It is said to have been, "I do not know the engineer who located and built that line, but I do know that if you were so foolish as to give him money enough he would build a railroad to Hell."

I cannot vouch for the truth of the story and I do not know whether it was a tribute to or a criticism of the engineer; but if true, it is evidence that Mr. Willard knew, and I am sure appreciated, the determination and perseverance that characterizes all efficient engineers.

It is difficult to define the science of engineering or to formulate a definition of an engineer. But I quote two definitions that I think are good:

> "Engineering is the art and science of utilizing materials and directing the forces of nature for the use and convenience of man."

> "An engineer is one who applies science in an effective manner to supply human needs and designs."

A definition not so formal, and which I like is:

> "An engineer is one who can do more with less and do it better and more quickly than can anyone else."

That, I think, summarizes what the railroad engineer has done and the conditions under which he did it. There never has been, and I fear there never will be, an engineer in railroad service who had half the money he knew he needed and which he knew he could use to great advantage.

The subject on which I have been asked to speak is broad and gives me a wide range. It includes all branches of engineering as practiced in railroad service—civil, mechanical, signal, electrical, chemical, and others of a more specialized nature.

Before attempting to say what each or all of these have contributed to the welfare of the country, we should first make sure we have clearly in mind the great contributions the railroads themselves have made. If I were so rash as to try to do justice to that subject, we would be here much longer than any of us want to be, but we might venture a brief review. We could sum it up in a very few words and say: The railroads made

* Presented as the feature address at the Railroad Engineering Banquet, Palmer House, Chicago, September 8, 1952, sponsored by the AREA as a part of its participation in the Centennial of Engineering.

possible, first, the creation, and second, the continued existence, of our country as it is today—one great, undivided nation.

The oldest railroad in the United States, the Baltimore & Ohio, has just celebrated its 125th anniversary; history tells us what our country was like when the B&O was started. If we adhere to the span of years of which I am supposed to speak and disregard the first 25 years of railroad performance and history, even 100 years ago the country was primitive and sparsely settled and we can hardly say it extended even to the Mississippi river. Compare that with the rich, prosperous and powerful country we have, and of which we are so proud today, and then answer the question—what made it possible? The answer is: dependable, fast, and cheap mass transportation to almost every part of the country, from the Atlantic to the Pacific, and from the Canadian border to the Gulf and the Rio Grande.

Even the most unfair and unfriendly critic will admit the railroads provided that transportation which was all important. Without it we would almost certainly have had on the North American continent several small and relatively weak countries competing and possibly fighting with each other, instead of the one great and powerful nation of which we are so justly proud.

If you will pardon a personal word, I cannot remember when I did not want to do the work I have been permitted to do for the past nearly 47 years; that is, be a civil engineer and work for a railroad. It is a wonderful thing to be granted the privilege, as I have been, of doing the work you love to do for that length of time. I will admit my early ideas of what the work would be were somewhat in error. I dreamed of building bridges across mighty rivers and of driving tunnels through majestic mountain ranges. What I did not then know was that I had been born at least 25 years too late.

While I have had a small part in building some railroad line I have had much more experience in taking up lines which were being abandoned because they no longer served any useful purpose.

The First 75 Years of Railroad History

Railroad history may, I think, be divided into two periods. The first 75 years was the period of location, construction, and building. In those years most of the present railroad mileage was built, the pattern was fairly well set. In the last 50 years there has been some extension of lines but, in general, this has been a period of improvement and refinement, and that applies both to the fixed properties and the rolling stock.

There is no question as to the contribution made by the engineer during the first period. In those years the profession was limited almost entirely to two branches—civil and the mechanical. The other branches had not yet come into the picture, at least, in any large way.

It was the responsibility of the civil engineer—and in this classification the structural engineer is always included—to locate and build the lines so they would best serve the purpose for which they were intended. Next only to the men who provided the money, he was the most important man in the railroad organization. How well he did the job assigned him is proven by the splendid way in which much of the mileage built in those early years has served our needs in these later times, when the demands made by speed, comfort, safety, heavy tonnage, and economy of operation have become so much greater and more exacting.

To appreciate fully the work of those pioneer engineers and builders we must keep in mind the facilities they had and the tools with which they worked. On location, they did not have the advantage of accurate contour maps, aerial photographs, etc.;

in fact, a good part of the country was not mapped at all or, at best, rather inaccurately. Surveying instruments were not the precision tools we have today, and the theory and science of location had to be developed as the work was being done.

Grading was generally done with teams and slip scrapers. It was a marvelous advance when the wheeled scraper, dump wagon, and elevator grader came into the field; in fact, many miles of road were built by station men with wheelbarrows and spades or shovels. Compare that with the equipment we now have and the way we move material today.

Next in importance after the civil engineer who located and built the railroads came the mechanical engineer. On him rested the responsibility for designing and building the equipment, the locomotives and cars, both freight and passenger, without which the best built road would have been useless. Here again was a job well done, progressing from the early, crude and inefficient locomotive and primitive cars to the reliable and fairly efficient locomotive and reasonably satisfactory cars, both freight and passenger, including the ornate so-called Palace Sleeping Car, as we knew them 50 years ago.

The mechanical engineer also contributed to the general over-all progress in that he assisted in designing and built much of the improved equipment used by the construction and maintenance engineer. It was only fair that he should so assist, as from the very beginning, up to recent years (and I am not sure it has ended yet), it has been a race between the engineering and mechanical departments. Every new engine that came out of the shop was larger, heavier, and more powerful than the one before, and the same applied to cars and to the loads they were capable of carrying. The construction and maintenance engineer then strengthened the fixed property, both bridges and tracks, to meet the new demands, but before he caught up larger and heavier equipment was ready and in use. Almost the only thing that remained fixed was the gage of standard track—4 ft 8½ in—and many times even that was not entirely secure.

Possibly the operating officers of those early years would not agree with the order of importance in the railroad organization as I have stated it, but I think it is fair and proper. The rating today should perhaps be different, as successful, efficient and economical operation under the conditions we face is much more difficult than it was even 50 years ago. Unfortunately, that is true even with all the help which all classes of engineers in railroad service can give the operating officer.

So we come to the end of the first period, 75 or 50 years as you prefer, during which the country was crossed and gridironed by the railroads—the era of expansion in which railroads made possible the settlement of the entire country and bound it together with bands of steel. It was the time of transition from a poor and sparsely settled pioneer territory, the very future of which was uncertain, to the time of a well developed, prosperous, progressive, and vigorous country, the future of which there was no doubt. As this development progressed the natural resources of the country were opened up, made available, used, and I regret to say, often abused. The value of land was multiplied many times and the wealth, both of the nation and of the individual, increased to an even greater extent.

All of this was made possible by the transportation provided by the railroads. This could have been provided in no other way, nor by any other means, at least at that time. Without the knowledge, skill, courage, and determination of the engineer in locating, building, and equipping the railroads, progress would have been much slower, the cost would have been much greater, and the results would have been much less satisfactory—if they could have been accomplished at all. Such is the contribution of the engineer in the first period.

The Last 50 Years of Railroading

We now enter upon the second period, the past 50 years, largely the time of improvement and refinement of the work so well started, and the era which many of us know from personal experience. Important as the first period was, this second span of years has been fully as essential as the first, both to the continued development of the country and to the continued existence of the railroads of our country as private enterprise. What has been accomplished and what has been the contribution of the engineer in this period?

Somewhat strangely, the second period of 50 years seems to fall into 2 distinct divisions of about 30 and 20 years each. During the first 30 years the railroad industry was still expanding. Some new territory was being developed. With periodic ups and downs business was increasing at the rate of about 10 percent per year and the railroads were keeping up, prepared to handle the increase. Double or multiple track was being built where needed, grades were being reduced wherever justified to increase operating efficiency and decrease expenses, and alinement was improved.

The track structure was gradually strengthened, roadbeds were widened where necessary, more ballast and ballast of better quality were put in, and drainage was given much more attention.

It was just about 50 years ago that the practice of treating ties and timber to prevent, or at least retard, decay was started. Progress was slow at first but treating methods and procedure were rapidly improved. However, the saving made possible by the use of treated material was quickly proven, and the use of treated ties in track and treated timber in bridges, and to some extent in buildings, soon became standard on nearly all roads. Today, practically all track and switch ties are treated, and the same applies to nearly all piling and timber used in bridges; also in buildings where conditions justify.

Improvements in treating methods and practices continued; ties were adzed, bored, and incised before being treated, the treated tie was protected with an adequate tie plate to reduce mechanical wear, and greater care was used in handling both ties and bridge timber. As a result the number of ties used per year was reduced from an average of over 300 to 100 or less per mile of track, and there was a similar saving in piling and bridge timber. A somewhat more recent development has been the very general treatment of poles for telegraph, telephone, and power lines, and the use of specially treated timber in buildings.

Possibly no single development has brought about as great a saving to the railroads, not to mention the great advantage to the entire country in the conservation of one of its most valuable resources, timber, as the use of treated ties and timber, for which the engineer is largely responsible.

The weight of rail gradually increased from 85 lb, the heaviest in general use 50 years ago, to 110 lb and 112 lb, and the length of rail from 30 and 33 ft to 39 ft. The quality of the steel and the design of the rail were improved. This trend has continued to the present time. The lightest rail now generally laid is 115 lb, the mileage of 132 lb is substantial, and some 140-lb and 155-lb rail is in use on very heavy-traffic lines.

Two important developments in connection with rail, both largely in the past 20 years, have been: first, the detector car, which locates transverse fissures and other interior and hidden defects, making possible the removal of the defective rail before actual failure occurs; and second, the perfecting of the controlled-cooling process, which has practically eliminated the interior transverse fissure, the most dangerous type of failure with which we had to contend.

The end hardening of rail to retard batter, and the building up of rail ends when batter has developed, are now general practice.

All of this, together with greater care in the handling and laying rail, including the maintenance of proper expansion and the prevention of rail running by proper and adequate anchoring, has resulted in a greatly improved rail condition, longer service, and safer operation, from which the railroads have realized a very substantial saving. Again, the engineer is largely responsible for this development.

There are many rail problems yet unsolved and improvements that could and. I think, will ultimately be made. One of these is the use of longer rail, at least 78 ft, instead of the present 39-ft, if the rail mills would show a progressive and cooperative attitude and furnish this longer rail at a reasonable price, as I think they could.

There was a continued increase and improvement in the weight, tractive effort and efficiency of locomotives. Freight cars became larger to carry heavier loads, and various types of cars for specialized service were developed. If one attempted to name the special types of cars now in use, the list would be long. It would include, in addition to the more usual type of cars, such as box car, stock car, and open-top car (and even some of these are now of a specialized type), tank cars for handling various kinds of liquids, ore cars, refrigerator cars, etc.

The handling of perishables on the railroads has resulted in a further division in the engineering field, which, for lack of a better title, I term refrigerating engineer. The improvement in refrigeration from the first crude, and not too effective, car to the present efficient car, in some of which mechanical means are now used to improve performance, has done much to increase railroad revenue and to raise the standard of living in the country as a whole. In this we must include not only the car artificially cooled but also the car artificially heated.

Passenger cars were less ornate but much more comfortable. Heat from the locomotive replaced the old stoves that once ornamented each end of almost every coach, and electric lights took the place of the old oil lamp. The wooden coach was largely replaced by heavier and stronger steel cars with improved trucks and springs, and better and more comfortable seats—and the pleasure of a trip by rail was greatly increased.

The link and pin was replaced by the automatic coupler and the air brake took the place of the hand brake. This greatly increased safety of operation and made possible higher speed in both passenger and freight service. Crude and not too reliable at first, both coupler and brake were quickly improved, and this is steadily continuing. Again, the engineer made this development possible.

Due largely to the devices just mentioned, a gradual increase in the speed of both freight and passenger trains was made possible and, while at no time was the increase spectacular, it was steady and continued. Schedules were more exacting, and on-time performance was more important. To meet the demands of the faster schedules, it was important that the standing time of trains be decreased. This called for larger fuel and water tanks and improved servicing facilities of all kinds, such as fuel and water stations, engine terminals, etc. Freight yards were enlarged to handle the longer trains and increased business, and were often entirely rearranged and rebuilt to expedite the movement of cars through terminals. It was to meet this need that first hump yards, and later hump retarder yards, were designed and built.

In all of this, the civil and mechanical engineer had the same important part they had during the first 50 years of railroad development, and again, without them, progress would have been much slower, less sure, and more costly. Frequently the engineer had to be a better salesman than his predecessor, to convince his management that the plans and recommendations made were sound economically.

It was during this period that two other branches of the engineering profession developed rapidly, and the signal and electrical engineer became prominent in the railroad industry. The electrical engineer has had a rather limited field insofar as the fixed property is concerned. The mileage of electrified line is relatively small and it is doubtful if it will be greatly increased. Where the electrical engineer has had the opportunity he has acquitted himself well, and it is in no way to his discredit that electrification is as limited as it is.

It has been in the improvement of lighting and other electrical work in equipment that the electrical engineer has been most important, and sometimes it is difficult to draw a line between the electrical engineer, the signal engineer, and the engineer responsible for communications.

Signal engineering in the railroad industry is now a most important branch of the profession. Growth has been rapid and the signal engineer is becoming more essential as the complexity of signaling increases.

Starting a little over fifty years ago with mechanical interlocking plants and a few automatic signals, and progressing to a very general and extensive use of roadside automatic signals, we have now gone far beyond that, with cab signals, automatic train control, and centralized traffic control, all to increase safety, speed, and efficiency of operation.

Automatic interlocking, or plants electrically controlled, have almost entirely replaced the mechanical plant. Crossing protection signals of several kinds have decreased the hazard to both railroad and highway traffic at grade crossings, and have practically rendered the once numerous, but not too efficient, crossing flagmen almost extinct.

The hump retarder yard has been made possible by civil, signal, electrical, and communication engineers, working together. Development of improved equipment is so rapid that a retarder yard is almost obsolete before it is quite finished. The saving in time and in cost of operation made possible by these modern yards is very great and is a most important factor in the efficient operation of an entire system.

Spectacular Advances During Last 20 Years

We have now come to the latest period of railroad development—the last 20 years. Twenty years ago we were in what was called a depression, and were just about at the bottom of the longest, if not the deepest, depression this country has ever known. Practices were started and things were done at that time under various pretexts that were entirely foreign to our previous ideas and ideals. We are still suffering the consequences of some of these practices, and I fear we will continue to do so for perhaps a long time to come. In this statement, I am not referring to the railroads alone.

Traffic, both passenger and freight, had decreased and in some cases almost disappeared. Many roads were in trustee or receivership, and all were in distress. It was a question whether the railroads could survive as a private industry. It was then that the most sudden and dramatic change began to develop. The visible evidence of the change was the diesel-electric locomotive, which has now displaced the steam locomotive to a very great extent, and the streamlined, air-conditioned, colorful passenger train, with luxurious and attractive equipment and accommodations never before known, which is now almost the standard on all long-distance trains. Some trains were provided with additional features, such as Vista Domes, unusually attractive lounge-observation cars, recreation cars, etc. All of this was spectacular, and attracted attention.

At the same time, speeds were greatly increased and schedules shortened. Braking equipment was improved and made more efficient to permit and to conform to the faster speeds, and many other improvements were made, such as better lighting, roller bearings, and tight-lock couplers. All of these were good, but the satisfactory air-conditioning of nearly all passenger equipment did more than any other thing to make railroad travel attractive and comfortable.

While the improvement in equipment and increase in speed have been more noticeable in passenger service, there has been almost equal progress in freight equipment and service, and this has done much to attract new business so vital to the railroads. Once more the engineer contributed to all of this.

In this development—the design and building of new equipment—the mechanical engineer, perhaps, appeared the most prominent, but the civil and signal engineers also had to do their part. To permit the much faster speeds, line and surface of track were improved and brought to a higher standard. Superelevation of curves was increased and spirals were lengthened. Any curve over 1 deg 30 min became restrictive and was reduced or eliminated, if possible, and this had to be done quickly—in fact, almost at once, as the faster speeds were in many cases already in effect. Vertical curves became almost as important as horizontal curves, and many had to be modified and the rate of change lessened to insure a comfortable ride on passenger trains, and fully as important, to prevent or reduce slack action and shock on long freight trains, which had also been speeded up.

In many cases signals had to be relocated to give longer braking distance, and the length of the ringing sections of highway grade crossing protection had to be adjusted. The work of the signal engineer became even more exacting.

Radio communication rear-end to head-end, and in some cases train to station, came into very general use and almost all yards of any size were equipped with radio or walkie-talkie communicating systems. The electrical engineer was probably generally responsible for this development, but the signal engineer and the engineer in charge of communications were so involved in many cases that placing the responsibility or awarding the credit was at times difficult.

The spectacular changes I have tried to touch on briefly did much to change the fortunes of the railroads. Greatly increased traffic, due largely, I fear, to World War II, was no doubt the deciding factor. In some cases the roads were probably in better financial condition than ever before. At present most railroads are in fair financial condition and all, or nearly all, are in good physical condition, and the engineer deserves much credit for helping bring this about. But the way ahead is somewhat uncertain, the margin of safety is small, and it will require the continued whole-hearted, united effort not only of the engineer, but of everyone who wishes railroad management to remain in private hands, to achieve that much-to-be-desired end.

As I check back on the subject assigned me, I see I was to talk on the contribution the railroad engineers have made to the welfare of the country. As I review what I have tried to say, I fear I have spent most of the time talking about the railroads and the contribution they have made. I do not apologize for that, as one could not speak of what the engineer has done until he spoke of what the railroads have done. In other words, the whole is greater than any part. The railroads have made a great contribution to the welfare of our country. I have utterly failed to do that subject justice, but I repeat what I have said several times: it would have taken longer, cost more, and been less successful and efficient, if the engineer had not been able and more than willing to do his part; so what the railroads have done is largely the contribution the engineer has made to the welfare of our country.

Inspired by, but not contented with, these achievements of the past, the engineering fraternity, and especially those who devote their time, energy, and ability to the railroad industry, will continue to make the contribution needed to insure that the railroads in the future, as in the past, will provide the transportation services required to keep our country powerful and secure. This is the creed and the purpose of the engineers who serve directly in railroad service, and of those who serve more indirectly by supplying the railroads with the improved materials and equipment, they must have if they are to maintain the position they have held for the past 100 years as the most reliable, efficient, and economical form of mass transportation any country has ever enjoyed. That is the future of opportunity, and in it there is a chance and a challenge for all young men who may desire to make serving our country through its railroads their life purpose.

Report of Committee 30—Impact and Bridge Stresses

J. P. Walton, *Chairman,*
D. B. Barge
D. S. Bechly
J. H. Brown
E. E. Burch
A. B. Chapman
Abram Clark
F. H. Cramer
C. P. Cummins
J. A. Erskine
S. F. Grear
R. R. Gunderson
A. R. Harris
R. H. Heinlen
C. S. Johnson
Frank Kerekes
M. B. Lagaard
A. N. Laird
C. T. G. Looney
J. F. Marsh
J. P. Michalos
C. H. Newlin
N. M. Newmark
M. J. Plumb
E. S. Birkenwald, *Vice Chairman,*
E. W. Prentiss
C. A. Roberts
J. H. Shieber
C. E. Sloan
C. B. Smith
R. L. Stevens
W. M. Wilson
E. Wollett, Jr.
J. D. Woodward
L. T. Wyly
Committee

To the American Railway Engineering Association:

Your committee reports on the following subjects:

1. Viaduct columns, collaborating with Committee 15.
   No report.

2. Steel girder spans with open decks and with ballasted decks.
   No report.

3. Dynamic shear in girder and truss spans.
   No report.

4. Impact and bending stresses in columns and hangers of truss spans.
   No report.

5. Concrete structures, collaborating with Committee 8.
   Progress report, presented as information .... page 622

6. Determination of braking and traction forces in bridge structures, collaborating with Committees 7, 8 and 15.
   Progress report, presented as information .... page 622

7. Stresses and impacts in timber stringer bridges, collaborating with Committee 7.
   No report.

8. Steel truss spans with open decks and with ballasted decks.
   Progress report, presented as information .... page 622

9. Distribution of live load in bridge floors.
   (a) Floors consisting of transverse beams.
   (b) Floors consisting of longitudinal beams.
   Progress report, presented as information .... page 623

10. Stresses in lateral bracing of bridges.
    No report.

The Committee on Impact and Bridge Stresses,
E. S. Birkenwald, *Acting Chairman.*

AREA Bulletin 505, December 1952.

Report on Assignment 5

Concrete Structures

Collaborating with Committee 8

A report of the investigation of static and dynamic compressive stresses in the concrete and tensile stresses in the reinforcing bars of four reinforced concrete bridges on the Chicago and North Western Railway, Missouri Pacific Railroad, and the Grand Trunk Western Railway was presented in AREA Bulletin 503, September–October 1952, page 243.

The AAR research staff has completed analysis of the data secured during the laboratory testing to failure of twenty-four 4-ft lengths of reinforced concrete pipe varying in size from 24 in to 84 in, and, as a result of this analysis, it is planned to test additional pipe to determine the effect of the concrete strength on the load carrying capacity of the pipe.

Report on Assignment 6

Determination of Braking and Traction Forces in Bridge Structures

Collaborating with Committees 7, 8 and 15

A report of the investigation of braking forces resisted by the running rails and the concrete piles of two reinforced concrete bridges on the Missouri Pacific Railroad was presented in AREA Bulletin 503, September–October 1952, page 273.

During the past year, the AAR research staff conducted tests on a structure consisting of steel beam spans supported by cylindrical steel pile bents. Tests were conducted to determine the braking and traction forces resisted by the rails and pile bents as part of this assignment.

Progress is being made in the analysis of the accumulated data and a report on these tests will be presented as soon as possible.

Report on Assignment 8

Steel Truss Spans with Open Decks and with Ballasted Decks

During the past year, the AAR research staff measured the stresses in the counterweight truss members of two bascule bridges on the Great Northern Railway and the Northern Pacific Railway to determine the primary and secondary effects of the concrete counterweight during the opening of the bridge. These tests were conducted at the request and expense of the railway, and a summary of the results will be published.

The AAR research staff is analyzing the data and preparing a report covering tests conducted on a 350-ft double-track, deck truss span having a ballasted timber floor. The tests consisted of the determination of the dead load, live load, and dynamic stresses in the various truss members, and the data is being analyzed with particular emphasis on the dead load and live-load secondary stresses.

Progress is being made in the analysis of the accumulated data and a report covering the tests on the 350-ft truss span will be published in 1953.

Report on Assignment 9

Distribution of Live Load in Bridge Floors

(a) Floors consisting of transverse beams
(b) Floors consisting of longitudinal beams.

The AAR research staff is analyzing the data and preparing a report covering tests on six girder spans having transverse beams and two girder spans having longitudinal beams to determine the distribution of the axle loads to these beams, under both static and high-speed locomotives.

Progress is being made in the analysis of the accumulated data and a report covering the tests will be published in 1953.

Report of Committee 3—Ties

P. D. Brentlinger, *Chairman,*
J. E. Armstrong, Jr.
R. S. Belcher
C. S. Burt
W. J. Burton
R. F. Bush
G. B. Campbell
C. M. Coates
E. L. Collette
B. S. Converse
R. L. Cook
R. W. Cook
B. E. Crumpler
L. P. Drew
H. R. Duncan
W. F. Dunn, Sr.
T. H. Friedlin
A. K. Frost
W. E. Fuhr
L. E. Gingerich
B. D. Howe
M. J. Hubbard
C. E. Jackman
G. R. Janosko
F. O. Johnson, Jr.
W. J. Kernan
L. W. Kistler
W. G. Lindeman
C. M. Long
L. C. Collister, *Vice Chairman,*
Roy Lumpkin
D. E. Patton
M. H. Priddy
W. C. Reichow
N. B. Roberts
H. S. Ross
T. D. Saunders
Stuart Shumate
P. V. Thelander
S. Thorvaldson
C. D. Turley
R. G. Wintrich
Committee

To the American Railway Engineering Association:

Your committee reports on the following subjects:

The Committee on Ties,
P. D. Brentlinger, *Chairman.*

AREA Bulletin 505, December 1952.

Report on Assignment 1

Revision of Manual

C. D. Turley (chairman, subcommittee), P. D. Brentlinger, W. J. Burton, E. L. Collette, R. L. Cook, L. P. Drew, H. R. Duncan, B. D. Howe, Roy Lumpkin, R. G. Wintrich.

Looking to the reprinting of the Manual in 1953, your committee has for another year concentrated much of its attention upon a review of the material in its chapter in the Manual, looking to its reapproval, or revision where necessary. As a result, your committee makes the following recommendations.

Pages 3–1 to 3–5, incl.

SPECIFICATIONS FOR CROSS TIES (Revised 1952)

Reapprove without change.

Page 3–7

APPLICATION OF THE SPECIFICATION FOR CROSS TIES (Revised 1952)

Reapprove without change, except revise title to read "Application of the Specification for Cross Ties as to Size Acceptance".

Page 3–7

MARKING TIES TO INDICATE SIZE ACCEPTANCE (Rewritten 1952)

Reapprove without change.

Pages 3–9 and 3–10

SPECIFICATIONS FOR MACHINING CROSS TIES (Reapproved 1948)

Reapprove without change.

Pages 3–11 to 3–14, incl.

SPECIFICATIONS FOR SWITCH TIES (Revised 1952)

Reapprove without change.

Page 3–15

DIMENSIONS OF TIES (Approved 1942)

Reapprove without change, except change title to "Explanation of Cross Tie Design"

Pages 3–15 to 3–16.1, incl.

ECONOMIC COMPARISON OF CROSS TIES OF DIFFERENT MATERIALS (Reapproved 1952)

Reapprove without change, except change title to "Economic Comparison of Ties".

Pages 3–16.2 to 3–18, incl.

THE HANDLING OF TIES FROM THE TREE INTO THE TRACK (Approved 1945)

Reapprove with the following changes.

Under Conditioning, page 3–16.3, revise third paragraph to read as follows: It is good practice to hold soft wood ties at least 30 days after treatment before placing them in track.

Under Control of Splitting, page 3–16.3, delete last part of third paragraph, beginning at "or their ends should". Also delete "Either Chemical or" first line of fourth paragraph.

Page 3–19

MARKING TIES FOR SERVICE RECORDS (Approved 1947)

Reapprove without change.

Page 3–19

INSTALLATION AND KEEPING RECORDS OF CROSS-TIE TEST SECTION (Reapproved 1947)

Reapprove without change, except omit CROSS-TIE from title.

Page 3–20

SIZE OF HOLES BORED FOR SPIKES (Approved 1946)

Reapprove without change.

Page 3–20

TRAFFIC UNIT FOR USE IN COMPARING CROSS TIE LIFE (Reapproved 1948)

Reapprove without change, except omit CROSS from title.

Page 3–20

BEST PRACTICE FOR TIE RENEWALS (Reapproved 1948)

Reapprove without change.

Pages 3–21 and 3–22

SPECIFICATIONS FOR TIE PLUGS (Reapproved 1947)

Reapprove without change.

Pages 3–23 and 3–24

SPECIFICATIONS FOR DATING NAILS (Reapproved 1948)

Reapprove without change.

Pages 3–27 and 3–28

FUNDAMENTALS TO BE CONSIDERED IN DESIGNS OF SUBSTITUTE TIES

Reapprove without change.

Pages 3–28 and 3–29

CONSERVATION OF TIMBER SUPPLY (Approved 1947)

Reapprove without change.

Report on Assignment 2

Adherence to Specifications

P. D. Brentlinger (chairman, subcommittee), C. S. Burt, G. B. Campbell, R. L. Cook, H. R. Duncan, W. F. Dunn, Sr., T. H. Friedlin, A. K. Frost, L. E. Gingerich, C. E. Jackman, G. R. Janosko, L. W. Kistler, P. V. Thelander, R. G. Wintrich.

The report on Assignment 2 is confined to one field trip taken during June 1952. The personnel of Committee 3 inspected approximately one million cross ties purchased by the Canadian National Railway and the Canadian Pacific Railway. These ties were mainly various species of pine ties, with some hardwoods from the eastern provinces, and were well stacked and separated on well kept seasoning yards. The ties in storage were located at Sudbury, Ont., and Delson, Que.

In conjunction with the above inspection the committee visited the Forest Products Laboratory of Canada at Ottawa, Ont. Here, the laboratory personnel lectured to the group on wood-destroying fungi, wood preservatives, and research progress on laminated cross ties. Each subject was expertly covered, and of particular interest to the group was the assembly of a laminated tie and the curing of the glue lines by dielectric heating.

It is the recommendation of the committee that field inspection trips be resumed; the 1952 fall trip was eliminated in order that members could attend the Centennial of Engineering in Chicago during September.

Report on Assignment 4

Tie Renewals and Costs Per Mile of Maintained Track

L. W. Kistler (chairman, subcommittee), J. E. Armstrong, Jr., R. F. Bush, R. W. Cook, F. O. Johnson, W. J. Kernan, C. M Long, D. E. Patton, Stuart Shumate.

This is a progress report, presented as information.

The statistics compiled annually by the Bureau of Railway Economics, AAR, providing information in regard to the number and cost of cross ties laid in maintenance in 1951, are shown in Tables A and B in Bulletin 502, June–July 1952, following page 174. These tables will also appear following page 174 in the Proceedings, Vol. 54, 1953.

It will be noted that there were approximately 1,400,000 fewer ties laid in replacement in the United States in 1951 than in 1950. However, average tie costs were up 20 cents each so that the renewal cost per mile of maintained track increased from $252 to $257. Special attention is called to the fact that for the first time in the history of the American railroads, the 5-year average of tie renewals per mile of maintained track was below 100. This reflects an average service life of over 30 years, and is due in great part to the use of treated ties.

Report on Assignment 6

Bituminous Coating of Ties for Protection From the Elements

W. J. Burton (chairman, subcommittee), J. E. Armstrong, Jr., R. F. Bush, B. S. Converse, R. L. Cook, B. E. Crumpler, W. F. Dunn, Sr., M. J. Hubbard, F. O. Johnson, Jr., W. G. Lindeman, M. H. Priddy, T. D. Saunders.

This is a progress report, submitted as information.

A questionnaire was sent on February 25, 1952, to 54 chief engineers to develop this new subject.

QUESTIONNAIRE

The assignment is considered to include coatings resulting from preservative treatment, as well as those applied specifically as coatings. Also, coatings will be included whether these are technically of bitumen or of some other material applied for the same purpose.

Q 1—If you have ties in your track which have been coated intentionally, please give details. Please include number of such ties, locations, dates coated, extent of coating, how applied, nature of coating material, kinds of wood, and, if available, approximate cost. Please also include remarks as to results or expected benefits.

Q 2—If you have, or have had, ties in track with coatings resulting more or less incidentally from preservative treatment, please give general statement of kind of treatment, retention secured, kinds of wood, locations of use, and remarks as to about what proportion of ties treated retained coatings, and whether coated ties give, or gave, longer life. If statistics are available upon which answer to this question is based, these would be very welcome.

Q 3—Please give any other facts or your opinion, which may aid the committee. If your road has no coated ties, please give any information you may have as to such coated ties elsewhere.

ANSWERS

The 41 replies may be summarized as follows:

Atchison, Topeka and Santa Fe, May 1, 1952.

D. L. Murray, manager treating plants

Texas Company's emulsified asphalt applied to 25 ties in August 1950; 2/3 gal per tie. Barrett Company's tie seal applied to 25 ties in August 1950; ½ gal per tie. Insufficient time to evaluate results.

In 1908–10 western pine ties treated at Bakersfield, Calif., with straight asphalt-base petroleum oil (no creosote). During 1951 removed 870 of these ties which had averaged 41.73 years. At present treating with 30 percent creosote, 70 percent crude oil residue, 10 lb per cu ft. Many of these ties retain a coating. "Coating effects are very beneficial .... do not season check or split as badly........."

Baltimore and Ohio, March 4, 1952.

C. B. Harveson, chief engineer, maint. of way

Expect to install both asphalt-base and bituminous coatings near Green Springs, W. Va., this spring. No results to date. "Coatings believed to be of doubtful economic value; surprised if total life is increased enough to pay the cost."

Central of Georgia, March 20, 1952.

H. G. Carter, chief engineer

Kopper's Company "16" brush applied to 228 bridge ties and guard timbers on Walnut Creek bridge, Savannah Dist., in May 1950. 55 gal used. Same treatment to 596 bridge ties and guard timbers on Hatchett Creek bridge, Birmingham Dist., in November, 1950. 165 gal used. Too soon to evaluate results.

Chesapeake & Ohio, April 8, 1952.

J. Hubbard, Gen. supr. B. & B.

Kopper's Company "16" applied following regular mixture of 60–40 creosote–coal tar in December 1951 as follows: Double-track bridge at Mt. Carbon, W. Va., 162 ties. 55 gal 60–40 creo.–coal tar, then 55 gal Kopper's "16". Bridge at Deepwater, W. Va., 180 ties. 55 gal each of creo.–coal tar and Kopper's "16". In each of these applications 3600 lb of "grit" was also applied.

Chicago and Northwestern, March 11, 1952.

E. C. Vandenburgh, chief engineer

No ties coated intentionally. In 1914, 800 loblolly pine track ties were treated with a mixture of 50 percent water gas tar and 50 percent coke oven tar, with average retention of 14.2 lb per cu ft. They were placed, 100 in each, in track in 8 locations in Illinois, Iowa, Michigan, Minnesota and Nebraska.

"These ties retained coating to more or less degree until removed from track. One hundred and ninety-six of the 800 remained in track as of August 1, 1951, as compared with 69 of 3200 similar ties, 800 of which were untreated, 800 treated by the Card process, 800 treated by the Burnett process, and 800 with 7 lb creosote. Average life of untreated ties 5 years. Card expectancy 18.13 years. Burnett expectancy 14.75 years. Creosote, 7 lb expectancy 28.65 years. The coke oven–gas tar expectancy 30.87 years."

Chicago, Milwaukee, St. Paul & Pacific, March 10, 1952.

W. G. Powrie, chief engineer

Kopper's "16" applied in August 1950 to creosoted oak cross ties, 7 in by 9 in by 10 ft, placed alternately between size 5 cross ties 8 ft long. Pea gravel spread on surface. Only the 10-ft ties were coated. Location east of Dawn, Mo., between M.P. 236.3 and 237.8.

Section 1, 303 ties, Section 2, 250 ties not coated, left for comparison, section 3, 150 ties, and section 4, 424 ties. Application by compressed air. Amount used. 0.44 gal per tie. Foreman and five laborers averaged 300 ties per day. Inspection in June, 1951, showed good condition. Expected to add at least five years life.

Delaware, Lackawanna & Western, April 1, 1952.

G. A. Phillips, chief engineer

Kopper's "16" applied to 2955 cross ties at 27 locations. Application varied from 0.51 gal per tie to 1.21 gal per tie. Applications made between August 16, 1950, and November 20, 1951. It is too soon for definite conclusions.

Erie, March 21, 1952.

B. Blowers, chief engineer m. of w.

Kopper's "16" applied by air spray to 1200 cross ties at Greenville, Pa., October 10, 1947. One gallon averaged 3.65 ties. Results favorable. Same to 1300 ties in summer of 1950. Results good.

Florida East Coast, March 29, 1952.

L. C. Frohman, chief engineer

No coatings have been applied intentionally. Cross ties are mostly sap pine, with some gum and some heart red cypress. The pine and gum are treated 50–50 creosote–coal tar with a retention of 9.5 lb per cu ft. A large number of ties have a rather heavy coating of preservative on their surfaces. This will undoubtedly afford protection against splitting and checking.

Great Northern, March 24, 1952.

H. J. Seyton, chief engineer

Kopper's "16" applied to 1722 track ties at Cedar Lake yard, Minneapolis, in June, 1950. Coating floated on ties and brushed evenly over the top surface, about 3½ ties per gallon. Fine aggregate sprinkled onto coating.

Illinois Central, March 7, 1952.

C. H. Mottier, chief engineer

Koppers "16" applied to 1000 bridge ties at Rialto, Tenn., in November 1950. Also same number at same location were coated with Protek-Coat. Fine stone screenings applied to each. One gallon will cover three 2 in by 9-in by 8-ft 6-in ties. One operator can spray 100 ties per hour.

Texaco R C #2 cut-back asphalt applied to 3536 cross ties and seven sets of switch ties near Ackley, Iowa, in September 1951.

Based on results obtained with hot asphalt applied to ties at Manteno, Ill., in 1943, these coatings should increase tie life at least five years.

The 1943 work at Manteno consisted in spraying the entire ballast section with hot asphalt. This resulted in spraying the ties also. After eight years tie renewals have been at the rate of 49 ties per mile per year, as compared with 117 per mile per year on same track unsprayed.

"We are of the opinion that by keeping surface water and air away from the checks in the top surface of ties in track, service life will be increased materially."

Kansas City Southern, March 3, 1952.

E. F. Salisbury, chief engineer

Protek-Coat applied to 105 cross ties at Pittsburg, Kan., July 11, 1951. Application by spray. Ties covered with chats. An additional 28 ties sprayed but not covered. One minute per tie required to spray. One 54–gal drum used. Too soon for results.

Louisville and Nashville, Feb. 27, 1952.

L. L. Adams, chief engineer

See AREA Bulletin 495, page 67. Koppers "16" applied to cross ties in connection with trial of tie pads. The test is not designed to evaluate the coatings separately from the pads.

New York Central System, March 4, 1952.

E. A. Dougherty, chief engineer

Kopper's "16" applied with long-spouted can to fill the checks on between 100 and 200 bridge ties which had been in service for almost 20 years near Middletown, Ohio. First application did not completely fill some of the checks. A second application also did not fill some of them. Work then stopped. Anticipated benefits did not seem worth the cost.

Ties coated with tar as the result of treatment almost invariably found to be in high state of preservation when the coating is removed.

New York New Haven & Hartford, April 2, 1952.

T. P. Polson, chief engineer

Kopper's "16" applied to 500 oak ties at Providence, R. I., in November 1951. Material poured into large checks first, then entire top surface covered by brushing. Surface covered with ¼-in stone. Too soon for evaluation.

Norfolk & Western, March 10, 1952.

A. B. Stone, chief engineer

Kopper's "16" applied out-of-face to a total of one mile of eastbound track at Montvale and Villamont, Va., in August 1951. On old ties material applied except under tie plates. On ties being applied new entire top area covered. Application made by spray. Fine stone applied on top.

In August, 1951, a "mastic compound" was applied to the tie plate area only of 317 cross ties near Roanoke, Va. The material was placed in a daub or puddle in the tie plate area only and allowed to squeeze up through the spike holes and out around the edges of the plate when the plate was set on the tie. It is too soon to evaluate results.

Northern Pacific, February 29, 1952.

W. R. Bjorklund, prin., asst. engr.

Kopper's "16" applied to 230 bridge ties near Duluth, Minn., on July 6, 1950, by crew of foreman and four men. Net working time 2 hr 50 min, after deducting for delays. On the 230 ties, guard timbers and tops of floorbeams, 110 gal were used, or 2.09 ties per gallon. Material sprayed. Pea gravel applied.

On September 8, 1950, 40 more of the ties on this bridge were covered, using a brush and only 14 gal. The brush was more efficient with less waste.

Kopper's "16" also applied on two bridges in eastern North Dakota in August 1950. On one bridge 156 ties were coated with 60 gal and 1¼ yd pea gravel. On the other bridge 38 gal and ⅔ cu yd of gravel were applied to 84 ties. These two applications were by brush.

Toch Bros. R.I.W. self-healing cement applied in August 1950 to 71 bridge ties in Western Minnesota. Foreman and 4 men applied 30 gal and ½ cu yd gravel in one 8-hr day. Also, same time and general location, 80 gal same cement and 1½ cu yd gravel applied to 112 bridge ties by foreman and 4 men working two 9-hr days.

Applications are too recent to evaluate.

Pennsylvania, April 11, 1952.

J. L. Gressitt, chief engineer

Kopper's "16" applied by brush to new block (short) ties, tracks 1, 2 and 4, through 30th Street Station, Philadelphia, Pa., in 1950. Endeavor to have coating ⅛ in thick.

Same material applied to 67 bridge ties near Pittsburgh, Pa., in October 1950. Spray used. Ties were oak, 1½ years old, but badly split. Heavy application—to fill checks. Over 1 gal per tie used.

Same material applied to 110 cross ties at Rennerdale, Pa., in September 1951, and to 110 ties at Union Furnace, Pa., in October 1951.

Protek-Coat sprayed on 110 cross ties at Rennerdale in September 1951, and to 165 ties at Union Furnace, in October 1951.

Reading, April 1, 1952.

E. L. Gosnell, chief engineer

Protek-Coat applied to ties on bridges near Reading, Manheim and Harrisburg, Pa., by brush in fall of 1951. Quantities not given.

St. Louis–San Francisco, March 4, 1952.

E. L. Anderson, chief engineer

Have made application to some bridge ties but time too short to evaluate.

Soo Line, March 5, 1952.

L. V. Johnson, chief engineer

Kopper's "16" applied to 476 bridge ties and 308 cross ties near Somerset, Wis., on July 3, 1950. The bridge ties received 210 gal and 30 cu ft of ¼-in torpedo sand. Application was by spray.

At the same time the 308 track ties received 110 gal and 16 cu ft of sand.

It is expected that the bridge ties will give many additional years life due to the coatings. There are tie pads under the plates.

The track ties appear only 75 percent as effectively protected as the bridge ties, but some additional life is expected.

Southern, April 21, 1952.

J. B. Akers, chief engineer

Test applications made on bridge deck near Washington, D. C., on August 13 and 14, 1951.

Kopper's "16" applied to 162 ties, using 35 gal.

Protek-Coat applied to 162 ties, using 35 gal.

Southern Railway Specification 97 Car Cement applied to 162 ties, using 46 gal.

The car cement was applied with a trowel, the other two products by brush.

Applications too recent to evaluate.

Southern Pacific, March 10, 1952.

E. E. Mayo, chief engineer

Bituminous material brushed on adzed surface of cross ties (apparently) in connection with relaying rail. Bitumin applied hot to form thick coat. Created seal between plate and tie. Location between Kaiser and South Fontana. (Evidently the ties were not coated except the adzed surface).

Texas and Pacific, March 4, 1952.

R. J. Gammie, chief engineer

Bituminous material applied to 985 bridge ties, Trinity River bridge, in September 1948. Material applied as a fire protection.

Union Pacific, March 3, 1952.

L. P. Drew, asst. chief engineer

No intentional application except some bridge ties coated for fire protection.

Have noticed number of locations where ties have been accidentally coated with fuel oil which has added considerably to the life of the ties. Lodgepole pine ties, treated with 50–50 creosote–petroleum residue in 1927, now coated with mixture of fuel oil, grease, etc, opposite treating plant at Laramie, Wyo., are now in almost perfect condition.

Wabash, February 28, 1952.

J. C. Bousfield, chief engineer

A coating made by R. E. Hussey, Mercer, Wis., was mopped on to seven ties near Page Ave., St. Louis, on November 30, 1949. No change noticeable to date.

Western Maryland, March 7, 1952.

E. C. Shreve, chief engineer

Kopper's "16" applied to 92 ties on bridge near Hancock, and to 128 ties on bridge near Cumberland, Md., in July 1951. Limestone chips, ¼ in added. Too soon to evaluate.

Western Pacific, April 2, 1952.

F. R. Woolford, chief engineer

Nothing to report. Experimental use of "Zone" process as fire protection on one bridge.

Other Roads

The following roads had nothing to report: Bessemer and Lake Erie; Canadian National; Canadian Pacific; Chicago & Eastern Illinois; Chicago, Burlington & Quincy; Chicago, Indianapolis and Louisville; Denver & Rio Grande Western; Duluth, South Shore and Atlantic; Elgin, Joliet and Eastern; Gulf, Mobile and Ohio; Lehigh Valley; New York, Chicago and St. Louis; Pittsburgh & Lake Erie; St. Louis Southwestern; and Seaboard Air Line.

Discussion by Committee

Practically all installations are too recent to evaluate results.

Two materials predominate. Kopper's "16" is stated to be derived mostly from coal tar, but as no toxic value is claimed, it may be mostly coal tar pitch. The composition is not stated by the producer. Some of those reporting think that it contains ground asbestos.

Protek–Coat is stated to be a true bituminous product. No toxic value is claimed.

Each material apparently has a volatile solvent, or solvents, added to produce best consistency for application and then hardening after application. Each may be brushed or sprayed.

There can be little doubt that sealing checks and surfaces of ties against moisture tends to increase tie life. Data is not at present available by which the over-all economic results can be determined.

Reports with ties which have received a coating incidental to treatment are so universally favorable that attention should be given to treatment which will secure this result, while retaining those features of present treatment which have been so productive of long tie life.

It is recommended that the subject be continued.

Report on Assignment 7

Causes Leading to the Removal of Ties

L. C. Collister (chairman, subcommittee), E. L. Collette, B. S. Converse, L. E. Gingerich, W. J. Kernan, C. M. Long, D. E. Patton, N. B. Roberts, H. S. Ross, T. D. Saunders, Stuart Shumate.

A questionnaire was sent to 46 chief engineers to develop this subject.

Questionnaire

1. Does your organization maintain experimental cross tie test sections?
2. Approximate number of ties under test?
3. Is any record made of cause of removal of ties from test sections?
4. If such a record is maintained, will you furnish copies of the record for inclusion in the data being studied by the committee?

Summary

The accompanying table contains a summary of the causes of removal of 6,232,928 treated ties from 5 reporting railroads.

These data are presented as a progress report for information only.

CAUSES OF TIE RENEWALS - ALL WOODS - ALL TREATMENTS

RAILROAD	Number of Treated Ties	Decay	Crushed or Shattered	Plate Cut	Broken	Spike Killed	Tamp Killed	Split	Natural Defects	Derail Dragging Equipment	Miscel-laneous Causes
A	141,122	34,516	23,360	42,348	1,004		483	35,383	2,527		1,501
B	16,219	13,692		956	167			1,404			
C	5,352,354	3,493,719		854,890				646,913		234,742	122,090
D	404,010	20,892	115,895	130,719	3,659	1,202		98,552	8,672	24,419	
E	319,223	43,962	5,029	36,627		3,751		184,921		34,172	10,761
TOTALS	6,232,928	3,606,781	144,284	1,065,540	4,830	4,953	483	967,173	11,199	293,333	134,352
Percents		58.10	2.30	17.20	0.80	0.80	0.10	15.60	0.20	4.70	0.20

Report of Committee 27—Maintenance of Way Work Equipment

R. K. Johnson, *Chairman,*
R. M. Baldock
Edgar Bennett
R. E. Berggren
C. T. Blume
W. S. Brown
R. E. Buss
L. B. Cann, Jr.
E. L. Cloutier
L. E. Conner
W. M. S. Dunn
F. L. Etchison
C. L. Fero
J. M. Fisher
J. M. Giles
Haynie Hornbuckle
Herbert Huffman
N. W. Hutchison
M. E. Kerns
S. H. Knight
W. F. Kohl
W. E. Kropp
Jack Largent
C. F. Lewis
H. H. Main
Francis Martin
Harry Mayer
F. H. McKenney
H. E. Michael
A. W. Munt
E. H. Ness
H. C. Nordstrom
V. W. Oswalt, Sr.
P. G. Petri
T. M. Pittman
J. F. Piper
C. E. Morgan,
Vice Chairman,
J. W. Risk
R. S. Sabins
P. S. Settle, Jr.
F. E. Short
R. J. Smith
W. I. Stadter
M. M. Stansbury
C. E. Stoecker
C. M. Strachan
M. C. Taylor
T. H. Taylor
H. A. Thyng
S. E. Tracy
E. E. Turner
A. H. Whisler
F. E. Yockey

Committee

To the American Railway Engineering Association

Your committee reports on the following subjects:

9. Means of conserving labor and materials, including the adaptation of substitute noncritical materials, and specifications for the reclamation of released materials, tools and equipment, collaborating with Committee 3–A, General Reclamation, Purchases and Stores Division, AAR.

   Progress report, submitted as information .... page 698

THE COMMITTEE ON MAINTENANCE OF WAY WORK EQUIPMENT,
R. K. JOHNSON, *Chairman*.

AREA Bulletin 505, December 1952.

Report on Assignment 1

Revision of Manual

S. E. Tracy (chairman, subcommittee), Edgar Bennett, C. L. Fero, J. M. Giles, Haynie Hornbuckle, N. W. Hutchison, H. E. Michael, C. E. Morgan, T. M. Pittman, G. M. Strachan, A. H. Whisler.

Your committee offers the following recommendations with respect to the Manual:

Pages 27–1 to 27–8, incl.

MOTOR CARS

Reapprove without change.

Page 27–8.1

RECOMMENDED COLORS FOR PAINTING MOTOR CARS, ROADWAY MACHINES AND WORK EQUIPMENT

Reapprove without change.

Pages 27–9 and 27–10

CARE AND OPERATION OF MAINTENANCE OF WAY WORK EQUIPMENT

Reapprove without change.

Pages 27–11 to 27–23, incl.

WORK EQUIPMENT REPORTS AND RECORDS

Reapprove without change.

Pages 27–24 to 27–29, incl.

WIRE ROPE USED WITH WORK EQUIPMENT

Withdraw the present material under this heading and substitute the following:

1. General

While wire rope and manila rope have certain advantages for specific uses, the latter is limited to manual operations, because it is softer on the hands and because of its qualities of flexibility and elasticity. For use with work equipment, wire rope has the advantage of greater strength for the same diameter and weight; its strength remains equal whether wet or dry; and its length is constant under all weather conditions.

2. Construction

In the construction of wire rope, iron and steel (plow, and improved plow) are the usual materials. Iron wire has a tensile strength of 70,000 to 80,000 psi and may be used where strength is unimportant. Plow steel has a tensile strength of 200,000 to 220,000 psi, while improved plow steel has a tensile strength varying from 220,000 to 240,000 psi and is generally used for making all-purpose rope.

Wire rope is made with different numbers of strands and numbers of wires to the strand, according to the purpose for which the rope is to be used. Flexibility is gained by increasing the number of strands and number of wires per strand in a given diameter. Standard wire ropes are made with either a fiber core, a wire rope core, or a metallic (wire strand) core. The fiber core is usually saturated with a lubricant which acts as a cushion to preserve the shape of the rope and helps to lubricate the wires. Factory lubrication of a wire rope cannot be expected to last throughout the life of a rope. Failure to lubricate wire ropes, and especially those exposed to corrosive elements or under severe stress or bending conditions, will cause an early exhaustion of the core preservative and rapid deterioration of the core. The life of the rope is largely measured by the life of the core. A metallic core or wire rope core adds about 7½ percent to the rope's strength, and the cost is about 15 percent more than a rope with a fiber core.

3. Lay

Lay refers to the twist or helical form which is characteristic of all wire rope. The strand lay refers to the twist of the individual wires composing a strand. The rope lay refers to the twist of the strands around the core. In a right lay rope the strands are laid similar to a right hand screw thread, and a left lay rope is laid in the opposite direction. Regular lay applies to rope of either direction of lay in which the wires in the individual strands are laid in the opposite direction from that of the rope itself.

Lang lay refers to a rope in which the wires composing the strands are laid in the same direction as the rope. Ropes may be either right lang lay or left lang lay. Ropes with lang lay, unless preformed, are more apt to kink than ropes made with regular lay.

In reverse lay wire, the alternate strands are laid right and left. Ropes of this type eliminate twisting and rotating and reduce stretching to the minimum.

4. Various Strand Constructions

Round Strand. This construction consists of a number of round wires twisted in a round strand. The wire rope usually consists of 6 or 8 strands generally made of 7, 19 or 37 wires each.

Flattened Strand. This construction usually consists of 5 or 6 keystone or oval strands and a hemp core; thus the outer wires conform to a circle and provide a greater wearing surface between strands and a smooth outer surface in contact with drums, sheaves and pulleys.

Non-rotating. The usual type of round strand, non-rotation wire rope consists of 18 strands of 7 wires each, of which the outer 12 strands are laid in the opposite direction. This arrangement equalizes the rotating or twisting tendency that is present where all strands are laid in the same direction.

Steel Clad. This is a round strand construction having each strand wound spirally with a flat steel wire. By so wrapping each strand the wires at the surface and where the strands adjoin are relieved of considerable wear.

Locked Coil. This construction is that of a succession of concentric layers of special shaped wires, the surface layer being of locked section. The locking outside wires give a smooth, cylindrical surface.

Preformed Wire Rope. Preforming is a process of shaping wires and strands to the normal form they will occupy in service and is applied to both round and flattened strand construction where conditions require a rope that will not unravel or fly apart if the ends are not seized, that will not kink easily, is more flexible for spooling and easily handled.

5. Factors of Safety

The factor of safety should be determined after consideration of such data as types of loads; acceleration and deceleration; rope speed; rope attachments; number, size, and arrangements of drums and sheaves; conditions causing corrosion and abrasion; and the time the rope has been in service.

For general use, the working load should not exceed one-fifth the breaking strength of the rope. This means the factor of safety should not be less than five; and in some cases, a safety factor of as much as 8 is required for safe and dependable operation.

6. Causes of Failure

Following are some of the more common causes of failure of wire rope:

a. Use of ropes of incorrect size, construction or grade.

b. Allowing ropes to drag over obstacles. In this manner rope is exposed to unnecessary wear, kinking, etc.

c. Lack of proper lubrication. This causes heating and excessive friction wear.

d. Sheaves and drums of inadequate size that cause short radius bends. The largest practical size of drums, sheaves, and pulleys should be employed, and high speed should be avoided. The tread diameter in a drum or sheave should be in accordance with Table 1.

e. Over winding or cross-winding on drums.

f. Sheaves and drums defective or out of alinement. Badly worn sheaves cause winding and cutting of strands. Poor alinement of sheaves causes excessive wear and often overstresses the rope.

g. Ropes jumping sheave flanges. Rope should be let out slowly so as to be taut at all times.

h. Effects of heat, moisture or acid fumes.

i. Improper fittings. Clamps, thimble, and other fittings must be of proper size.

j. Permitting rope to untwist. This can be avoided if the ends are properly seized.

k. Kinking. Rope should be allowed to twist when slack; if a kink is formed, it must be straightened out before it enters a sheave or a strain is placed on the rope.

l. Severe overloads, reverse bends, and other excessive strains.

m. Internal wear because of grit penetrating between strands and wires. Unless absolutely necessary, ropes should not be allowed to drag along the ground or through piles of material where they are liable to pick up grit.

n. The angle between the center line of the sheave and the rope as it winds on and off the drum is called the fleet angle. Keep the fleet as low as possible (1½ deg). A large fleet angle may cause the rope to spool loosely on the drum or crowd itself until it jumps back to the previous layer, and also cause the rope to rub against the flanges of the sheave and thus produce undue wear.

7. Recommended Types for Maintenance of Way Use

A Full Knowledge of All Operating Conditions. The various kinds of stresses and strains, and the nature of the work to be done or handled should be known to determine the particular rope to give the most economical service. Regular lay and lang lay cost the same. Lang lay ropes are about 15 percent more flexible than regular lay ropes. Because of the greater wearing surface of the wires in the lang lay ropes, less wear results on the sheave and drum equipment. Lang lay ropes should always be specified in the preformed type. As a rule, swivels should not be used with lang lay ropes, except under conditions as individually recommended for particular equipment.

Hoisting Ropes. For elevators of all kinds, coal hoists, derricks and similar equipment—six strands with 19 wires, either flattened or round construction with fiber cores. For unusually heavy loads, wire rope cores are best.

Dirt-Moving Equipment. Hoist lines, drag, boom, and haul back lines—6 strands with 19 wires, or 6 x 25 flattened strands—wire rope core. Trip line—6 strands with 19 wires—fiber core.

Shop Cranes. As a rule, the drums and sheaves are small, so ropes of 6 strands of 37 wires, fiber core, are preferred.

Bridge Cranes. Six strands of 19 wires with fiber core.

Sash and Bell Cords. Six strands of 7 wires with fiber core.

Guy Ropes. Galvanized rope made with 7 steel wires forming 1 strand.

Aerial Tramway or Cableway. Use locked coil or smooth coil track strand.

8. Lubrication

When one realizes that in a 6 x 19 rope there are 114 wires and a fiber core, a total of 115 working parts, the necessity for lubrication is evident. Crude oil should not be used for rope lubrication as it is very apt to contain impurities that are harmful to both the core and the steel wires. Whenever possible, hot lubricants should be used and applied when the rope is under a very light load so as to get the most penetrating effect possible. The frequency of lubricating must be determined by judgment based on the service being performed, and often enough to keep the rope pliable and with evidence of lubrication in the valleys between the strands.

Ropes used on draglines, which are necessarily drawn through sand and dirt, should be kept well wiped and oiled as this coating of the lubricant keeps the grit from penetrating under the strands and extends the life of the rope more than enough to offset any bad effect of grit that may cling to the lubricant on the outside of the rope. When placed in storage the rope should be protected against the possibility of rust and drying by a protective coating of lubricant of a non-corrosive nature.

9. Seizing

To prevent ends unravelling, seizing or binding the ends of rope should be done with a small galvanized 7-wire seizing strand or with low-carbon annealed steel wire. The wire should be about 1/12 to 1/15 the diameter of the rope, varying from No. 13 gage wire for ½-in rope to No. 9 gage wire for 1-in rope. The seizing wire is wound tightly around the rope by hand, keeping the coils together. To secure the bindings the ends of the seizing wire are pulled taut with a pair of pliers or Carew cutters to take up the slack and then twisted counter-clockwise and the surplus cut off. Pound the twist flat against the rope. Three bindings should be applied to insure full protection of the rope ends. Before cutting a rope it is most important that the seizings are placed on each side of where the rope is to be cut.

10. Sockets and Mandrels

When it is necessary to anchor an end of a wire rope in a hitching or holding device, the following procedure should be carried out:

a. Properly seize the rope from the end to a point on the rope beyond where the rope will be inserted.

b. Thread the rope through the anchoring or holding device.

c. Remove the seizing twists on the portion of rope end to be housed, referred to as the mule tail.

d. Untwist the strands and cut out the core.

e. Unravel the wires and clean them thoroughly. If acid is used to cut grease, follow by cleansing with boiling water containing a small amount of soda.

f. Use a vise or clamp to hold the mandrel or socket in the correct location on the rope.

g. Seal the bottom of the device with putty or clay.

h. Make sure the axis of the rope is in proper alinement and pour in melted zinc. When the zinc has solidified, remove the clay or putty seal. The zinc should be worked at a temperature of about 830 deg F; a higher temperature will anneal the wires. Do not use babbit metal or lead, as the strength of the fastening will be less than the rope.

i. Wire rope clips. Where clips are applied to obtain maximum strength, make sure the proper size is used. The U-bolt and saddle grooves should fit snugly on the rope. All clips should be applied in the same manner, namely, the U-bolts over the free end and the saddle to that portion of the rope carrying the load. As a rule three clips should be applied and tightened to make sure there is no slipping.

TABLE 1

The minimum tread diameter for various constructions of steel rope may be taken as follows:

Construction of Rope	*Minimum Recommended Tread Diameter*
6 x 7	42 d*
18 x 7	34 d
6 x 19	30 d
6 x 31	22 d
6 x 37	18 d
8 x 19	21 d

* d = rope diameter in inches.

TABLE 2

DATA ON VARIOUS TYPES OF WIRE ROPE USED WITH MAINTENANCE OF WAY WORK EQUIPMENT

Rope Diameter, Inches	*Construction*	*Approx. Wt. Per Foot, Pounds*	*Strength, Tons*	
			Plow Steel	*Improved Plow Steel*
¼	6 x 7 fiber core	0.095	2.30	2.64
½	6 x 7 " "	0.38	8.96	10.3
¾	6 x 7 " "	0.84	19.8	22.7
1	6 x 7 " "	1.50	34.5	39.7
1¼	6 x 7 " "	2.50	53.0	61.0
1½	6 x 7 " "	3.38	75.0	86.2
¼	6 x 19 " "	0.10	2.39	2.74
½	6 x 19 " "	0.40	9.35	10.7
⅝	6 x 19 " "	0.63	14.5	16.7
¾	6 x 19 " "	0.90	20.7	23.8
1	6 x 19 " "	1.60	36.4	41.8
1¼	6 x 19 " "	2.50	56.2	64.6
1½	6 x 19 " "	3.60	80.0	92.0
2	6 x 19 " "	6.40	139.0	160.0
¼	8 x 19 " "	0.09	2.04	2.35
½	8 x 19 " "	0.36	8.02	9.23
⅝	8 x 19 " "	0.57	12.4	14.3
¾	8 x 19 " "	0.82	17.8	20.5
1	8 x 19 " "	1.45	31.3	36.0
1½	8 x 19 " "	3.26	69.1	79.4
¼	6 x 37 " "	0.10	2.25	2.59
½	6 x 37 " "	0.37	8.85	10.2
⅝	6 x 37 " "	0.61	13.7	15.8
¾	6 x 37 " "	0.87	19.6	22.6
1	6 x 37 " "	1.55	34.6	39.8
1¼	6 x 37 " "	2.42	53.5	61.5
1½	6 x 37 " "	3.49	76.4	87.9
2	6 x 37 " "	6.20	134.0	154.0
½	18 x 7 " "	0.43	8.57	9.85
⅝	18 x 7 " "	0.68	13.3	15.3
¾	18 x 7 " "	0.97	19.0	21.8
1	18 x 7 " "	1.73	33.3	38.3
1¼	18 x 7 " "	2.70	51.5	59.2
1½	18 x 7 " "	3.89	73.4	84.4

Note—For wire rope core construction add 7½ percent to the listed strength.

Report on Assignment 2

Motor Cars, Trailers and Push Cars

C. E. Morgan (chairman, subcommittee), E. L. Cloutier, Jack Largent, E. H. Ness, P. G. Petri, R. S. Sabins, R. J. Smith, M. M. Stansbury, M. C. Taylor, H. A. Thyng, S. E. Tracy, F. E. Yockey.

This is a progress report, including three plans which are offered for adoption and publication in the Manual.

In 1943 the Association adopted a 16 and 20-in demountable plate wheel to fit a $1\frac{7}{16}$-in axle.

Since that time 14-in demountable plate wheels have been developed that are applicable to $1\frac{3}{16}$ and $1\frac{1}{4}$-in axles. The 16-in demountable wheel has also been applied to these two axles by means of special hubs.

In order that there may be interchangability of parts, it is the thought of your committee that a design showing the dimensions for interchangability was desirable. In developing this design present practices of manufacturers have been followed as closely as consistent with interchangability.

The following are, therefore, offered as recommended practice and are submitted for adoption and publication in the Manual.

Fig. 1—AREA $1\frac{3}{16}$-in motor car axle and end nut.

Fig. 2—AREA 14-in bolted demountable-plate insulated wheel and bushing for motor cars, trailers and push cars using $1\frac{3}{16}$-in axles.

Fig. 3—AREA 16-in bolted demountable-plate insulated wheel and bushing for motor cars, trailers and push cars using $1\frac{3}{16}$-in axles.

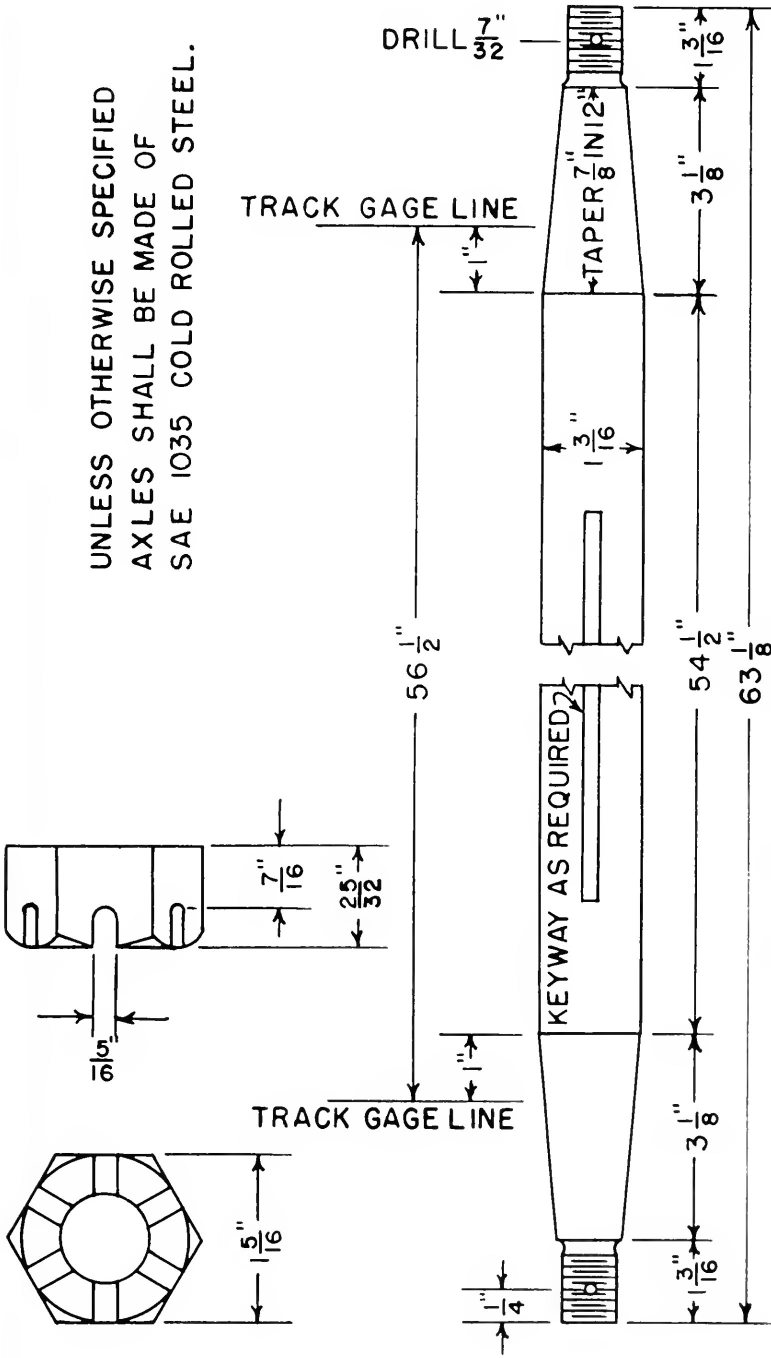
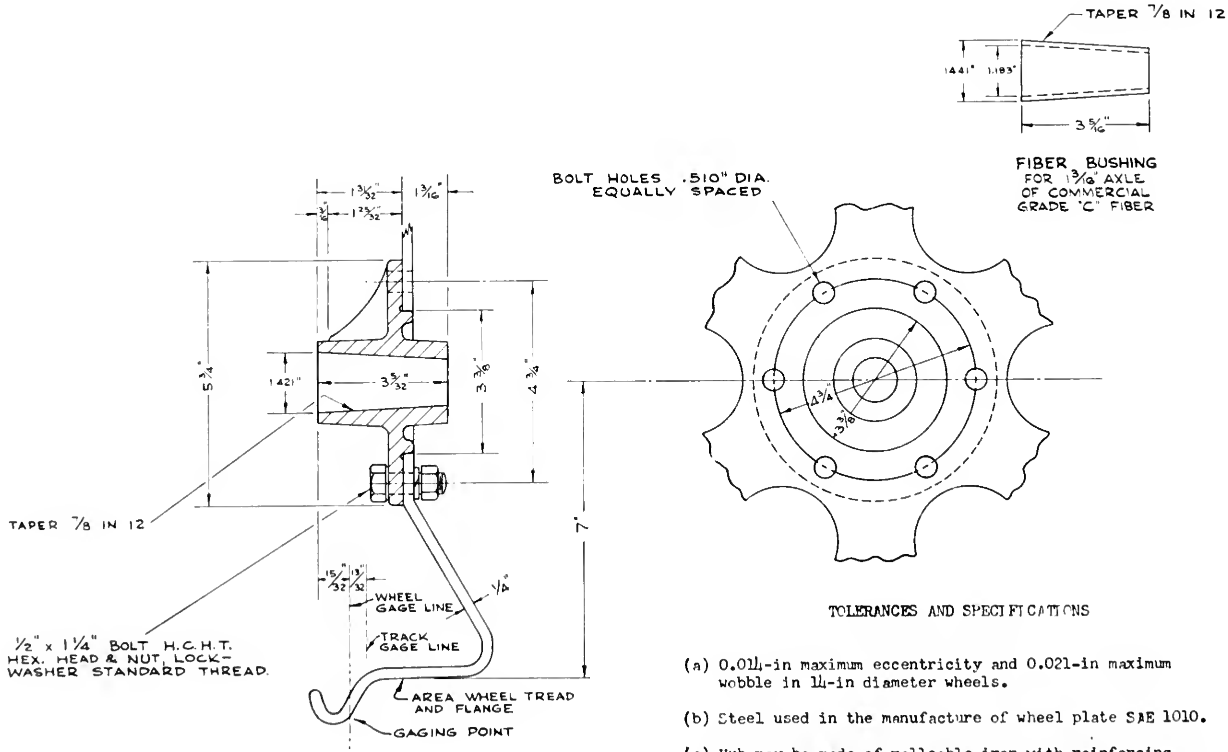


Fig. 1—AREA 1 $\frac{3}{16}$-in motor car axle and end nuts.



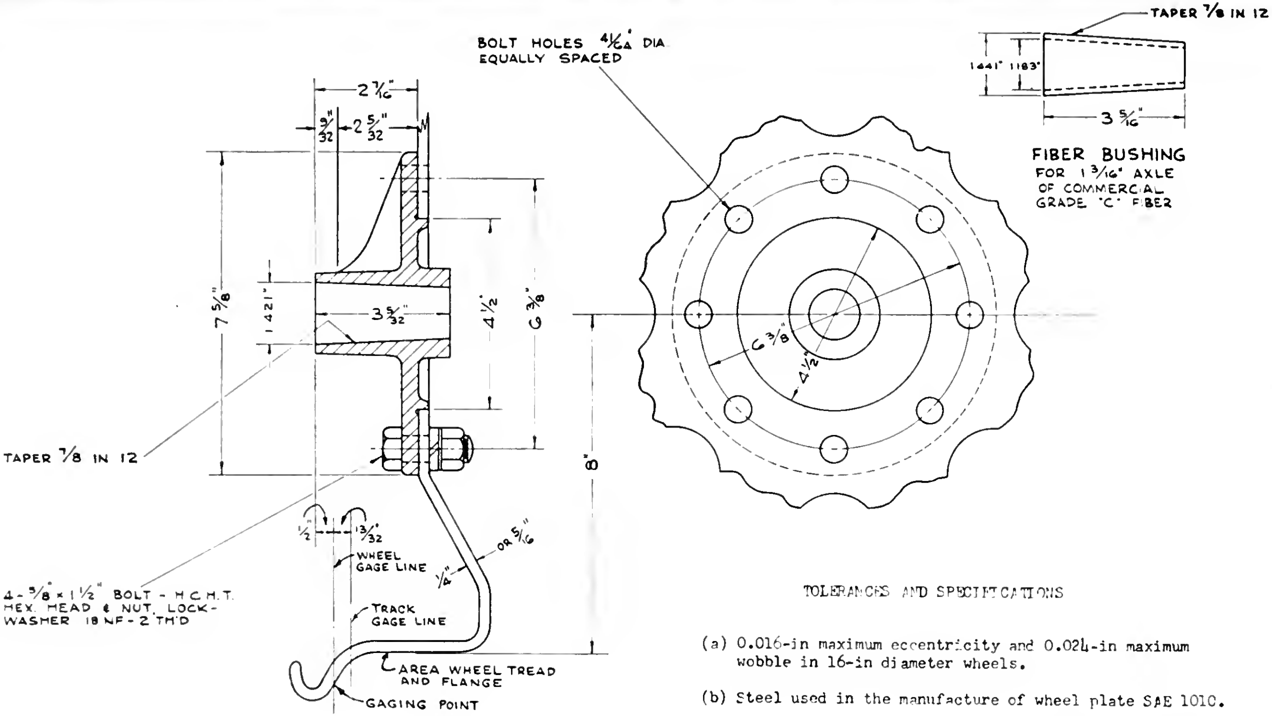
TOLERANCES AND SPECIFICATIONS

(a) 0.014-in maximum eccentricity and 0.021-in maximum wobble in 14-in diameter wheels.

(b) Steel used in the manufacture of wheel plate SAE 1010.

(c) Hub may be made of malleable iron with reinforcing ribs or forged steel SAE 1025 without reinforcing ribs.

Fig. 2—AREA 14-in bolted demountable-plate insulated wheel and bushing for motor cars, trailers and push cars using 1 3/16-in axles.



TOLERANCES AND SPECIFICATIONS

(a) 0.016-in maximum eccentricity and 0.024-in maximum wobble in 16-in diameter wheels.

(b) Steel used in the manufacture of wheel plate SAE 1010.

(c) Hub may be made of malleable iron with reinforcing ribs or forged steel SAE 1025 without reinforcing ribs.

Fig. 3—AREA 16-in bolted demountable-plate insulated wheel and bushing for motor cars, trailers and push cars using 1 $\frac{3}{16}$-in axles.

Report of Assignment 3

New Developments in Work Equipment

H. E. Michael (chairman, subcommittee), R. M. Baldock, R. E. Berggren, W. S. Brown, L. B. Cann, F. L. Etchison, C. L. Fero, J. M. Fisher, W. F. Kohl, H. H. Main, J. F. Piper.

This is a progress report, presented as information.

Previous reports on this subject are to be found in the Proceedings, Vol. 45, 1944, pages 100 and 101; Vol. 50, 1949, pages 350 to 353, incl.; Vol. 52, 1951, pages 340 to 395, incl., and Vol. 53, 1952, pages 380 to 395, incl. This report covers new machines marketed since the last report, with the exception of switch heaters, which are to be reported separately under Assignment 8. This report also includes, at its end, the major improvements or additions that have been made to existing machines since the last report on that subject (Proceedings, Vol. 53, 1952, pages 393 to 395, incl.).

Air Compressor

A radically new 600-cfm portable air compressor, mounted either on rubber-tired or flanged wheels, is now available. This machine incorporates a new type of rotary compressor, containing no valves, pistons or clutch, and driven by a diesel engine. The outstanding features of the machine, as pointed out by the manufacturer, include: Two-stage compression with oil-injection cooling; air discharge temperature of below 200 deg; separate cooling systems for the engine and the compressor; a capacity control which maintains the output of 600-cfm at 100 psi; and hinged side covers. This type of compressor is also now available in 315-cfm, 210-cfm and 105-cfm sizes. See Fig. 1.

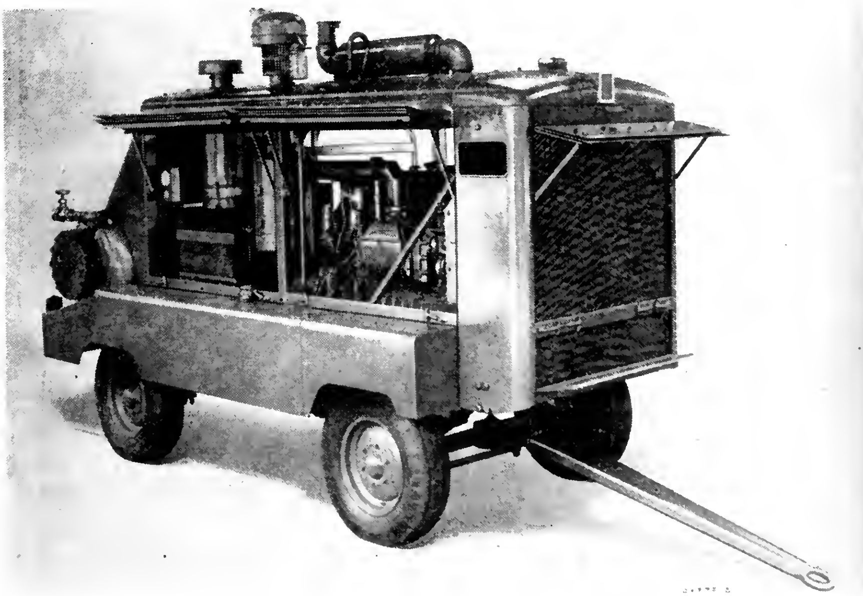


Fig. 1—New-type rotary air compressor.

Ballast Distributor

A track-mounted machine for placing ballast in position for tamping was developed during the year. The self-propelled unit, which can be operated by one man, is designed to pick up ballast from the intertrack space or shoulder by means of two conveyors mounted on opposite sides of the machine, and deposit it in the correct position for tamping—both inside and outside the rail. The amount of ballast picked up is controlled by raising and lowering hydraulically-operated bucket conveyors. Ballast is pulled into the path of the conveyors by means of adjustable gathering wings. This construction is said to permit the wings to pull the ballast in from the entire intertrack space without fouling the adjoining track. For traveling or loading the unit for shipment, the conveyor sections can be folded into the machine.

The ballast picked up by the conveyors is deposited in a 2-cu yd hopper, which is equipped with bottom openings so located as to permit ballast to be placed at the desired position with relation to the rail. The quantity of ballast distributed is controlled by raising and lowering the hopper. Slides in the hopper openings can be closed for carrying ballast to crossings or switches where ballast cannot be unloaded from cars. All functions of the machine are controlled from the operator's position. The operating speed of the machine is said to be between 800 and 1000 ft per hr. Traveling speed is 18 mph. See Fig. 2.

Fig. 2—Bucket-conveyor ballast distributor.

Ballast Regulator and Scarifier

Another ballast regulator and scarifier has been announced. This machine is designed for use with out-of-face surfacing gangs as well as to scarify, de-weed, regulate, and shape the ballast shoulder. With a surfacing gang, it can be used ahead of the gang to regulate and distribute the ballast after unloading. After surfacing is completed, the machine can be used to regulate and shape the ballast shoulder.

Powered by an 85-hp, heavy-duty engine, the unit consists of two ½-yd regulator-and-dresser wings, complete with scarifying teeth, dresser and plow blades, all mounted on a track car.

Bituminous Mixers

Two mixers, designed to handle bituminous materials, have been made available to the railway market this year.

(1) A portable, non-tilting bituminous mixer, said to have had wide usage in the last year by contractors and municipalities, is now offered for railway use.

Furnished on four pneumatic-tired wheels for portability, or on skids for central-mix locations, the mixer is of the pugmill type, equipped with a charging skip, asphalt pump and piping, asphalt-measuring, tip-over type tank, and burners and fuel tank to supply heat to the mixing drum while in operation.

Mixing blades, specially designed for bituminous materials, give pugmill action by thoroughly working the aggregates and oil from end to center of the drum. This is said to coat all the aggregate quickly, giving the minimum batch-time cycle. After mixing, a full batch can be dumped in 6 sec. Although each unit is provided with heaters for batching "hot mixes," emulsified and cut-back asphalts can be used in the mixer to produce "cold mixes" if desired.

An auxiliary loader can be attached to the mixer to handle the mixed material from ground to truck, or to a railroad gondola if desired. The mixer is available in two sizes, one delivering 10 cu ft of mixed material, and the other 14 cu ft.

(2) By combining an aggregate dryer with a twin-shaft pugmill mixer, one company has developed a new unit designed for maintenance and patching work with either hot or cold bituminous mixes or concrete. The machine has a 3-cu ft capacity and the ability to produce up to 5 tons of hot mix or 10 tons of cold mix per hour. Mounted on 2 pneumatic-tired wheels, the unit weighs 6650 lb, and is powered by a 22-hp gasoline engine. The mixer is 7 ft 7½ in. in height, 10 ft 3 in long, and 7 ft 11 in wide. The skip, which is equipped with an automatic top limit throw-out, features a 14-in shoveling height and a 50-deg dumping angle. The dryer is equipped with a low-pressure oil burner for burning kerosene, and a blower and pump for use with furnace or diesel fuel

Bolt Tightener

A new bolt-tightening machine has been put in production during the year. This machine is said to be easy to operate and to maintain, and will enable 2 men to do the work of 8 men equipped with hand wrenches, or an average of 200 to 300 joints a day.

This machine has two socket wrenches, one for turning nuts on each side of the rail, which are driven by an air-cooled gasoline engine through a chain drive, a reverse gear box, and a power-torque clutch. The wrench chucks operate at one speed and their direction of rotation can be instantly reversed by means of a lever. An automatic torque-release lever engages or disengages the clutch to insure uniform tightness to all bolts. Although automatic in action, this feature is easily adjusted to the desired tensions. The sockets are changed by merely raising slide bars.

A pilot wheel at the rear of the machine is adjustable for the different rail sections so that the chucks are at the correct height for engaging the nuts. Set-off wheels are provided for clearing the track quickly.

Bulldozer—Less Push Beams

The cooperative efforts of two manufacturers have developed a new, big-capacity bulldozer, in which the bulldozer frame is bolted directly to the tractor frame to form an integral unit. Thus the tractor frame itself becomes, in effect, the push beam. The integrated tractor-dozer is raised and lowered by double-acting hydraulic cylinders connected to the track frame by a new type of lifting mechanism.

The new bulldozer weighs 3400 lb and is 8 ft wide—1 ft 6 in narrower and 1150 lb lighter than the conventional bulldozer used on the tractor for which it is designed. The new blade has about the same total blade area and capacity as the conventional blade, and has the advantage that it can be transported over highways without permits, whereas the longer blade requires a special permit.

In mounting the new blade, the front spring and saddle are removed from the tractor, and the spring pads are replaced by special brackets to which the lifting mechanism is attached. This type of mounting and suspension is reported to increase clearance greatly, thereby improving operating characteristics in swampy ground. The center of gravity of the tractor, with blade attached, is said to remain well back of the second roller, regardless of blade position. This feature is reported to assure maximum traction under all conditions and permits use of the front-end track bearings.

The new blade has a maximum rise of 37 in above ground level and a drop of 13 in below. The angle of approach, however, is reported to be steeper than might be expected from the 13-in drop, because of the closer mounting of the blade to the tractor frame, permitting the blade to swing on a shorter radius than is possible with a conventional mounting.

Chain Saw—Electric

A new type of electric hand chain saw, for cutting heavy building timbers that are too large for circular saws and that ordinarily must be sawed by tedious hand methods, has been developed. Weighing under 20 lb, the new saw is light enough for one-hand use, although a helper's handle can also be attached so that two men may saw at sharp angles with ease.

The new saw has a thin chain guide and a narrow special-toothed chain designed to produce extremely smooth and precise finish cuts. The cutting bar is 18 in long. Models are available for either 115 or 230-v ac–dc current.

Chain Saw—Gasoline

One manufacturer has announced the availability of a new light-weight chain saw. It has fingertip controls and full 360-deg swiveling. Furnished complete with an 18-in guide bar and chain, the gasoline-driven saw weighs only 27 lb. The use of aluminum and magnesium parts makes possible light weight and yet affords ruggedness to withstand hard usage. An innovation in this saw is an automatic chain oiler which is designed to supply oil to the chain during all cuts.

The newly designed planer-type chain is said to assure fast cutting of all timbers. The rewind starter and the flywheel-type magneto are designed to provide quick starting under all conditions. An automatic clutch halts the chain when the engine is idling.

Crawler Cranes

(1) A completely new ¾-yd crawler crane has been announced which is available with a choice of fronts—crane, shovel, dragline, or pull shovel. This machine, which is in the 45,000-lb class, is equipped with double-walled track pads and special steel castings

with full-length pins. The steel used is a special development that is said to reduce abrasive wear to the minimum, yet withstand the shock and strain of rough travel without breakage. A special alloy steel is used in the boom.

Of significance is a high-speed boom hoist with a controlled lowering arrangement which is standard equipment. It is claimed that the boom radius may be changed with perfect control and without danger of dropping the boom, since the boom lowers against the compression of the engine and can be lowered at any speed desired by the operator. The maximum lowering speed is the same as the maximum raising speed. Ball-joint rod and bearings are used in the hoist, swing and travel linkage systems, while anti-friction bearings are used in the brake linkage systems. This feature is said to reduce pedal-operating effort approximately 60 percent and to give the operator a better "feel" of the brakes. The shovel is equipped with an electric, push-button-operated dipper trip.

(2) One company has added to its line of excavating and materials-handling equipment a new ¾-yd shovel-crane. The crawler base, machinery side frames, and deck of the machine are made of castings and rolled structural steel shapes, used either separately or in combination. The machinery is mounted well back on the deck to give stability and high lifting capacity with the minimum amount of counterweight. Ground bearing pressures are reported to be low. Twin-disk clutches are used for swing and travel motions, for raising and lowering the boom, and for retracting the shovel. Contracting band clutches are used on the hoist drums. Independent travel is an optional feature.

This model can be easily converted from crane to shovel, clamshell, pile driver, dragline, or hoe operations in the field. The standard shovel boom is 18 ft 8 in long, and the standard crane boom is 35 ft long.

Crane–Pile Driver Leads

Another type of folding pile-driver leads for application to a line of diesel-electric locomotive cranes has been announced by one manufacturer. The new leads feature automatic folding into the clearance position, as well as power folding so that the leads may be placed on a car in front of the crane and quickly disconnected for transport from job to job. The leads can be arranged for either manual or power battering, and can accommodate standard pile hammers of various sizes. The cranes are supplied in models which have traveling speeds of 12 mph and higher, and draw bar pulls of up to 18,000 lb at low speed. The electric travel motors under the cranes can be quickly disengaged when it is desired to include the units in trains.

Crow's Nest Platform

A safety platform has been developed by one railroad to attach to the boom of a locomotive crane, primarily to support workmen in cleaning loose rock from high ledges in cuts. Other beneficial uses have also been found for the device.

The nest is 4 ft long by 3 ft wide, and 3 ft high, and is designed to swivel on the ends of the crane's boom-tip shaft. It is kept level by a worm and worm-wheel device attached to arms which, in turn, are hinged to the boom. The worm is operated by a hand wheel attached to a shaft extending just above the top railing of the nest.

Diesel Engine—Horizontal

The availability of a new 200-hp horizontal diesel engine has been announced. The engine is a 6-cylinder full diesel, which operates at 2100 rpm with a compression ratio of 15.5 to 1. Total displacement is 743 cu in, with a bore and stroke of 5⅛ in by 6 in.

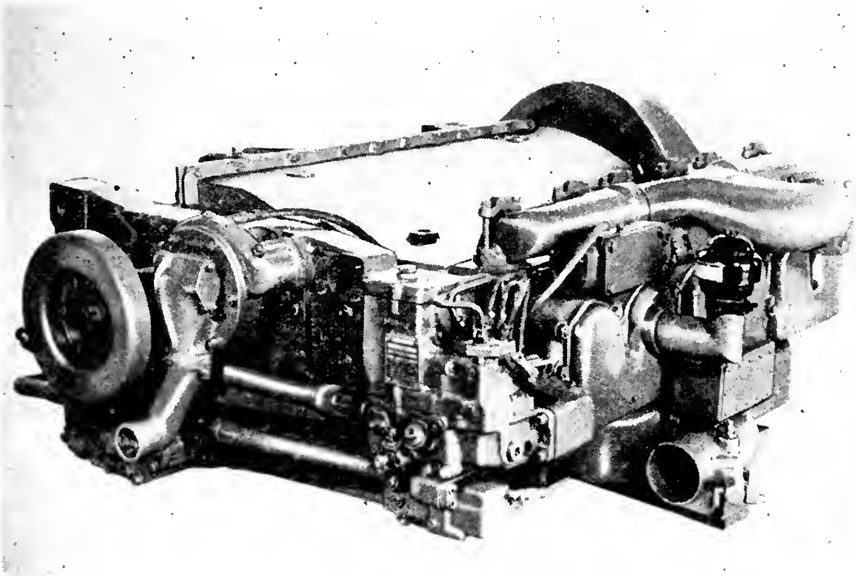


Fig. 3—Horizontal diesel engine.

The new engine is 63 15/16 in long, 55 ¼ in wide, and 22 ¾ in high. Its weight is 2285 lb.

Double-End Loader

A double-end loader which can dig either in the front or rear is now available. Dumping is always accomplished in the front and, since the operator is free to select either front or rear digging, he can load without twisting or turning the tractor. Since the load can be carried in the rear, greater rear-wheel traction is attained and front-wheel pressure diminished to facilitate steering. Whenever the loading bucket is lifted 5 ft off the ground, the bucket assumes a vertical position which it maintains during its swing over the tractor to the front dumping position. In the entire operation of digging and loading the operator need operate only two controls.

The accessories available for the unit include a combination bulldozer and angle-dozer which can be used without removing the bucket from the loader, a double-end load-spotting crane, and six different loading buckets for various operations.

Drills—Pneumatic

Two drills permitting one-hand operation in overhead or "awkward spot" jobs are now being marketed. One unit weighs only 7½ lb and is intended for drilling holes up to 1¼ in. in diameter. It is equipped with a "quick change" chuck which speeds up drill changes and holds rotating drill steels, non-rotating chisels, and moil points, while adapters are available for "A" and "B" taper-shank star drills. The other unit weighs 14 lb and is for drilling holes up to 1¾ in. Air consumption for both units is reported to be relatively low.

Electric Plane—Portable

A new portable electric plane that is claimed to be equally efficient for both flat surface and edge planing has recently been introduced. The plane, features a 3-in width of cut and a depth-of-cut capacity of ⅛ in. A lever controls the depth of cut and can be set at graduations of 1/64 in. A special chip deflector removes chips from the work area and may be directed to the right or left as desired. The cutter head, which travels at a speed of 13,500 rpm, is said to produce a smooth, ripple-free surface which normally requires no sanding. Power is transmitted from the motor through a reinforced non-slip sprocket-type belt, designed to prevent stalling even in the hardest wood. Bevel adjustments are made by loosening two wing nuts and tightening them at the desired angle. The unit weighs 10½ lb, is encased in an aluminum-alloy housing, and incorporates ball-bearing construction throughout. Standard equipment furnished with the plane includes a steel carrying case, a pair of steel alloy blades, a hex locking key, and a blade honing adjustment gage. See Fig. 4.

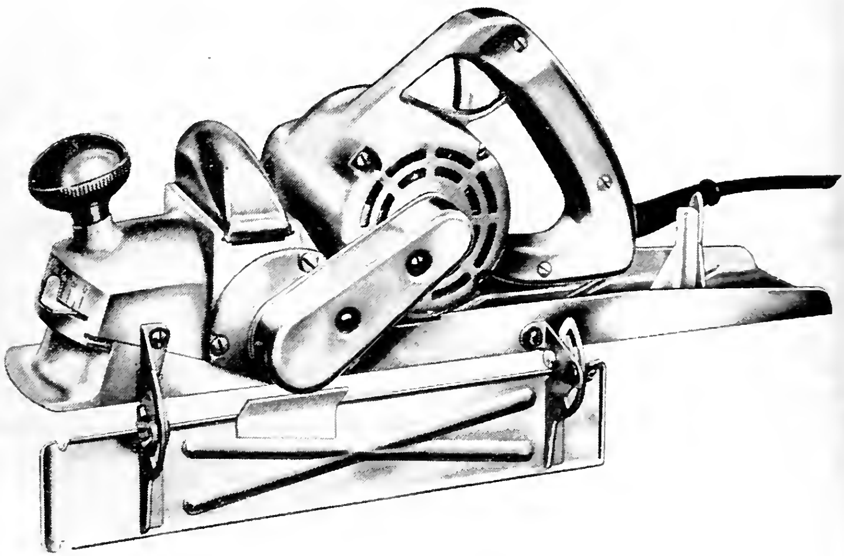


Fig. 4—Portable electric plane.

Gaging Machine

The cooperative efforts of members of Committee 27 and a railway supply company have produced a new gaging machine. It rides one rail on special conical rollers. A gliding shoe or runner, adjusted to the exact width of the base of the rail being laid, glides along the rail seats of the distributed new tie plates, bringing them to a line which produces exact gage of the running rail. This machine carries a multiple wood drill for boring holes simultaneously for two anchor spikes, by inserting the bits through the anchor-spike holes of the tie plates. The gaging machine is preceded by a sliding template, by means of which the tie plates are placed in approximate alinement. In its original form, the gaging machine also carried a spike hammer for driving anchor spikes, and an air compressor driven by a separate gasoline engine. Subsequent improvements have included the removal of the spike hammer, air compressor and engine, with the result that the weight of the machine has been substantially reduced, while its mobility has been increased. Also, a detachable side frame with wheels has been developed for the glider side to permit the machine to be run along both rails to and from the job. When working, this side frame is detached and placed on outrigger arms on the other side of the machine, where it serves as a counterweight. The shoe has been equipped with rollers so that it is now unnecessary to daub grease ahead of the machine on the rail seats of the tie plates, as was formerly done to reduce friction. Also, the shoe is now adjustable for various rail-base widths. See Fig. 5.

Fig. 5—Gaging machine.

Generator—High Cycle

A new, dual-purpose, high-cycle generator, has been introduced which provides high-cycle alternating current for the operation of electric tools, as well as direct current for floodlighting and the operation of universal tools. The unit is powered by a one-cylinder, air-cooled, two-cycle gasoline engine, which is said to operate for 1¾ hr on a gallon of fuel at full load. It develops 2500 w of 180-cycle, 3-phase, 230-v alternating current, as well as 2500 w of 110-v direct current. Outstanding features of the generator include large-size carbon brushes, specially treated armature and field coils, and "V" ring commutator construction. Weighing 125 lb, the generator unit is 25 in long, 18 in wide, and 20 in. in heighth.

Motor Graders

Two completely new motor graders have been announced. One of them weighs 23,000 lb, is powered by a 4-cylinder, 2-cycle diesel engine developing a brake horsepower of 104, while the other, weighing 22,700 lb, is powered by a 3-cylinder, 2-cycle diesel engine developing 78 hp.

Features of these motor graders include tandem drives; completely enclosed hydraulic booster systems; high axle clearances; and accurate blade control. Accessories and special attachments are available for each.

New standards of operating ease include complete visibility, needle-bearing-mounted operators' seats, freely accessible controls, large roomy platforms on single tubular frames, and all-around operator comfort. Accessibility to major assemblies for repair or service is another important feature of these machines. By simply tilting forward the combined fuel tank and seat, the transmission, clutch and drive-shaft assemblies are exposed, enabling both the clutch and transmission to be removed without disturbing the engine or floor plates.

Power Saw, Tractor Mounted

A new power-saw drive that mounts either a heavy-duty chain saw or a circular saw to a two-wheel tractor has been announced. The saw units mount directly on the front of the tractor and are interchangeable by removing and replacing a heavy self-locking nut and two metal collars. The chain-saw unit, designed for timber falling and bucking, incorporates a 24-in bar, with longer bars available on special order. The circular unit, designed for the clearing of scrub trees and brush, has a blade diameter of 26 in. The units may be purchased singly or in a combination.

Pump

An 18-lb portable pump that attaches to a chain-saw engine without any modification has recently been developed. Especially adaptable to fire fighting, the pump will deliver 50 gpm at 125 psi. The manufacturer claims that the change from pump to chain saw and vice versa can be accomplished in less than 1 min without the use of any tools. See Fig. 6.

Rail Drill Bit Dresser

A new grinder has been developed for dressing flat beaded rail-drill bits. The complete unit consists of two grinding wheels driven by an electric motor or gasoline engine. Three fixtures are provided by which a flat beaded bit can be dressed to the proper cutting angle. Other special holders and arms can also be supplied for dressing other types of bits. When driven electrically, the machine is equipped with a 1-hp, 3450-rpm, 60-cycle, single-phase 115/230-v motor. Thus equipped, the machine weighs 200 lb, and is 21 in high, 37 in long and 22 in wide.

Rail Drill Bit-Sharpener Attachment

An attachment for sharpening flat-beaded rail drill bits has been designed for use with a bit grinder. This device is said to fulfill all the requirements for obtaining perfectly sharpened bits.

Rail Lifter—Hydraulic

During the year one manufacturer announced a hydraulic rail lifter for removing and inserting tie plates. The actual lifting mechanism of this machine is incorporated in a semi-enclosed beam, mounted on pantograph arms. These arms are spring counter-

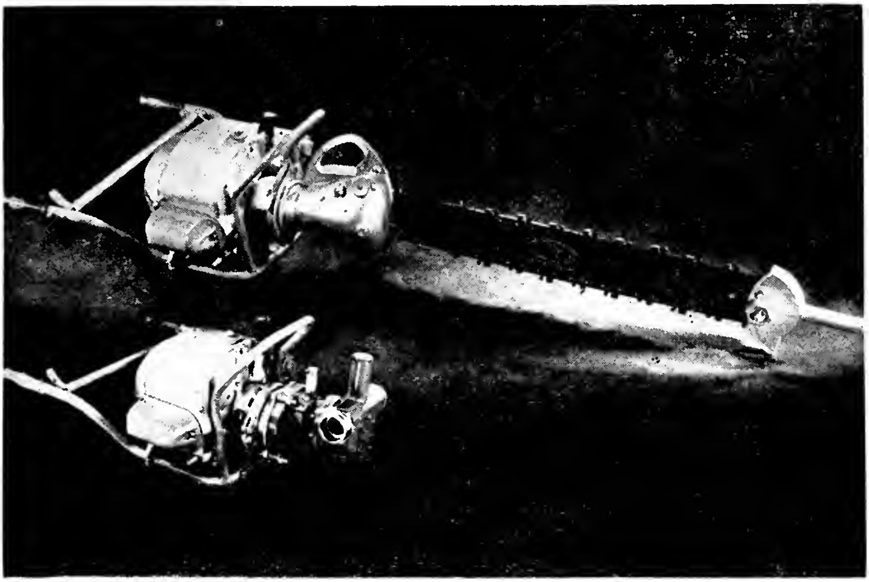


Fig. 6—High-pressure water pump driven by chain-saw engine.

balanced, so that the lifting beam can be raised or lowered with minimum effort. Mounted on the beam are two single-acting hydraulic rams, a control valve, a rail-clamp lever, and rail clamps. The linkage for these clamps is such that the greater the pull, the tighter they grip the rail. The supporting frame or chassis is of welded construction, and has four alloy cast-steel rail wheels that turn on sealed-for-life ball bearings. Also on this chassis are the engine and direct-driven hydraulic pump, unloading valve, pneumatic set-off wheels, and self-storing extension lift pipes.

In operation, the machine is placed over the tie from which the tie plates are to be removed. Then the lifting beam is moved down against the rail and the clamp engaged to the rail. Opening the hydraulic valve causes the two rams to push down against the tie. This forces the lifting beam upward, raising the rails. Tie plates can then be removed or inserted as desired. With the pneumatic wheels lowered and the lift pipes extended, it is relatively easy for two men to remove the machine from the track. See Fig. 7.

Rod Cutter

A hydraulic cutter, which is said to cut reinforcing rods up to ½-in. in diameter with ease, has been offered to the railway market. This model weighs 12 lb and is 21 in long. It is claimed that a pressure of 8500 psi is exerted in the hydraulic cylinder, which is equivalent to a thrust of 10 tons at the cutter. The tool has a newly designed dual-ratio pump, which combines rapid traverse with high power to minimize cutting time.

Rotary Broom

A rotary broom has been developed for application to one of the baby bulldozers reported by this committee last year. As a result the tractor can now be used for such jobs as cleaning snow or debris from walks, driveways, platforms, etc. It can

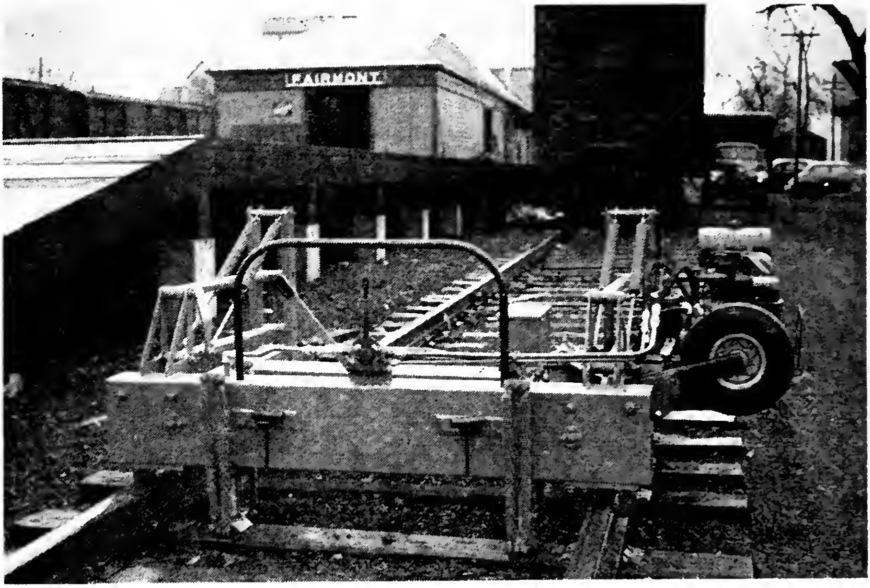


Fig. 7—Hydraulic rail lifter.

also be used for cleaning the interior of cattle cars where larger tractors cannot be maneuvered.

The rotary broom is attached to the front end of the tractor by special shafts and is driven at speeds ranging from 120 rpm to 200 rpm by an auxiliary 2-hp engine. The broom is available with either India–Palm bristles or with wire bristles.

Scraper

During the year one manufacturer announced the production of two scrapers.

(1) One unit has a flat-bottom bowl and stinger blade engineered for loading and finishing characteristics. The reversible blade cuts a 7-ft 8-in swath; the bottom is double with steel-beam fillers. The capacity of the scraper is 9 cu yd heaped. Top extensions or side-boards are available to boost this capacity to 8.3 cu yd struck, and 11.5 cu yd heaped. Maximum carrying capacity is 11.5 tons. Also included are such design details as an unobstructed bowl, tapered roller bearings at the axles, induction hardened sheaves and bulldozer-type ejection. Operation is by means of a cable control available for attachment to the manufacturer's crawler tractors.

(2) The second model has a struck capacity of 21.2 cu yd; is designed for use with a relatively large crawler tractor and moves dirt with the aid of a hard-surfaced, reversible cutting edge. Material is carried in a flat, double-bottom bowl of high-tensile steel. The scraper is operated through a cable-control unit which can be mounted on the rear of the tractor to provide for positive loading and ejection.

The scraper is equipped with two 24.00–29 tires at the front and two 27.00–33 tires at the rear. Each axle is equipped with tapered roller bearings. When the scraper is loaded, 60 percent of the weight is carried on the rear tires.

The scraper's struck capacity is 21.2 cu yd, which can be increased to 25.5 cu yd through the use of top extensions or sideboards. Likewise, through the use of sideboards, the heaped capacity of the unit can be increased to 31 cu yd.

Snow Blower and Melter

A dual-purpose machine combining a rotary snow blower with a snow melting tank has been developed and has seen service on several railroads during the past year. It consists essentially of a large steel tank mounted on a 70-ton flat car, which also incorporates, at the forward end, rotary rakes, rotors, and chutes for picking up and discharging snow and ice in any direction or into the snow melting tank. Also mounted at the forward end of the car over the rotary power unit and pump mechanism is the operator's cab. When in operation the unit is pushed by a steam locomotive, which also furnishes steam for melting snow.

The rotary snow blower at the forward end of the machine is similar in design to that used widely on highway equipment. Gathering wings are provided to allow a coverage of 14 ft when they are in the extended position. When adjusted inward the wings span a width of 11 ft, or they can be folded back behind the moldboard to width of 9 ft. Near the forward end of the flat car is a hydraulic power-operated scarifier which plows and loosens packed snow and ice to a depth of 3 in below the tops of the rails. When the combination unit is used merely as a snow blower it is said to be capable of casting snow approximately 75 to 100 ft in either direction.

The snow-melting function of the machine takes place in an enclosed section of the main tank, which has ventura openings at its top front end to permit the entry of snow from the rotary blower. The top half of this chamber contains multiple water-spray units to form a dense shower of heated water into which the snow enters in disintegrated form. The melting tank has a capacity of 19,000 gal. When this amount of water has accumulated from melting snow, the unit is moved to a bridge or other suitable location and the water is discharged through 16-in dumping gates in the lower sides of the tank. There are four such outlets, two on each side. The gates in the outlets are operated manually by levers on top of the tank. When dumping, a total of 3300 gal of water is retained in a reservoir in the tank, which is circulated to the sprays during the next melting cycle.

Spike Driver

A new spike-driving machine has been developed for use with pneumatic hammers. It carries a pneumatic spike hammer, 50-gal air storage tank, and a 30-cfm air compressor, powered by a single-cylinder, 8-hp gasoline engine—all mounted on an all-welded undercarriage of tubing and angle iron. It is manually propelled on four small flanged wheels with roller bearings, and can be stopped quickly by pulling back on a push handle which applies brakes to two of the wheels. When pressure is applied to the push handle, as when pushing the machine forward, the brakes are released, and, when the push handle is released, as when unattended, a spring action brings the brakes in contact with the wheels.

In addition to the usual safety valve, the compressor is equipped with an automatic unloader valve which prevents the accumulation of more than 110 lb of pressure, and automatically idles the engine and compressor until the pressure drops to 95 lb. When this point is reached the engine resumes its governed speed.

Two men—a machine operator and a helper—are required for the operation of the machine. One man holds the spike in a spike-holding tool, while the other operates the hammer. The machine is also equipped with two 8-in by 4-in pneumatic set-off wheels on one side of the unit. These wheels can be locked in the "up" position while the machine is operating, and in the "down" position when setting it off. Two handles on the opposite side of the machine enable the two men to remove the unit, which has a total weight of 580 lb. The lifting weight is 210 lb. See Fig. 8.

Spike Puller—Hydraulic

A hydraulic spike puller was introduced during the year which requires only one man to operate it. Because of its weight distribution, an operator can remove it from the track without help. To aid in set-offs and re-railing, there are two hinged, pneumatic set-off wheels and self-storing lift pipes.

Construction is such that the pulling assembly takes all the load. The guides for the puller jaws act as legs and support the hydraulic cylinder. The pulling assembly has a ball and socket mounting to permit some variation in order to locate the jaws properly over the spike. The puller mounting has sealed-for-life ball-bearing grooved wheels operating on a transverse alloy-steel track. This track allows the unit to pull spikes from either rail while traveling in one direction by merely shifting the pulling assembly from one side to the other.

For easier operation, the pulling assembly, mounting, and track are supported by spring counter-balanced pantograph arms. A single-cylinder, air-cooled engine is direct connected to a gear type, self-lubricating pressure pump by a flexible coupling. The hydraulic system features an unloading valve for longer pump life, and a precharged bladder type of pressure accumulator to give faster action. This spike puller, primarily intended for use by tie-renewal gangs, can also be used in other work where operating economy can be effected by a machine having a pulling capacity of 8 to 12 spikes per minute. See Fig. 9.

Tie-End Remover

In tie removal work the task of removing the old ties without trenching or jacking the track is frequently carried out by sawing each tie into three pieces, and then pulling out the pieces separately. A new machine has been designed which permits one man to remove both end pieces simultaneously. This machine consists essentially of a double-ended hydraulic cylinder mounted in a horizontal position at right angles to the track on one end of a steel frame with four double-flanged wheels. The cylinder pistons are actuated by a hydraulic pump driven by an air-cooled engine.

After a tie has been cut on both sides with a tie cutter, the operator of the tie-end remover moves up to the cut tie, lifts out the center section with a pair of tongs, and lowers the hydraulic cylinder into the tie bed. Then he opens a valve, which causes the pistons to move outward and push the tie ends clear of the rails. The pistons exert sufficient force to push out the tie ends regardless of the weight of rail or type of tie plates, and no jacking or trenching is necessary.

Tie-End Trimmer

One manufacturer has added a tie-end trimmer to supplement its tie-cutting machine. This machine is designed to saw off the ends of long ties to a uniform line so that ballast cleaning equipment, scarifiers, diskers, etc., can work up close to the ends of the ties, thereby avoiding the formation of mud dams at the ends of the shortest ties. The under-carriage consists of a four-wheel underslung trailer provided with removable extension bars that serve as a mounting for the tie cutter which, in its working position, is clamped to the bars with the saw from 4 to 4½ ft from the center of the track.

Fig. 8—Pneumatic spike-driving unit.

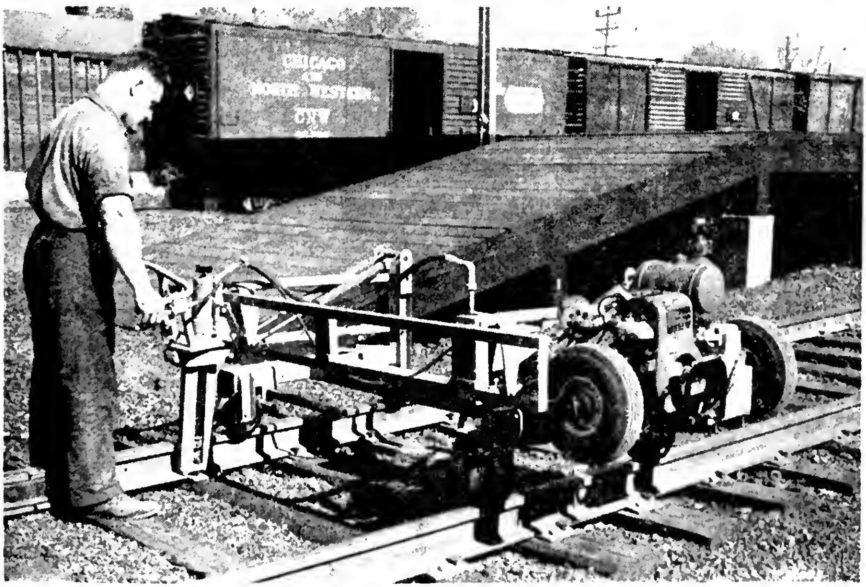


Fig. 9—Hydraulic spike puller.

When clearing for trains, the tie-end cutter is quickly unclamped from the bars and set off, after which the trailer is removed from the rails. For towing the unit behind a motor car while deadheading, the tie cutter is removed from its working position and set on the deck of the trailer where it, as well as the extension bars and clamps, can be unbolted to present a clear deck if it is desired to use the trailer for other hauling when not in tie-end trimming use.

Tie Inserter and Remover

Two new tools, designed to facilitate tie renewal work, have been announced. One is for removing old ties, and the other—a companion tool—is a replacer for inserting new ties. Each tool consists essentially of a manually-operated jacking mechanism which, when hooked to a rail, exerts horizontal power through a rack bar.

Operation of the tie remover calls for three steps: (1) Tie plates are removed; (2) ballast is loosened at both ends of the tie and removed at the pushing end to a depth flush with the bottom of the tie; and (3) the tie remover's rail grip is hooked over the top of the rail and the pushing head of the rack bar is placed against the tie end.

The tie replacer is used by placing the new tie partly under the first rail in the cavity left by the old tie. A hook on the end of the rack bar is placed over the rail and the new tie is pushed into place by the tie replacer housing traveling along the rack bar.

Portability of both devices is made easy by a roller on the end of each unit, which fits over the rail so that the unit can be rolled along the rail top. The tie remover weighs 62 lb and has an overall length of 98 in, with a travel of 80½ in. The tie replacer weighs 60 lb and has an overall length of 116 in, with a travel of 86 in.

Tie Nipper

The production of two tie nippers has been announced.

(1) One of these devices consists of a crossbeam supported on one side by a roller and on the other by a pair of double-flanged wheels which ride on the rails. Mounted on the crossbeam is a frame which serves as the fulcrum for a lever, by means of which the lifting action for nipping the ties is applied. Fastened to the forward end of the lever is a pair of tie tongs, which can be fastened and released by means of a lever within convenient reach of the operator. One man can easily exert enough pressure to nip the tie against the rails while spikes are being driven.

(2) The second tie nipper announced during the year weighs 130 lb and has a welded steel frame, insulated cast-alloy steel wheels, and heat-treated cast steel hooks with renewable heat-treated alloy steel points.

The connecting block for fastening the hook-links to the handle is offset. When in use, this offset is down and the hooks are in position to grab the tie. Giving the handle a 180-deg turn brings the offset to the top and holds the hooks up and away from the ties. A workman can then push the unit along the track with the handle at a convenient height.

Tie Puller and Inserter

A combination tie puller, tie inserter, and light crane, designed primarily for use in out-of-face tie renewal and track raising operations was recently put on the market. The new machine is comprised basically of a frame mounted on four wheels, a power-driven winch, and a telescoping boom. When employed in its tie-pulling capacity, the boom, fully extended, is lowered to an almost horizontal position at right angles to the track, and a brake and thrust member is placed in contact with the gage side of the head of the rail on the operator's side. The winch cable, extending from the end of the boom, is fastened to tongs attached to the end of the tie, so that when power is applied, the tie is pulled from the track.

To insert new ties with the unit, the boom is first raised to a position approximately 45 deg to the horizontal. A demountable sheave is locked in position on the lower portion of the frame and a detachable thrust member is placed in position on the machine and against the rail under which the tie must first pass. The cable is then passed around the sheave and out over the head of the rail. The free end of the cable is fastened to a specially designed tong which grips the end of the tie. The operator causes the winch to draw in on the cable, and the operator's helper guides the tie as it is pulled into place by means of a long handle attached to the special tong. The helper can control the tie both in direction and elevation by the pressure he exerts on the handle.

When used as a crane, the machine will handle loads up to 2000 lb, and may be employed to load or unload ties and other material, and to lift comparatively light track machines on or off the track.

The unit is powered by an air-cooled, single-cylinder, 4½-hp gasoline engine, which drives the two double-bevel frictions (for propulsion and winch) through a fluid coupling. See Fig. 10.

Track Dresser, Power-Operated

A power track dresser has been designed to sweep ballast from the ties, establish a toe line, pick up and relocate excess ballast where desired, and to shape the ballast of both shoulders to the desired contour.

Powered by a 35-hp gasoline engine, this machine is operated by one man who has finger-touch control of all the machine functions. It is designed to perform the hourly track dressing output of the 8 to 10 laborers usually assigned to this type of work following a production tamping operation. It has a work-speed of approximately ¾ mph, a running speed of approximately 25 mph, and a power set-off mechanism which facilitates its use in single-track territory. See Fig. 11.

Tractor Shovel

Another rubber-tired, high-lift was made available during the year. Some of the features of this unit include a 4-wheel drive with full-reversing transmission, providing 4 speeds in each direction; a 1-cu yd capacity hydraulically controlled bucket; rear-wheel steering with power booster; powerful hydraulic brakes; unusual operator visibility; and large pneumatic tires. This machine, available with either diesel or gasoline power, has a total weight of 12,400 lb, a large portion of which can be applied to the bucket cutting edge to facilitate penetration in hard digging and below-grade excavation.

Track-Tool Transporter

A demountable track-tool transporter has been designed with a 4-ft by 5-ft weatherproof plywood deck backed with corrugated steel, which is supported on a 4-piece tubular steel frame mounted on four 6-in insulated wheels. The unit is provided with a tubular steel push handle which may be attached at either end of the car. It is said that the entire unit may be easily set up or dismantled in less than a minute for easy loading on a truck, bus or motor car. Although it weighs only 160 lb, the new car is said to be capable of carrying up to 1000 lb of tools and materials.

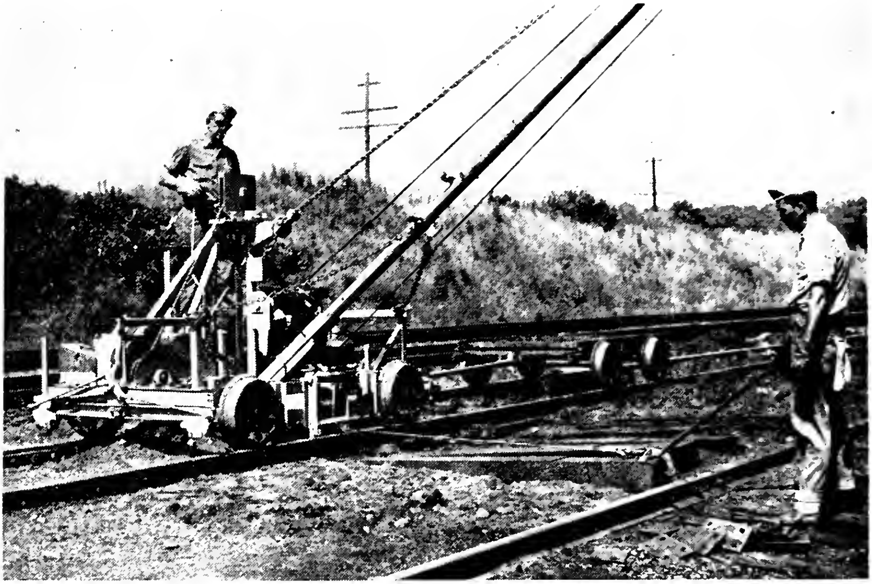


Fig. 10—Tie puller and inserter.

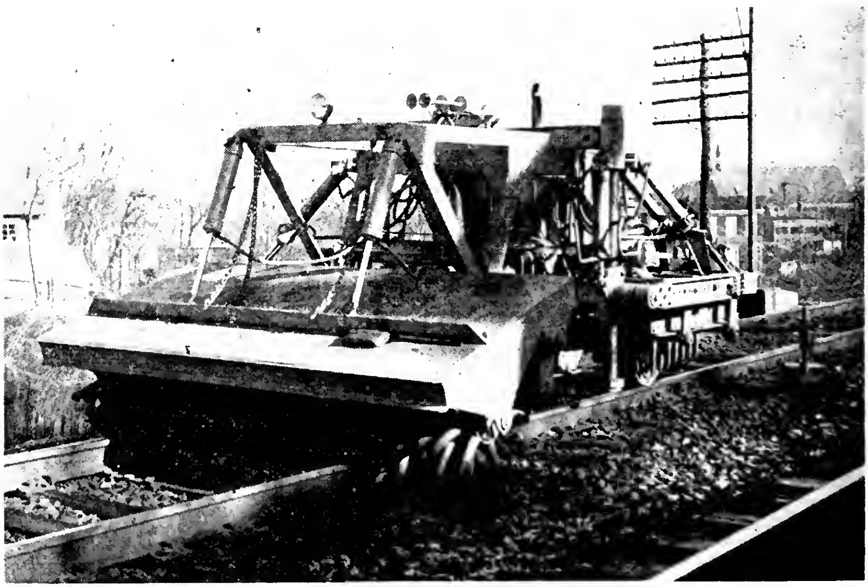


Fig. 11—Power-operated track dresser.

Wagon Drill, Self-Propelled

A new self-propelled, self-powered wagon drill has been announced. The drill is said to have the ability to operate in a 180-deg arc at any angle, and at a distance of 6 ft from the rear of a tractor-compressor by means of an extension arm attached to a vertical centerpost. The device, which can be used for both rock drilling and paving breaking, is constructed so as to permit drilling horizontally at a distance of 10 ft above ground level, or 3 ft below. When in transit, the unit fits in front of the rear tractor wheel and close to the tractor body, permitting normal travel.

IMPROVEMENTS TO EXISTING MACHINES

Dump Units—Portable

Dumping units for use on push trucks are now furnished with several improvements in design. Lifting handles are now secured to the sides of the body and a new trip-gate mechanism has been added which permits "remote-control" dumping. Other improvements include a new locking catch, new stake pockets, new pump mounting, and new tail-gate design.

Multiple Electric Tamper

Two improvements have been announced in the multiple electric tamper as the result of suggestions made by Committee 27. One is a hydraulically-actuated indexer for moving the machine from tie to tie, and the other a hydraulic set-off.

(1) The indexer provides instantaneous forward and reverse action with positive braking. A single control lever regulates this movement in such a way as to assure high speed and quick stops. For emergency and special use, a hand wheel for manually moving the tamper from tie to tie has been retained, although the wheel is not mounted on its vertical shaft when the hydraulic indexer is in use. It is said to be a simple matter, however, if the need should arise, to use the manual indexing feature to apply the hand wheel and cut out the hydraulic indexer.

(2) The hydraulic set-off lift has a tri-point, three-ram lift. With this device the operator can raise the tamper off the track in 3 sec or less by actuating a valve at the control stand. Then two men can quickly position the set-off rails under the set-off rollers. The machine is then lowered by the operator to engage the rails, and the tamper pushed onto the set-off. The manufacturer claims that this operation may be accomplished in 60 sec by the operator and two assistants.

Power Saw

The pneumatic saw listed in last year's report has recently been improved through standardization of certain features. Chrome-plated saw blades with all-steel rivets are now standard on all units. The use of these blades, according to the manufacturer, results in reduced friction which maintains blade sharpness and reduces corrosion. Micarta wear plates have been installed on the pistons, with a consequent reduction in friction and increase in power. A nylon shuttle valve has increased the service life of the steel valve assembly. New heavy-duty pistons have been installed, giving the saw greater strength for all load conditions.

Track Cleaner

In response to the pleas of Committee 27 one of the manufacturers of track cleaners has improved its machine so as to make it possible to load material into hopper cars at least 11 ft 6 in above the top of rail. In fact, the redesigned machine is said to be capable of discharging material at a height of 15 ft 7 in.

Tractor Mower

A side-arm, hydraulically-operated mower adapted for use with an industrial tractor has been improved by: a redesigned flywheel having a ball-bearing crank pin that requires lubrication but once each season; a Pitman drive; a knife assembly with double back-bar and machined ball; a cast mounting plate assembly; and an improved comination valve and tank assembly.

Report on Assignment 4

Improvements to be Made to Existing Work Equipment

L. E. Conner (chairman, subcommittee), Edgar Bennett, W. S. Brown, R. E. Buss, J. M. Giles, M. E. Kerns, S. H. Knight, W. E. Kropp, V. M. Oswalt, Sr., J. W. Risk, W. I. Stadter, H. A. Thyng.

This is a progress report, submitted as information.

This is a continuation of the progress report submitted by this committee and found in Vol. 53, 1952, page 396, and covers changes in work equipment that this committee has found to be both practical and desirable.

Rail Saw. This is a portable machine, gasoline driven, and is used to saw rails in the field.

Suggested improvements to this machine are: Redesign the present rail clamp so as to clamp the machine positively to the rail; redesign the gibs and adjustment so as to prevent the present gib liners shearing off the gib adjusting screws.

Power Rail Layer. This machine is designed for placing rail in the track from the shoulder of the roadbed, requiring three men to operate the older model and two men to operate a recent model.

Suggested improvements to this machine are: Redesign the worm gear drive case so as to incorporate anti-friction bearings and provide means to properly adjust the worm and gear; change the physical characteristics of the steel used in the dollie wheels so as to increase their service life; provide a pressure-type grease fitting for lubricating the dollie wheel bearings.

Mechanical Spike Puller. This machine is an on-track mechanical device for pulling track spikes.

Suggested improvements to this machine are: Discontinue the present brass bushing loose wheel design and incorporate some form of differential axle; change the design of the axle bearing so as to prevent the bearing rollers from running directly on the axle.

Power Adzing Machine. This machine is used to adze the cross ties to a predetermined level in rail relay programs.

Suggested improvement to this machine is: Redesign the axle bearings so as to prevent the bearing rollers from running directly against the axle.

Adzing Machine Bit Grinder. This is a portable, gasoline-powered grinder for sharpening adzing machine bits and small tools.

Suggested improvements to this machine are: Redesign arbor for the present anti-friction-type bearings to eliminate present friction-type bearings; replace the present flat belt with V-type belts; provide a larger engine so as to increase service life.

Machines Incorporating Hydraulic Equipment. There are a number of machines, such as ballast cleaners, bulldozers, cribbers, tie tampers, yard cleaners, etc., that are equipped with hydraulic pumps and fluid motors.

Suggested improvements to these machines are: Provide for the checking of hydraulic pressures by placing a tee and other suitable fittings in the lines at all points at which pressures must be determined to enable the repairmen to quickly locate the source of any trouble which may develop. The plugged end of the tee or other fitting should be placed where a pressure gage can be mounted without disturbing the hydraulic lines or other parts of the equipment.

Ballast Removing Machine. This machine is used for removing foul ballast from the cribs between the ties.

Suggested improvement to this machine is: When installing the boom idler bearing tube, it is proposed that after this tube is welded in place, to internally grind the inside of the tube to size. This will result in a better finish to a closer tolerance, giving a better support to the ball bearing and, at the same time, prevent it from turning in the tube.

Report on Assignment 5

Instructions for Lubrication of Work Equipment

N. W. Hutchison (chairman, subcommittee), Haynie Hornbuckle, Herbert Huffman, S. H. Knight, C. F. Lewis, Harry Mayer, H. C. Nordstrom, J. W. Risk, R. J. Smith, M. M. Stansbury, M. C. Taylor, E. E. Turner.

This is a final report, submitted as information.

In 1942 this committee presented a comprehensive report on this subject under the title "Lubrication of Roadway Machines", which dealt primarily with the description, selection, testing, and specifications for oils and greases. It is recommended that those interested in the subject read and study this previous report, which is found in Vol. 43 of the AREA Proceedings for 1942, on pages 193 to 206, incl. As an introduction to this current report, the following remarks, excerpted from the previous report, appear pertinent to the subject of lubrication instructions:

"To use lubricants economically, it is necessary for the users to have an accurate understanding of their source and nature."

"Before discussing the qualities of a serviceable lubricant, it is necessary to answer the question as to why a lubricating oil or grease for a piece of work equipment, after once adopted, cannot be standardized for all railroads. As each section of the country has a different crude petroleum base it would be more economical to use a lubricant from a crude oil supply convenient to the point of use rather than from distant locations.

"Service tests will give facts as to the desirability of a lubricant for the purpose intended; however, the human element of personal preference has a considerable effect on the choice of the lubricant. That is, where two or more oils give satisfactory service, the same oil will not always be selected by different individuals. Atmospheric temperatures in the various sections of the country also govern the lubricant used."

"In the selection of a lubricant due consideration should always be given to economy; that is, the lubricant which will give the best average friction reduction at the most economical cost. The important considerations may be summed up as follows:

1. The equipment to be lubricated.
2. Safe operation.
3. Confidence in the refiner from whom the lubricant is secured.

"Having in mind the various crudes from which lubricants are obtained, and the properties and chemical terms used, it is important then to give consideration to the properties and chemical composition which are desirable when selecting a lubricant. These are as follows:

1. Proper viscosity to keep the surfaces apart under maximum pressure.
2. Small carbon residue.
3. Pour point.
4. Separation from emulsion.
5. Low coefficient of friction.
6. Capacity for absorbing and carrying away heat.
7. Freedom from tendency to oxidize or gum.
8. High flash point or temperature at which vaporization takes place.
9. Freedom from corrosive acids.
10. Freedom from abrasives."

Failure to lubricate a machine, or faulty lubrication of it, is a prime factor contributing to the eventual failure and destruction of the machine. In general, the machine manufacturer includes in his operating manuals specific instructions covering his machine, stating where and when to lubricate. In a report of this nature it is impractical to attempt to give directions for the lubrication of all types of work equipment. However, while certain operating manuals give complete instructions covering lubrication, others have little or nothing on the subject. In addition, there are general principles relating to the lubrication of railroad maintenance of way work equipment that cannot be covered by manufacturers' instructions. To fill this void is the aim of this report of your committee, and the following instructions are intended as a means of providing railroad officers with the nucleus for a manual of instructions to be placed in the hands of those charged with the responsibility of operating and maintaining work equipment.

GENERAL INSTRUCTIONS FOR LUBRICATION OF WORK EQUIPMENT

1. Many machine failures are caused directly or indirectly by lack of, or improper lubrication. Application of a lubricant is ineffective unless it reaches and protects the wearing and bearing surfaces.

2. It is essential that the correct lubricant be used. The operator of a machine must know what oils and greases are suitable for use with his machine and how, where, and when to apply them. In the absence of other specific instructions, the machine manufacturer's instructions should be followed relative to the kind of lubricant and the method of application.

3. Lubricants should be protected carefully to insure that dirt does not get into them. They should be kept in closed containers.

4. All grease and dirt must be removed from lubrication fittings and from the nozzle of a grease gun before grease is applied. Caps must be kept on grease cups at all times, except when filling.

5. Oil should never be applied where grease is required, nor grease applied where oil is needed.

INSTRUCTIONS FOR LUBRICATION OF GASOLINE AND DIESEL ENGINES

6. There are four important functions that an engine oil must perform:

a. Minimize friction and wear.
b. Absorb and dissipate heat.
c. Serve as a piston seal.
d. Carry away contaminants.

7. The important points to remember about engine lubrication are:

a. Use oils of known quality only.
b. An oil should be selected which has the correct body for the particular service and temperature in which the engine is to be used. Lighter oil is required during cold weather; heavier oil during hot weather. In cold climates an oil should be used which has a pour point at least 10 deg F below the lowest temperature to be encountered.
c. It is very important that the viscosity of an oil be correct. An oil should be viscous enough to maintain a fluid film between the bearing surfaces, in spite of the pressure tending to squeeze it out. It should be recognized that the viscosity of oils is no measure of their quality, but is merely a set of numbers to indicate their relative fluidity at a set temperature. The viscosity of an oil is measured by observing the time required for a predetermined quantity of it to flow from a reservoir through a standard size orifice, at a given temperature. The lower the SAE number of an oil the easier it will flow, and the lighter it is.

NOTE: A new classification of SAE numbers covering crankcase lubricating oils was adopted in 1950 and became effective as of April 3, 1952, and the old classification has been discontinued. The new SAE viscosity numbers for crankcase oil are 5–W, 10–W, 20–W, 20, 30, 40, and 50.

8. The correct lubrication of an engine is one of the most important necessities in its design, construction and operation. The life and service of an engine depend directly upon its lubrication; therefore, the best of attention and care should be given to the selection of the proper lubricant and to its effective use in the engine.

9. Engine troubles, such as scored cylinders; leaky and loose piston rings; worn, hot, and cut bearings; misfiring cylinders; dirty spark plugs; and excessive fuel consumption are due largely to inefficient or defective lubrication.

10. The correct oil level should be maintained in the crankcase of the engine at all times, and no engine should be started until the operator has assured himself that the crankcase oil is at the proper level and that other lubrication has been provided.

11. The crankcase should not be more than full, as indicated by the full mark on the oil level indicator. Overfilling a crankcase causes excessive quantities of oil to be thrown against the cylinder walls, resulting in oil pumping, smoking, excessive carbon deposits, and fouled spark plugs.

12. Oil should be drained from the crankcase when it becomes dirty or contaminated and replaced with fresh oil. The oil pan should be cleaned as required, and at least once a year.

(In deciding when crankcase oil should be drained, consideration must be given to whether the engine is equipped with an oil filter, and also to whether the crankcase oil in use is of a detergent type and whether it contains dispersion additives. The purpose of a detergent oil is to clean the engine, and dispersion additives are designed to carry the engine dirt in suspension. Therefore, a detergent oil may appear to be dirty when it actually is not. Under ordinary conditions, and in the absence of specific instructions from the engine manufacturer, where an engine is not equipped with an oil filter, the crankcase oil should be changed about every 50 hr of operation. With a new or rebuilt engine the oil should be changed every 20 hr during the first 100 hr of operation.)

13. Never drain oil or fill with oil while the engine is running. Drain the oil while the engine is hot.

14. When necessary to add oil to the crankcase between oil changes, it is considered desirable to use the same make and brand of oil which is in the crankcase. This is particularly true in the case of detergent oils because of the fact that different brands may contain dissimilar chemicals which may react unfavorably.

15. To prevent dirt or water from entering the engine while filling with oil, the filler cap and the outside of the filler tube should be wiped off before the cap is removed. The breather cap must always be replaced after oil is put in to prevent dirt from entering, make sure that the cap is clean before it is replaced.

16. When observation indicates that more oil is being used than should be used, report of this fact should be made to the person in authority.

17. In new four-cycle engines, or when cylinders have been rebored or new rings installed, ½ pint of light engine oil should be mixed with each gallon of gasoline during the first 100 hr of operation.

18. On pressure-lubricated engines an oil pressure gage is usually provided. If the gage fails to register normal running pressure, the engine should be stopped immediately and the necessary adjustments or repairs made.

19. When the overhauling of an engine is completed, a thin film of oil should be applied to each cylinder wall before the cylinder head gasket and cylinder head are replaced, to facilitate initial starting and to minimize cylinder wear.

20. When an engine is stored for long periods, lubricating oil may drain away from the cylinder walls and piston rings, causing them to rust. To prevent this, when the engine is taken out of service, and while it is still hot, the spark plugs should be removed and a small quantity of gas engine oil poured into each cylinder, the engine turned over a few times, and the spark plugs replaced. Each 30 days during the period of idleness, oil should be inserted in a similar manner.

21. The oil filter, if an engine is so equipped, should be serviced regularly and the cartridge replaced when it has served its useful life, as indicated by dirt or sludge.

22. To be effective as a lubricant and as a cooling agent, oil must circulate freely. Oil lines, oil pump screen, and oil filters must be kept clean.

23. When starting an engine, it should be idled slowly until the oil is flowing freely, before a load is applied. This is particularly important in cold weather. Although it is frequently more practical to let an engine continue to run, particularly in the case of diesel engines, unnecessary idling should be avoided.

24. When an engine is badly worn it is not advisable to use a heavier bodied oil to compensate for the wear of parts. Excessive clearances make oil pumping inevitable,

regardless of the grade of oil used. The use of heavier oils will simply result in greater carbon deposits and clogging of the lubrication system. No oil, no matter how heavy, can take the place of metal that has been worn away.

SPECIAL INSTRUCTIONS FOR THE LUBRICATION OF CERTAIN MACHINES, PARTS, AND APPLIANCES

Motor Cars

25. Two-cycle engines are lubricated by mixing the lubricating oil with the gasoline. This mixture is often called "mixed gas." The fuel tank on this type engine should be stenciled "Use Mixed Gas Only" because failure to provide suitable lubrication may cause heavy maintenance expense.

26. The oil used in mixed gas should be of high quality, and the amount and grade should be as specified by the engine manufacturer. Both oil and gasoline should be measured; the color of the mixture cannot be depended upon to determine whether the mixture is correct.

27. The gasoline and oil must be thoroughly mixed before being placed in the fuel tank. No attempt should be made to add additional oil to the tank because it may clog the carburetor jets and the engine may lose power or stop for lack of sufficient gasoline.

Water Pumps

28. In general, and except when otherwise instructed, all water pumps on engines should be lubricated with waterproof grease.

Pneumatic Tools

29. A teaspoonful of thin oil should be poured into the air inlet before operating each day, and at 2 or 3-hr intervals during the working day.

30. Light oil should always be used in lubricating, because heavy oil might gum and clog the tool.

31. On pneumatic tools equipped with pressure-gun fittings, the tools should be greased according to manufacturer's instructions.

32. Throttle valves should be lubricated with compressor oil at the close of each day's work to prevent rust as a result of moisture in the air supply.

33. When pneumatic tools are to be idle for long periods, they should be immersed in an oil bath, after all rubber parts have been removed.

Ball and Roller Bearings

34. Oil or grease should not be washed out of a new bearing.

35. Where grease is used to lubricate anti-friction bearings, the housing should be packed only ½ to ¾ full. More than this amount will cause the bearings to drag, causing heat, and excessive pressure will damage the seals. Grease should not be put in with grease guns or compression cups unless the bearings have relief vents. On plain bearings, the lubricant should be applied until it comes out at the side of the bearings, after which the excess should be wiped off.

36. Grease for ball and roller bearings should be free from acid-forming tendencies in order to protect the highly polished surfaces.

37. All foreign matter should be kept out of ball and roller bearing lubricants.

Chains

38. The outside of exposed chains should not be lubricated, except as recommended by the manufacturer. The rollers and pins generally require lubrication. When chains

require cleaning, they should be soaked in kerosene and then dried. They should then be soaked in hot oil and all oil on the outside surface carefully removed.

Distributors

39. Each bearing of a breaker-distributor unit should be given one or two drops of clean cylinder oil about every 50 hr of operation. Oil should be kept off the contact points. A trace of clean oil or grease placed on the cam will keep it from rusting. Distributors should not be overlubricated.

Oil Filters

40. The crankcase should be drained when a filter element is renewed and refilled with clean oil, adding sufficient to recharge the filter.

Flexible Shafts

41. Flexible shafts should be inspected frequently, and approximately once each month of operation all grit and dirt should be removed, cleaning the parts with kerosene or other approved cleaner, and new light-bodied, graphite-free, extreme-pressure grease should be applied. The shaft housing should also be flushed out. All parts should be permitted to dry thoroughly before being replaced, and special care should be taken to see that the parts do not collect dirt and dust while being cleaned.

42. Too much grease should not be applied to a flexible shaft. To do so will cause heating and damage the shaft. As long as the core has a slight film of grease throughout its length, there is sufficient lubrication. Grease should be applied at the driving end of the shaft because its motion will then have a tendency to spread the grease towards the driven end. A flexible shaft should never be lubricated with oil unless its speed is greater than 6000 rpm, in which case machine oil or a light-bodied sponge grease should be used.

Generators and Starter Motors

43. Starting motors and generators, if provided with oilers for lubrication of the bearings, should be oiled with five or six drops of light, high-grade oil. The generator should be oiled lightly about every two months. Care should be taken that neither is over-lubricated, and oil should be kept off the commutator or brushes.

Magnetos

44. Extreme caution should be used in oiling magnetos. Excess oil will seriously damage a magneto by causing arcing at the contact points. Oil should be put only into receptacles provided for that purpose. The oil used should be light, clean and of a good quality. A few drops every 50 hr of operation should be sufficient. Many magnetos are furnished with factory-packed bearings and no oiling of these should be attempted.

Electric Motors

45. They should be lubricated according to the manufacturer's instructions, in the receptacles provided, but oil and grease should be kept away from other parts of the motor.

Transmissions and Differentials

46. The correct grease or oil as recommended by the machine manufacturer should be used in transmissions and differentials. This must always be sufficiently fluid so that it will not channel. Transmission and differential oil should be changed twice a year,

(Text continued on page 675)

THE NORTH AND SOUTH RAILROAD

MAINTENANCE OF WAY DEPARTMENT

CIRCULAR MW-76

LUBRICATION CHART FOR WORK EQUIPMENT AND ROADWAY MACHINES

This chart will be followed for lubrication of Maintenance of Way Department work equipment and roadway machines.

Oils shall be changed and greases applied as per manufacturer's instruction sheet accompanying each unit of equipment. It will be the responsibility of the Division Engineer to see that the manufacturer's instructions are furnished to each machine operator.

New types of equipment will be acquired which this circular will not cover. For machines not included below, the manufacturer's recommendations for lubricants shall be followed. Requisitions for lubricants for such machines and for lubricants not covered by an item number, shall give the SAE number, the type of machine, make of engine, and part to be lubricated.

Machine	Make of Engine	Location for Lubricant	Summer SAE No.	Summer Item No.	Winter SAE No.	Winter Item No.
		ROADWAY EQUIPMENT - GENERAL				
Note: All water pumps on engines shall be lubricated with waterproof grease, item number 37-5-8, except as otherwise noted.						
Adzer	S&V	Crankcase	30	37-11-3	20	37-13L-3
		Grease fittings	-	37-6-10	-	37-6-10
Bolt Tighteners (Make B)	R (model Z)	Crankcase	20	37-13L-3	20 W	37-13L-3
		Gear cases	140	37-8-3	90	37-11-12
		Grease fittings	-	37-6-10	-	37-6-10
Compressor Make A All Models	Make U Various Models	Engine Crankcase	30	37-11-3	20	37-13L-3
		Grease Fittings	-	37-6-10	-	37-6-10
		Propelling Motors	30	37-11-3	30	37-11-3
		Chain Gear Case	90	37-11-12	90	37-11-12
		Starting Motors	10	37-13L-2	10	37-13L-2
		Magnetos	10	37-13L-2	10	37-13L-2
		Compressor Crankcase	20	37-13L-3	10	37-13L-2
Crane, Rail Laying Make F All Models	Makes Q&U	Crankcase	30	37-11-3	20	37-13L-3
		Gear Cases	140	37-8-3	90	37-11-12
		Journal Box	car oil	37-9-7	car oil	37-9-7
		Grease Fittings	-	37-6-10	-	37-6-10
		Distributor, Generator & Starting Motor	10	37-13L-2	10	37-13L-2
		Magneto	10	37-13L-2	10	37-13L-2
		Wire Rope & Open Gears	-	37-1-4	-	37-1-4
Tractor Bulldozer Make C	Make U	Crankcase	30	37-11-3	10	37-13L-2
		Air Cleaner	10	37-13L-2	10	37-13L-2
		Distributor	10	37-13L-2	10	37-13L-2
		Starting Motor	10	37-13L-2	10	37-13L-2
		Generator	10	37-13L-2	10	37-13L-2
		Hydraulic System	30	37-11-3	10	37-13L-2
		Final Drive Gear Housing	30	37-11-3	30	37-11-3
		Final Drive Clutch Housing	30	37-11-3	30	37-11-3
		Clutch Housing	30	37-11-3	10	37-13L-2
		Transmission	30	37-11-3	30	37-11-3
		Grease Fittings	-	37-6-10	-	37-6-10
Trenching Machine Make A	Make Y	Crankcase	30	37-11-3	10	37-13L-2
		Air Cleaner	30	37-11-3	10	37-13L-2
		Generator	10	37-13L-2	10	37-13L-2
		Starter	10	37-13L-2	10	37-13L-2
		Distributor Wick	10	37-13L-2	10	37-13L-2
		Oil Cups	10	37-13L-2	10	37-13L-2
		Gear Cases	140	37-8-3	90	37-11-12
		Grease Fittings	-	37-6-10	-	37-6-10

THE NORTH AND SOUTH RAILROAD

MAINTENANCE OF WAY DEPARTMENT

CIRCULAR MW-76

LUBRICATION CHART FOR WORK EQUIPMENT AND ROADWAY MACHINES (cont'd)

Machine	Make of Engine	Location of Lubricant	Summer SAE No.	Summer Item No.	Winter SAE No.	Winter Item No.
		ROADWAY EQUIPMENT - DIESEL OPERATED				
		Crane				
Crane, Locomotive Makes A, B, & C	Make P Model 1	Truck Journal Boxes	Car oil	37-9-7	Car oil	37-9-7
		Transmission	140	37-8-3	90	37-11-12
		Grease Fittings	-	37-6-10	-	37-6-10
		Gear Cases	140	37-8-3	90	37-11-12
		Boom Hoist Worm Gears	140	37-8-3	90	37-11-12
		Ball & Roller Bearings		37-7-11		37-5-10
		Wire Rope & Open Gears	-	37-1-4	-	37-1-4
		Electric Motor Bearings (ring oiled)	20	37-13L-3	10	37-13L-2
		Engine				
		Diesel Crankcase	30 HD	37-12A-11	10 HD	37-12A-3
		Starting Engine Crank case	30 HD	37-12A-11	10 HD	37-12A-3
		Fuel Injection Pump Housing	30 HD	37-12A-11	10 HD	37-12A-3
		Air Cleaners	30 HD	37-12A-11	10 HD	37-12A-3
		Lighting Generator				
		Crankcase	30	37-11-3	10	37-13L-2
		Magneto	10	37-13L-2	10	37-13L-2
Generator, Power Make F	Make X Model 3	Engine Crankcase	30 HD	37-12A-11	10 HD	37-12A-3
		Air Cleaners	30 HD	37-12A-11	10 HD	37-12A-3
		Fuel Injection Pump	30 HD	37-12A-11	10 HD	37-12A-3
		Fan Hub Bearing	-	37-6-10	-	37-6-10
		Magneto	10	37-13L-2	10	37-13L-2
		Charging Generator	10	37-13L-2	10	37-13L-2
		Motor Alternator & Exciter Grease Cups	-	37-6-10	-	37-6-10
		ROADWAY EQUIPMENT - MOTOR CARS				
Make A, Type 1	Make Q&S	Crankcase	30	37-11-3	20	37-13L-3
		Transmission	140	37-8-3	90	37-11-12
		Differential	140	37-8-3	90	37-11-12
		Axle Bearings & Pressure Fittings	-	37-6-10	-	37-6-10
Make A, Type 2	Make U	Crankcase	20	37-13L-3	10	37-13L-2
		Transmission	140	37-8-3	90	37-11-12
		Differential	140	37-8-3	90	37-11-12
		Axle Bearings & Pressure Fittings	-	37-6-10	-	37-6-10
Make A Type 3	Make N	Crankcase	40	37-13L-5	20	37-13L-3
		Transmission	140	37-8-3	90	37-11-12
		Differential	140	37-8-3	90	37-11-12
		Axle Bearings & Pressure Fittings	-	37-6-10	-	37-6-10
Make A Types 4, 5, & 6	Make M	Axle Bearings & Pressure Fittings	-	37-6-10	-	37-6-10

(Note: 3/4 pts. of SAE 30 motor oil, Item #37-11-3, to be mixed with each gallon of gasoline)

ITEM NO.	ESSO STAN
1	Diol 55
2	Arapen brak
3	Diol 65
4	Faxam 58
5	Diol 50
6.	Esstic 45
7	Surett Comp
8	Surett Comp
9	Surett Comp
10	WS-2464 Lub
11	Surett Comp
12	Coblax 5000
13	Essofleet HD
14	Essofleet HD
15	Essofleet HD
16	Essofleet HD
17	Essofleet HD
18	Diol RD 76 (
19	3449 Lubrica
20	3520 Arapen
21	Andok Lubric
22	Beacon Lubri
23	Esso Motor O
24	Esso handy o
25	
26	Esso bearing
27	Esso fibre g
28	Esso fibre g
29	Esso fibre g
30	Esso fibre g
31	Esso fibre g
32	Cylmer X-1
33	Cantone 140
34	Andok lubric
35	Castroleum O
36	Andok lubric
37	Andok lubric
38	Epic lubrica
39	Kutwell 40
40	Aresar 50
41	Esso gear oil
42	Esso gear oil
43	Esso track r
44	Esso track r
45	Esso track r
46	Esso XP comp
47	Esso XP comp
48	Diol 65
49	Diol 80
50	Diol 90
51	Diol 70
52	Essofleet HD-
53	Essofleet HD-
54	Essofleet HD-
55	Essofleet HD-
56	Essofleet HD-
57	Diol 80
58	Essofleet 10
59	Essofleet 20
60	Essofleet 30
61	Essofleet 40
62	Essofleet 50
63	Essolube SDX-
64	Essolube SDX-
65	*
66	*
67	Essolube HDX
68	Essolube HDX
69	*
70	Esso water pu

* Information not f

THE NORTH AND SOUTH RAILROAD

CHART OF EQUIVALENT LUBRICANTS - PRODUCTS OF VARIOUS OIL REFINERS AND PRODUCERS

(Note: This chart is a typical one. A chart for actual use should indicate products of refiners and producers readily available)

ITEM NO.	ESSO STANDARD OIL COMPANY	HUMBLE OIL & REFINING COMPANY	IMPERIAL OIL LIMITED	KENDALL REFINING COMPANY	THE PURE OIL COMPANY	SHELL OIL COMPANY	SINCLAIR REFINING COMPANY	STANDARD OIL COMPANY OF CALIFORNIA	STANDARD OIL COMPANY OF INDIANA	THE TEXAS COMPANY
1	Diol 55	Diol 55	Diol 55	52 machine oil	Klondyke heavy	Carnea Oil 41	Marine engine oil	Calol Diesel engine oil 55	Stanoil Industrial Oil #51	Algol
2	Arapen brake cylinder lubricant	Arapen brake cylinder lubricant 2	Galena AAR Brake Cylinder Grease	*	Poco HT Grease F	Brake Cylinder Lubricant	AAR Brake cylinder lubricant	Calol brake cylinder lubricant	Superla brake cylinder lubricant	AB Brake Cylinder Lubricant
3	Diol 65	Coray 65	Diol 65	Reliable 40	Klondyke special heavy	Carnea Oil 51	Gascon oil D	Calol journal oil 25	Indoil Industrial oil #75	Aries
4	Faxam 58	Necton 60	DB Oil 61	Reliable 30	Klondyke heavy	Carnea Oil 41	Gascon oil C	Calol red engine oil 20	Stanoil Industrial oil #51	Altair
5	Diol 50	Diol 50	Diol 50	Reliable 20	Klondyke heavy medium	Clavus Oil 33	Gascon oil B	Calol turbine oil 15	Stanolind Ice machine oil heavy	Alcaid
6	Esstic 45	Esstic 45	Polar 45	Reliable 10	Klondyke medium	Carnea Oil 29	Gascon oil A	Calol turbine oil 11	Stanoil Industrial oil #15	Cetus
7	Surett Compound 1100	Surett 1100	Surett 1000	SHV 20	Poco Compound #100	*	Onyx lubricant H	Calol pinion grease 1	Calumet compound #6	Crater #1
8	Surett Compound D-1500	Surett 1100	Surett Fluid 2	SHV 20	Poco Compound #100	*	Gear protective compound	Calol gear lubricant	Calumet compound #6	Crater #1X
9	Surett Compound 800	Surett 250	*	*	Poco Compound #50	Cardium Compound "C"	*	Calol gear lubricant	Calumet compound #1	Crater #A
10	WS-2464 Lubricant	Surett 2000	Surett Fluid 7	*	Poco Compound #200	Cardium Compound "F"	Gear protective compound	Calol pinion grease 2	RR gear lubricant #5	Crater #A-X
11	Surett Compound 310	Surett 250	Surett 400	All-oil gear lube SAE-250	Pure AF Mineral	*	Light onyx flange oil	Calol pinion grease 0	Calumet compound #5	Crater #00
12	Cohlax 5000	Surett 5000	Surett 5000	SR-1	Poco Compound #500	Cardium Compound "H"	Onyx lubricant IH	Calol pinion grease 5	RR gear lubricant #5	Crater #5
13	Essofleet HD-10	Necton HD (10)	Marvelube 10	F-L 10	Purol HD Motor Oil (10)	Golden Shell Motor Oil	Tenol (10)	RPM Delo heavy duty SAE 10	HD oil - SAE 10	D-303 oil (10)
14	Essofleet HD-20	Necton HD (20)	Marvelube 20	F-L 20	Purol HD Motor Oil (20)	Golden Shell Motor Oil	Tenol (20)	RPM Delo oil H. R. SAE 20	HD oil - SAE 20	D-303 oil (20)
15	Essofleet HD-30	Necton HD (30)	Marvelube 30	F-L 30	Purol HD Motor Oil (30)	Golden Shell Motor Oil	Tenol (30)	RPM Delo oil R. R. SAE 30	HD oil - SAE 30	D-303 oil (30)
16	Essofleet HD-40	Necton HD (40)	Marvelube 40	F-L 40	Purol HD Motor Oil (40)	Golden Shell Motor Oil	Tenol (40)	RPM Delo oil R. R. SAE 40	HD oil - SAE 40	D-303 oil (40)
17	Essofleet HD-50	Necton HD (50)	Marvelube 50	F-L 50	Purol HD Motor Oil (50)	Golden Shell Motor Oil	Tenol (50)	RPM Delo heavy duty SAE 50	HD oil - SAE 50	D-303 oil (50)
18	Diol HD 76 (or WS-2325)	Diol HD 76 (or WS-2325)	Galena HD 76	*	Purodiesel XD-40	Talona R Oil	Gascon oil GI-HD or GI-CC	RPM Delo oil R. R. SAE 40	HD oil - SAE 40	Dieseltex HD-40
19	3449 Lubricant	Veo Estan #1	Galena Grease No. 12	No. 7 pressure	Poco graphite cup grease #1	Unedo Grease 1	Pennant graphite grease #2	Calol rail & flange lubricant	Stanolind rail and flange lubricant	Grease (#904)
20	3520 Arapen pressure gun	Castroleum #1	Marvelube Grease No. 11	Chassis lube	Poco bearing grease #1	Bismeta Grease 1	Opaline chassis lubricant	RPM chassis grease T.B. medium	Pressure gun grease	Grease (Pressure #922)
21	Andok Lubricant B	Fybroleum C	Grease No. 165	*	*	Aero Shell Grease 5	#955 high temperature grease	Calol O. H. T. grease	Stanobar grease #2	Grease (High temp. #1999)
22	Beacon Lubricant M-285	Humble multipurpose	Beacon Lubricant M 285	*	*	Alvania Grease 1	Opaline pressure system grease #0	Calol grease 0-1-2-3-4-5	Artic cup grease #3	Grease (Low temp. #965)
23	Esso Motor Oil (or Essolube HD)	Esso extra motor oil	Essolube HD	Kendall 2000 mile oil	*	Shell X-100	Tenol	RPM motor oil	Polarine motor oil - SAE 30	Havoline
24	Esso handy oil (or Telura L-40)	Household lubricant	Esso Handy Oil	Household oil	#4402 Oil	Shell Handy Oil	Household oil	RPM handy oil	Finol household oil	Home lubricant
25	*	Necton 40	Porum 40	Lemon oil	#4403 Oil	Carnea 21	Ale-ther oil	*	Polar machine oil	Hydra Oil
26	Esso bearing grease	Andok B	Marvelube Grease No. 33	Universal joint grease	*	Simnia Grease 2	Sincolube #2	RPM chassis grease medium	Stanotar grease #2	Marfak #2 HD
27	Esso fibre grease A	Esso fiber Grease A	Marvelube Grease No. 1	*	Poco fibre grease #1	Simnia Grease 1	Sincolube #1	RPM tractor roller lubricant heavy	Stanotar grease S	Marfak #1
28	Esso fibre grease C	Andok C	*	Wheel bearing grease	*	Simnia Grease 3	Sincolube #3	RPM wheel bearing grease heavy	Wheel bearing grease - heavy	Marfak #3 HD
29	Esso fibre grease 9-F	Esso fiber grease 9-F	Marvelube Grease No. 0	*	Poco fibre grease #00	Simnia Grease 07	Bearing grease #00	RPM tractor roller lubricant light	Superla grease #18	Marfak #00
30	Esso fibre grease A-4	Esso fiber grease A-4	Marvelube Grease No. 7F	No. 0 fibre	Poco fibre grease #0	Simnia Grease 0	Sincolube #0	RPM Tractor roller lubricant medium	Superla grease #39	Marfak #0
31	Esso fibre grease C	Esso fiber grease C	*	Wheel bearing grease	Poco fibre grease #3	Simnia Grease 3	Sincolube #3	RPM wheel bearing grease medium	Wheel bearing grease medium	Marfak #5
32	Cylmer X-140	Cylanto T-140	Galena X 190	600 No. 1	Medal valve	Nassa Oil K79	Jade cylinder oil #290	Calol cylinder oil 155 PX	Indacyl oil W	Pinnacle cylinder oil
33	Centone 140	Velvet CC-140	Turbiol 140	Kendall oil GG	Pure C Mineral	Vitrea Oil 78	Rubilene oil super heavy	Calol marine oil 140	Stanoil Industrial oil #220	Regal oil K
34	Andok lubricant B	Andok B	Grease No. 252	*	Poco sponge grease #2	Alvania Grease 2	Bearing grease AF #2	Calol C. A. grease 2	Stanobar grease #2	Regal Starfak #2
35	Castroleum 0	Castroleum #0	Arctic No. 1	*	Poco super service grease #0	Unedo Grease 1	Opaline pressure system grease #0	Calol grease 1	Superla grease #39	Star grease #0
36	Andok lubricant M-200	Andok M-200	*	*	Poco sponge grease #2	*	Bearing grease AF #3	Calol grease 2	Superla grease #42	Starfak grease H
37	Andok lubricant M-275	Andok M-275	Grease No. 165	No. 50 fibre	Poco sponge grease #1	Nerita Grease 3	Bearing grease AF #2	*	Superla grease #39	Starfak M
38	Epic lubricant 4-F	Epic lubricant 4F	*	*	Poco sielube #1	Nerita Grease 2	No-Drip Lubricant #8	Calol liquid grease	Omega grease	Stazon C
39	Futwell 40	Kutwell 40	Futwell 45	*	Puroseal #10 or #10 A	Dromus Oil A	Trukut	Calol soluble oil	Superla Solube oil	Solube oil C
40	Aramar 30	Aramar 45 (or Rextone 60)	Galena CC30	41A	Poco journal box oil	Limea Oil 33	Sinco car oil #53	Calol all year car oil	Stanolind all weather car oil	Tamayco oil
41	Esso gear oil SAE-140	Gearol 140	Roxtone 150	All-oil gear lube 140	Poco industrial gear - 140	Dentax 140	Pennsylvania gear oil #140	RPM gear oil 140	Gear lubricant #140	Thuban 140
42	Esso gear oil SAE-90	Gearol 90	Roxtone 70	All-oil gear lube 90	Poco industrial gear - 90	Dentax 90	Pennsylvania Gear oil #90	RPM gear oil 90	Gear lubricant #90	Thuban 90
43	Esso track roller grease H	Esso track roller grease (H)	Marvelube Grease No. 2	Heavy duty chassis lube	Track roller lubricant #3	*	Shamrock lubricant F	RPM track roller lubricant heavy	Track roller lubricant summer	Track roller lubricant - heavy
44	Esso track roller grease M	Esso track roller grease (M)	Marvelube Grease No. 1	Chassis lube	Track roller lubricant #2	*	Shamrock lubricant A	RPM track roller lubricant medium	Track roller lubricant medium	Track roller lubricant - medium
45	Esso track roller grease L	Esso track roller grease (L)	Marvelube Grease No. 0	Track roller grease	Track roller lubricant #1	*	Shamrock lubricant A	RPM track roller lubricant light	*	Track roller lubricant - light
46	Esso XP compound SAE-140	Esso XP-140	Marvelube TT Gear Oil 140	Three star gear lube	Poco purelube DD	Spirax 140	Opaline multi-purpose gear lubricant CX	RPM multi-service lubricant 140	Multi-purpose gear lubricant #140	Universal gear lubricant EP-140
47	Esso XP compound SAE-90	Esso XP-90	Marvelube TT Gear Oil 90	Three star gear lube	Poco purelube EE	Spirax 90	Opaline multi-purpose gear lubricant PX	RPM multi-service lubricant 90	Multi-purpose gear lubricant #90	Universal gear lubricant EP-90
48	Diol 65	Diol 65 (or Esstic 65)	Diol 55	Reliable 30	Klondyke special heavy	Carnea Oil 51	Gascon oil D	RPM Delo heavy duty	Superla diesel oil	Ursa
49	Diol 80	Diol 80	Diol 75	*	Klondyke extra heavy	Carnea Oil 72	Gascon oil GL	RPM Delo heavy duty	Nonpareil diesel oil heavy	Ursa heavy
50	Diol 90	Teresso 100	*	Reliable 50	Klondyke super heavy	Carnea Oil 73	Gascon oil G	RPM Delo heavy duty	Nonpareil diesel oil extra heavy	Ursa FR
51	Diol 70	Teresso 85	Diol 65	Reliable 40	Klondyke extra heavy	Carnea Oil 69	Gascon oil F	RPM Delo heavy duty	Nonpareil diesel oil medium	Ursa MR
52	Essofleet HD-10	Essolube HD 10	Essolube HD 10	F-L oil 10	Purodiesel XD-10	Rotella Oil 10	Opaline TBT	RPM Delo special SAE 10	HD oil - SAE 10	Ursa X** - 10
53	Essofleet HD-20	Essolube HD 20	Essolube HD 20	F-L oil 20	Purodiesel XD-20	Rotella Oil 20	Opaline TBT	RPM Delo special SAE 20	HD oil - SAE 20	Ursa X** - 20
54	Essofleet HD-30	Essolube HD 30	Essolube HD 30	F-L oil 30	Purodiesel XD-30	Rotella Oil 30	Opaline TBT	RPM Delo special SAE 30	HD oil - SAE 30	Ursa X** - 30
55	Essofleet HD-40	Essolube HD 40	Essolube HD 40	F-L oil 40	Purodiesel XD-40	Rotella Oil 40	Opaline TBT	RPM Delo special SAE 40	HD oil - SAE 40	Ursa X** - 40
56	Essofleet HD-50	Essolube HD 50	Essolube HD 50	F-L oil 50	Purodiesel XD-50	Rotella Oil 50	Opaline TBT	RPM Delo special SAE 50	HD oil - SAE 50	Ursa X** - 50
57	Diol 60	Diol 80	Galena D 30	Reliable 40	*	*	Gascon oil GL	*	*	Ursa R
58	Essofleet 10	Velvet CC 45	Galena CC 10	41-A	Puropale light	Vitrea Oil 27	Rubilene Oil Extra Light	Standard Penn motor oil 10	HD oil - SAE 10	Ursa P - 10
59	Essofleet 20	Velvet CC 55	Galena CC 20	41-A	Puropale heavy medium	Vitrea Oil 33	Rubilene Oil Light medium	Standard Penn motor oil 20	HD oil - SAE 20	Ursa P - 20
60	Essofleet 30	Velvet CC 65	Galena CC 30	52 Machine oil	Puropale heavy	Vitrea Oil 41	Rubilene Oil Medium heavy	Standard Penn motor oil 30	HD oil - SAE 30	Ursa P - 30
61	Essofleet 40	Velvet CC 75	Galena CC 40	Reliable 40	Puropale special heavy	Vitrea Oil 69	Rubilene Oil Heavy	Standard Penn motor oil 40	HD oil - SAE 40	Ursa P - 40
62	Essofleet 50	Velvet CC 85	Galena CC 50	Reliable 50	Puropale extra heavy	Vitrea Oil 73	Rubilene Oil Extra heavy	Standard Penn motor oil 50	HD oil - SAE 50	Ursa P - 50
63	Essolube SDX-10	Essolube SDX-10	Imperial SDX Oil 10	Super D-10	Sultane SRD - 10	Rotella Oil 10	Tenol (10)	RPM Delo supercharged 2	Stanolube HIA motor oil SAE 10 W	Ursa super duty 10
64	Essolube SDX-30	Essolube SDX-30	Imperial SDX Oil 30	Super D-30	Sultane SRD - 30	Rotella Oil 30	Tenol (30)	RPM Delo supercharged 2	Stanolube HIA motor oil SAE 30	Ursa super duty 30
65	*	Essolube HDX-10	*	F-L oil 10	Sultane X - 10	Rotella Oil T 10	Super Tenol (10)	RPM Delo supercharged 1	Stanolube S-1 motor oil SAE 10 W	Ursa X Sup. one - 10
66	*	Essolube HDX-20	*	F-L oil 20	Sultane X - 20	Rotella Oil T 20	Super Tenol (20)	RPM Delo supercharged 1	Stanolube S-1 motor oil SAE 20 - 20 W	Ursa X Sup. one - 20
67	Essolube HDX SAE 30	Essolube HDX-30	*	F-L oil 30	Sultane X - 30	Rotella Oil T 30	Super Tenol (30)	RPM Delo supercharged 1	Stanolube S-1 motor oil SAE 30	Ursa X Sup. one - 30
68	Essolube HDX SAE 40	Essolube HDX-40	*	F-L oil 40	Sultane X - 40	Rotella Oil T 40	Super Tenol (40)	RPM Delo supercharged 1	Stanolube S-1 motor oil SAE 40	Ursa X Sup. one - 40
69	*	Essolube HDX-50	*	F-L oil 50	Sultane X - 50	Rotella Oil T 50	Super Tenol (50)	RPM Delo supercharged 1	Stanolube S-1 motor oil SAE 50	Ursa X Sup. one - 50
70	Esso water pump grease	Cesar 1 (or 2)	Marvelube Grease No. 77	Water pump grease	Poco water proof grease	Retinax P	Water pump grease	Calol W. P. grease 2	Water pump grease	Water pump grease

* Information not furnished

or oftener as necessary, using a grade suitable for the temperature. In changing, oil should be drained while warm and the transmission and differential flushed out with light oil. Plugs are usually provided to indicate the correct oil level and the oil should be kept at this level.

Wire Rope

47. Crude oil should not be used for wire rope lubrication. It may contain impurities that are harmful to the core and the wire. Whenever possible, the lubricants should be hot when applied to get the best penetration.

48. Wire rope used with dragline buckets, which are necessarily drawn through mud and sand, should be kept well wiped and oiled.

In instruction No. 2 in the foregoing list it is stated that the correct lubricant should be used and the operator of a machine must know what oils and greases are suitable for use with his machine. At first glance, this instruction appears practical, but a knowledge of the facts will show that, whereas the manufacturer may show in his instruction book that a certain type of lubricant should be used and gives the brand name, the operator may be unable to procure this lubricant because his company does not stock it and he does not know then what he should use. In many cases, while he may be conscientiously trying to take good care of his machine, he is unable to lubricate it correctly because his company has not provided him with a suitable ordering reference. It is apparent therefore, that each operator of a unit of work equipment, and others who may be responsible for the care of work equipment, should be provided with some sort of lubrication chart showing the parts of each machine to be lubricated, and what lubricant should be used on these parts. To assist any railroad which may wish to prepare such a chart, your committee includes, as part of its report (see page 673 and 674), a sample chart which may be used as a guide which is titled "Lubrication Chart for Work Equipment and Roadway Machines." In preparing this chart, manufacturers' names have been omitted, and item numbers are used to identify the lubricant rather than the use of refiners' brand names.

It is frequently necessary in an emergency for a machine operator to buy an oil or grease locally, primarily because he cannot wait for a company shipment, or he may not have a company ordering reference and, therefore, has recourse only to the manufacturer's recommendations which may not cover any lubricant locally available. As a result, he may purchase what is available but which may not be at all suitable. To cover such possibilities, it is considered important to furnish to work equipment operators and maintainers some sort of comparison chart by which they may know the one lubricant available from each of the more prominent oil refiners and producers which is equivalent to that recommended by a machine manufacturer. The accompanying chart (shown following page 674), titled "Chart of Equivalent Lubricants," which is to be used as a guide, lists the lubricants of several of the larger oil refiners and producers which are commonly used for the lubrication of maintenance of way work equipment. This chart may be revised or expanded to meet the needs of any railroad and, in its preparation, there was no intention on the part of this committee to favor those refiners or producers whose products are listed, or to discriminate against those whose products are omitted. It is impractical to list them all, and several oil companies preferred to refrain from furnishing the type of information requested.

(b) Open-Bed Service Type

The pick-up or canopy express bodies of this group are standard and are available with utility compartments for tools and small parts. This type fulfills the requirements with minimum investment when the open-bed type, of the capacity and dimensions available, meets the service requisites.

The bodies of this type are available in approximate lengths ranging from 78 to 108 in. in the pick-up type, and 89 to 120 in. in the canopy express type. A special canopy top can be installed on the 78-in pick-up bed. Each of the described open-bed types has an approximate GVW rating of 4900 to 8000 lb. This unit is desirable for service assignment to welders, water service mechanics, light and heavy equipment repairmen, etc. (Fig. 1).

(c) General Service Type

The general service body is basically a standard type, but is available in many arrangements too numerous to describe.

The general service bodies are applicable to vehicles with a GVW rating of 4900 to 8000 lb, and are available with body lengths ranging from 75 to 90 in at floor line (Fig. 2).

Typical services for this group are for signal maintainers, telegraph linemen, light equipment repairmen, track welders, water service mechanics, and similar employees.

(d) General Construction and Repair Type

This body may be obtained in many arrangements and is probably further developed than any of the other service body types. The overall length of the body may range from 90 to 168 in. The body is mounted on either a conventional or cab-over-engine chassis, with cab, and is provided with or without a crew compartment. The GVW rating for most designs of this type will range from 8800 to 16,000 lb. The vehicle is used on the railways by telegraph and electrical construction and maintenance crews and similar services. Fig. 3 illustrates one of the units mounted on a cab-over-engine chassis, with crew compartment.

(e) Service Shop Truck

This is a highly specialized piece of equipment and a valuable truck unit for equipment repairmen on heavy construction or maintenance of roadway projects; also for use by maintenance forces that do not have repair shops available in their maintenance organization. The repair equipment mounted in the body may include merely a work bench with vise, compartments and racks for small tools and parts, and welding equipment, or it may include a fully mobile machine shop with facilities normally found in a well equipped repair shop.

The committee recommends single-unit shop trucks with minimum GVW rating of 14,500 lb, and the combination units which may have a maximum rating of 76,800 lb. The maximum GVW of the heavy units is determined in certain applications only by the legal gross weight permitted in the states of operation, either on standard regulations or special permits. Figs. 4 and 5 illustrate two types of shop trucks.

2. Transporter

(a) Enclosed Transporter

A van type is used for the general hauling of machines, tools and materials, or as a crew carrier for short trips when provided with longitudinal folding seats. This type is generally more effective, at reduced maintenance expense, with a GVW rating of approximately 14,500 to 18,000 lb, but in a few applications it may be desirable to use a unit with a GVW rating of 22,000 lb. The body length will normally be from 10 to 16 ft. The 10-ft size with folding seats, including the truck cab, will accommodate approximately 14 men, including the driver, and the 16-ft size about 20 men, including the driver. This type is illustrated by Fig. 6.

(b) Stake and Flat-Bed Body Types

This type is a versatile material handler and can be fitted with any number of attachments to increase its service value. Provided with a solid low-side bed with end gate (similar to a grain body), and with an hydraulically-controlled bed dumping device, the unit is satisfactory for handling bulk materials. A few of the other attachments increasing the service value of this type unit are truck cranes, winch with gin poles, hydraulic tower, rolling tailboard, air compressor, etc.

The committee's recommendation for this specific type is a GVW rating of 14,500 to 22,000 lb, and in a few applications a maximum of 28,000 lb.

A combination unit may prove of advantage in exacting applications. The body length of a single unit may range from 10 to 16 ft, and 50-ft overall length on a combination unit, when permitted by standard regulation or special permits in the state of operation (Figs. 7 and 8).

(c) Dump Bodies

For economical operation and long service expectancy, the committee recommends a minimum GVW rating of 16,000 lb for this type.

Dump bodies are standard and available in various designs, such as the contractor's dump body, dropside body, combination platform and dump body, scoop-end bunker body, and many others. With few exceptions these bodies will range from 8 to 15 ft in length (Figs. 9 and 10).

(d) Crew Carrier

This type may range from a GVW rating of 5300 lb to 22,000 lb, and is a combination crew, tool and small material transporter. The arrangement and general design of this group vary quite extensively. Crew carriers will range from 9 to 16 ft in length, with few exceptions (Figs. 11 and 12).

(e) Bus Type

This type is available in a number of sizes and capacities, being the product of approximately 69 manufacturers. The busses are available in seating capacities ranging from 8 to 50 passengers. State regulations govern the actual maximum seating capacity or gross weight for industrial busses, and this should be determined for operation in each state involved. The lengths of these busses will range from approximately 10 to 34 ft. This type has the one definite purpose of transporting personnel within the capacity of the vehicle, without tools or materials.

(f) Carryall Suburban, Station Wagon

This type is a passenger vehicle with rated maximum seating capacity of 7, including the driver. This vehicle is used for transporting small gang or crews without tools, supervisors, inspectors, and engineering parties.

Fig. 1—Open-bed service type.

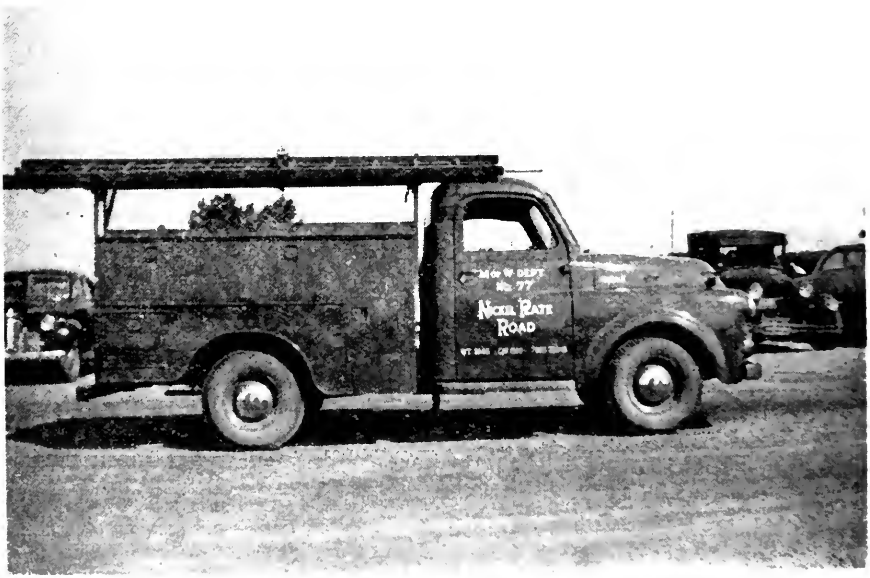


Fig. 2—General service type.

Fig. 3—General construction and repair type.

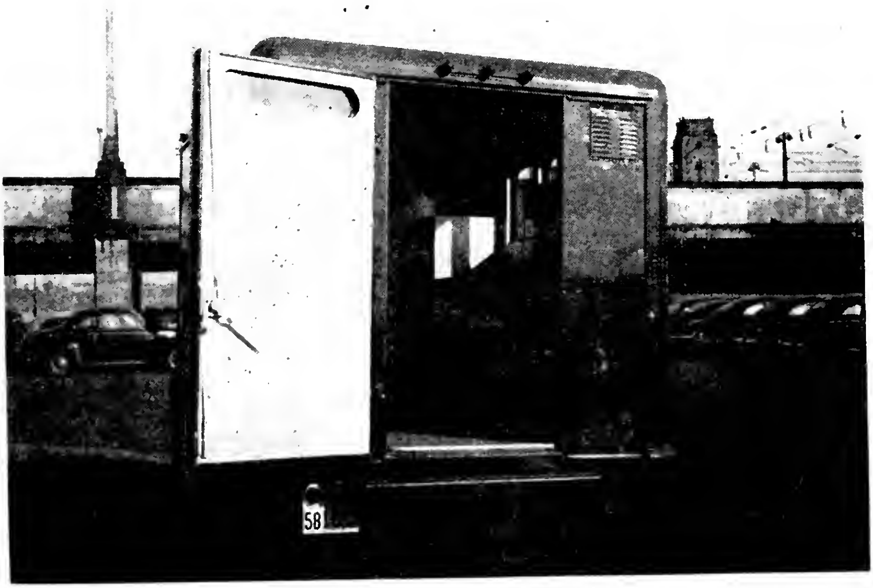


Fig. 4—Service shop truck.

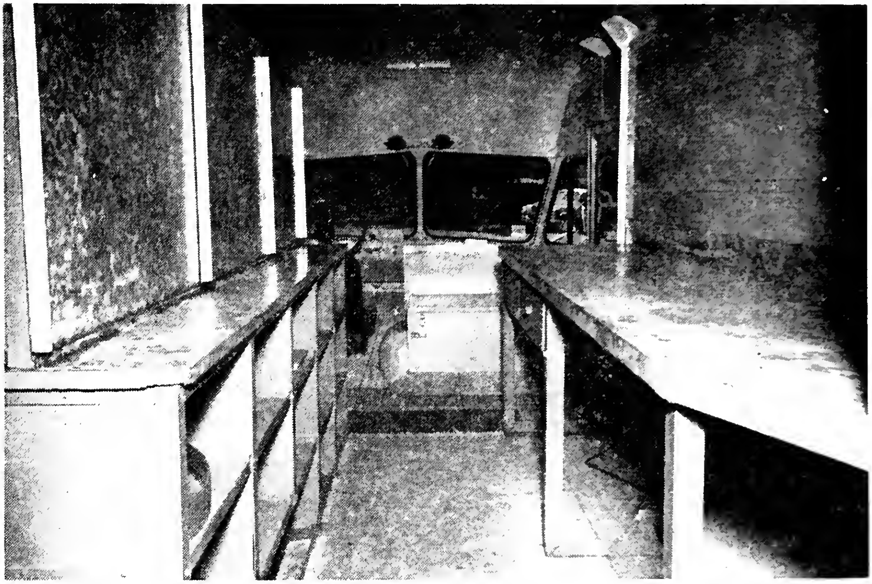


Fig. 5—Service shop truck.

Fig. 6—Enclosed transporter.

Fig. 7—Flat-bed body transporter.

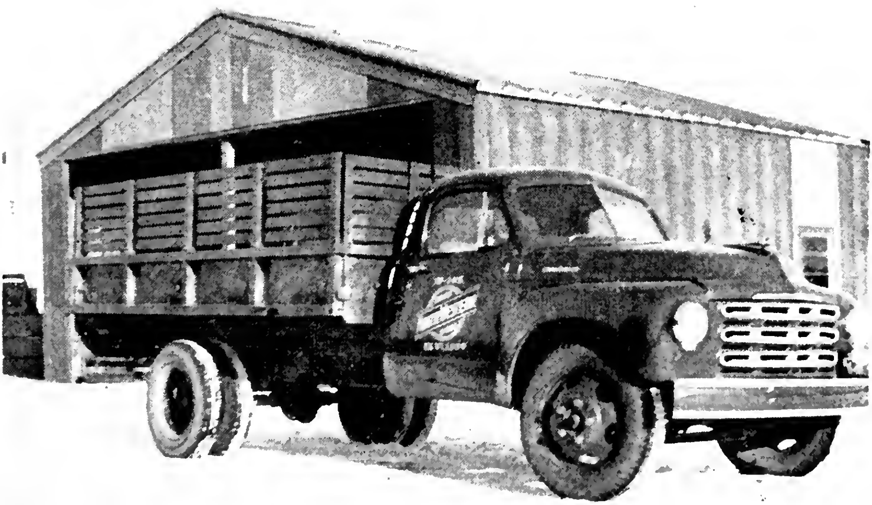


Fig. 8—Stake-body transporter.

Fig. 9—Dump body with drop sides.

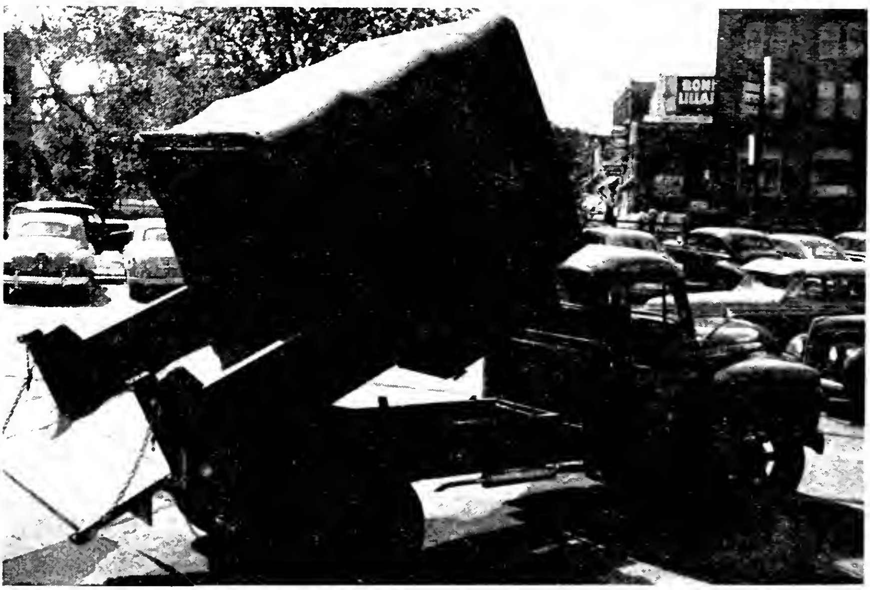


Fig. 10—Dump body, part enclosed.

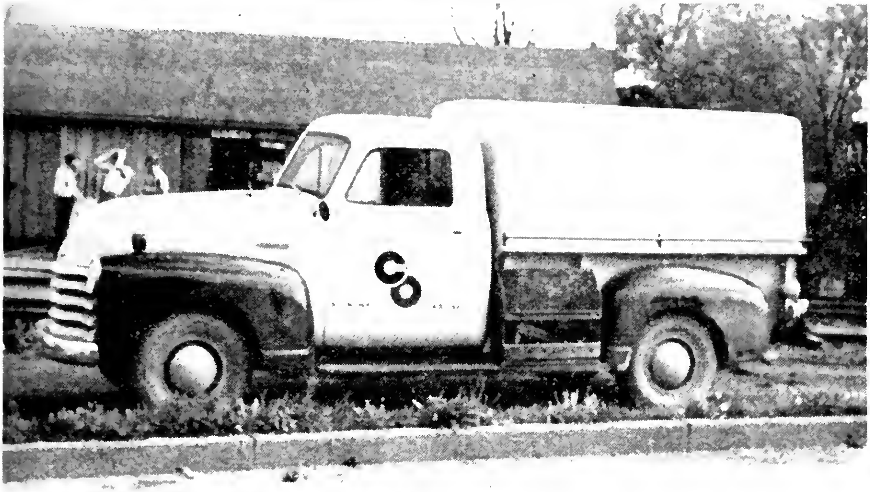


Fig. 11—Crew carrier.

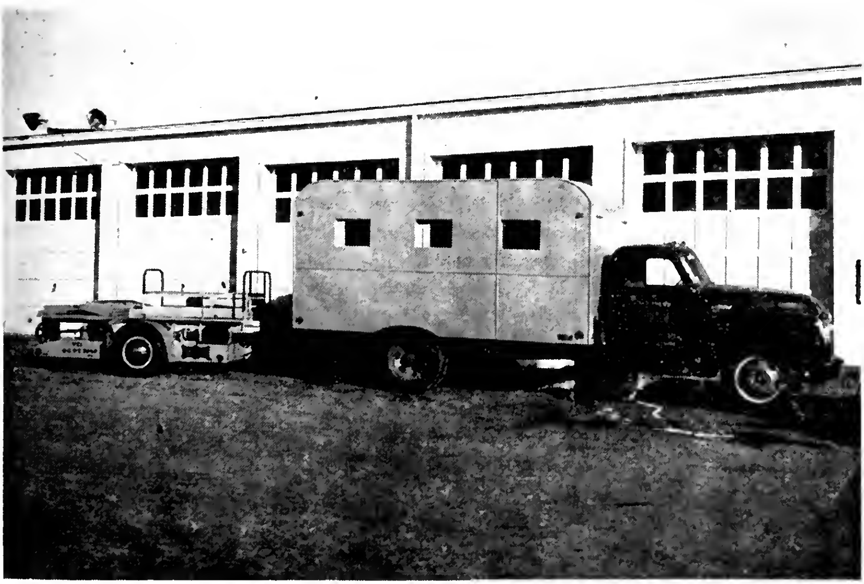


Fig. 12—Crew carrier with trailer.

Report on Assignment 8

Switch Heaters, Design, Location and Operation

Collaborating with Committees 5 and 14

A. W. Munt (chairman, subcommittee), W. M. Dunn, Herbert Huffman, Francis Martin, F. H. McKenney, J. F. Piper, P. S. Settle, C. E. Stoecker, G. M. Strachan, T. H. Taylor, E. E. Turner.

This report is presented as information, with the recommendation that the subject be discontinued.

A previous report on snow melting devices, which is very comprehensive, may be found in the Proceedings, Vol. 34, 1933, pages 258–383.

Some of the devices used for melting and removing snow from switches, as well as other purposes, during the early Thirtys have become obsolete and are no longer being used or manufactured, while many of them are still in use.

As far as can be ascertained from a canvass made of suppliers and railroads, a few improvements have been made in the design of some switch heaters by manufacturers who have been making them for many years, but there do not appear to be any entirely new types of these appliances on the market, except for one electric heater which will be mentioned in this report.

The purpose of this report is to present any additional data available from the experience gained through the use of switch heaters over the past 15 years, as well as to point out improvements in design, if any, locations where they are used to best advantage, and how they operate. As some of the devices mentioned in the previous report are no longer being used, only those that are currently being made and in use will be mentioned here.

The following will describe the current practice of melting snow and ice from switches and the types of switch heaters generally in use today. These will be described in the following order:

1. Steam coils under switches.
2. Snow melting cans for spreading hydrocarbon or naphtha gasoline.
3. Kerosene pots placed in cribs between ties.
4. Long or fixed heaters attached to rail for burning distillate or fuel oil, requiring compressed air to atomize the flame.
5. Electric heaters with and without timer.
6. Individual gas burners for burning commercial gas, attached to the base of rail in pairs.
7. Long or fixed heaters attached to rails for burning commercial or natural gas, or propane gas from cylinders or storage tanks.
8. Remote control for gas burning heaters.

1. Steam Coils

Steam coils were used many years ago and a few railroads still use them on a limited scale. The coils are laid between the switch ties with proper slope to provide drainage. Steam is usually furnished from a heating plant.

This is an economical and trouble-free method of melting snow from switches provided a surplus of steam from the heating plant which is used for other purposes is available and in sufficient volume, and at sufficient pressure to furnish adequate heat in the coils. If a steam plant had to be built to supply steam for heating the coils only, the cost would be prohibitive.

Many railroads are using steam flash boilers for furnishing steam for diesel operated pile drivers during the summer months. These boilers might well be utilized during the winter months for supplying steam for heating coils in switches.

Steam coils are generally used under switches at the entrance to main yard tracks and under power-operated switches in passenger yard terminals. One railroad reports that it has used steam coils under switches for the past 20 years with excellent results, even under severe storm conditions. Little trouble has been experienced with ice forming since the steam coils keep the ground from freezing and the melted snow and condensation have a chance to soak into the ballast.

Experience has shown that steam coils will keep switches clear of snow and facilitate the movement of traffic, particularly where movements are frequent and it is difficult and hazardous to use manpower due to poor visibility during storms.

2. Snow Melting Cans

Snow melting cans are used to pour a flaming liquid on snow or ice to be removed. The two types most commonly used are the safety snow melting can and the snow thawing can. Both types are basically the same. The unit usually consists of a 3-gal can having a pouring tube about 3 ft long, equipped with a pilot wick on the discharge nozzle which ignites the fuel immediately as it leaves the nozzle. The pilot wick continues to burn for some time after the flow of oil is shut off, precluding the necessity of relighting it in moving from place to place. A valve with a handle extending to the top of the can is used to regulate the flow of fuel. The fuel used is a highly inflammable, low-flash oil, such as hydrocarbon or naphtha gasoline.

Snow melting cans have been used for many years and are still being used by some railroads for melting light snow and ice from power-operated switches in congested yard tracks, slip switches in passenger terminals, and classification track switches in hump yards.

The flaming oil is spread around the switch rods and between the switch points and stock rails. Care must be taken not to burn the ties, signal apparatus, trunking, wires, etc. To ensure best results only enough burning oil should be poured on the switch at a time to keep the snow melted from the points, and the operation repeated as often as is necessary. In this way the flames can be controlled to a reasonable degree, particularly if high winds prevail. Some railroads report that this method has been used effectively for several years, but that judgment must be used in controlling the flames so as not to obscure signals, and to protect men and equipment.

Based on many years of experience it has been found that the use of snow melting cans has some merit for melting snow and ice from switches, but there is little economy in this practice as there is little, if any, saving in manpower, and fuel consumption runs about 3 gal per hr per can. While no economy can be shown for this method, it has merit for use in congested areas where it is practically impossible for men to clean snow from switches with hand brooms and shovels due to the frequency of train movements.

3. Kerosene Pots

Kerosene or oil burning pots generally consist of a steel box approximately 18 in by 5 in, by 6 in high. Most of these boxes have a capacity of about 1.5 gal, which is sufficient for about 10 hours' operation, while some are available with larger capacity of 2 to 3 gal for longer operation. A combustion or wick chamber about 3 in by 4 in, by 6 in high is inserted at the flanged end of the box, and since this chamber extends

Report on Assignment 8

Switch Heaters, Design, Location and Operation

Collaborating with Committees 5 and 14

A. W. Munt (chairman, subcommittee), W. M. Dunn, Herbert Huffman, Francis Martin, F. H. McKenney, J. F. Piper, P. S. Settle, C. E. Stoecker, G. M. Strachan, T. H. Taylor, E. E. Turner.

This report is presented as information, with the recommendation that the subject be discontinued.

A previous report on snow melting devices, which is very comprehensive, may be found in the Proceedings, Vol. 34, 1933, pages 258–383.

Some of the devices used for melting and removing snow from switches, as well as other purposes, during the early Thirtys have become obsolete and are no longer being used or manufactured, while many of them are still in use.

As far as can be ascertained from a canvass made of suppliers and railroads, a few improvements have been made in the design of some switch heaters by manufacturers who have been making them for many years, but there do not appear to be any entirely new types of these appliances on the market, except for one electric heater which will be mentioned in this report.

The purpose of this report is to present any additional data available from the experience gained through the use of switch heaters over the past 15 years, as well as to point out improvements in design, if any, locations where they are used to best advantage, and how they operate. As some of the devices mentioned in the previous report are no longer being used, only those that are currently being made and in use will be mentioned here.

The following will describe the current practice of melting snow and ice from switches and the types of switch heaters generally in use today. These will be described in the following order:

1. Steam coils under switches.
2. Snow melting cans for spreading hydrocarbon or naphtha gasoline.
3. Kerosene pots placed in cribs between ties.
4. Long or fixed heaters attached to rail for burning distillate or fuel oil, requiring compressed air to atomize the flame.
5. Electric heaters with and without timer.
6. Individual gas burners for burning commercial gas, attached to the base of rail in pairs.
7. Long or fixed heaters attached to rails for burning commercial or natural gas, or propane gas from cylinders or storage tanks.
8. Remote control for gas burning heaters.

1. Steam Coils

Steam coils were used many years ago and a few railroads still use them on a limited scale. The coils are laid between the switch ties with proper slope to provide drainage. Steam is usually furnished from a heating plant.

This is an economical and trouble-free method of melting snow from switches provided a surplus of steam from the heating plant which is used for other purposes is available and in sufficient volume, and at sufficient pressure to furnish adequate heat in the coils. If a steam plant had to be built to supply steam for heating the coils only, the cost would be prohibitive.

Many railroads are using steam flash boilers for furnishing steam for diesel operated pile drivers during the summer months. These boilers might well be utilized during the winter months for supplying steam for heating coils in switches.

Steam coils are generally used under switches at the entrance to main yard tracks and under power-operated switches in passenger yard terminals. One railroad reports that it has used steam coils under switches for the past 20 years with excellent results, even under severe storm conditions. Little trouble has been experienced with ice forming since the steam coils keep the ground from freezing and the melted snow and condensation have a chance to soak into the ballast.

Experience has shown that steam coils will keep switches clear of snow and facilitate the movement of traffic, particularly where movements are frequent and it is difficult and hazardous to use manpower due to poor visibility during storms.

2. Snow Melting Cans

Snow melting cans are used to pour a flaming liquid on snow or ice to be removed. The two types most commonly used are the safety snow melting can and the snow thawing can. Both types are basically the same. The unit usually consists of a 3-gal can having a pouring tube about 3 ft long, equipped with a pilot wick on the discharge nozzle which ignites the fuel immediately as it leaves the nozzle. The pilot wick continues to burn for some time after the flow of oil is shut off, precluding the necessity of relighting it in moving from place to place. A valve with a handle extending to the top of the can is used to regulate the flow of fuel. The fuel used is a highly inflammable, low-flash oil, such as hydrocarbon or naphtha gasoline.

Snow melting cans have been used for many years and are still being used by some railroads for melting light snow and ice from power-operated switches in congested yard tracks, slip switches in passenger terminals, and classification track switches in hump yards.

The flaming oil is spread around the switch rods and between the switch points and stock rails. Care must be taken not to burn the ties, signal apparatus, trunking, wires, etc. To ensure best results only enough burning oil should be poured on the switch at a time to keep the snow melted from the points, and the operation repeated as often as is necessary. In this way the flames can be controlled to a reasonable degree, particularly if high winds prevail. Some railroads report that this method has been used effectively for several years, but that judgment must be used in controlling the flames so as not to obscure signals, and to protect men and equipment.

Based on many years of experience it has been found that the use of snow melting cans has some merit for melting snow and ice from switches, but there is little economy in this practice as there is little, if any, saving in manpower, and fuel consumption runs about 3 gal per hr per can. While no economy can be shown for this method, it has merit for use in congested areas where it is practically impossible for men to clean snow from switches with hand brooms and shovels due to the frequency of train movements.

3. Kerosene Pots

Kerosene or oil burning pots generally consist of a steel box approximately 18 in by 5 in, by 6 in high. Most of these boxes have a capacity of about 1.5 gal, which is sufficient for about 10 hours' operation, while some are available with larger capacity of 2 to 3 gal for longer operation. A combustion or wick chamber about 3 in by 4 in, by 6 in high is inserted at the flanged end of the box, and since this chamber extends they are preferred for ease of control and trouble-free operation. To achieve best results under severe conditions the 500-w per ft unit is recommended.

While electric tubular heaters give excellent results, the cost of operation is objectionable, and sometimes prohibitive unless power is available at reasonable rates. The cost of electric current has been a deterrent to their more extended use. In most cases a high maximum demand or connected load charge prevails all year round, and the railroad must pay a considerable sum of money for current during the summer as well as when heaters are in service.

Recognizing that power costs have retarded the use of electric switch heaters, one manufacturer has recently developed a new type of electric switch heater which is equipped with a timing device to provide a method of limiting the current supply as required, thus reducing the cost of operation. This heater consists of a number of copper-clad heating elements, each of which is bolted with a stud bolt to the inside of the web of the switch point. About eight heating plates are required to a 16-ft 6-in switch point. The heating plates are approximately 3 in by 15 in, and enclose a ni-chrome wire heating element consuming 500 w. This heater is controlled by a special small motor operating a shaft on which are mounted a series of micro-switches. These switches can be set to any desired time interval so as to cut in four plates at a time, limiting the current consumption to 2000 w, and rotating the period and lengh of time each set of four plates is heated. The switches can be changed to give any time interval desired. The heater can also be rewired to consume 3000 w if that amount of power is available.

These heaters are now being tested on two or three railroads. One of these railroads reports that during a severe storm, when the temperature was + 5 deg F, the heater was unable to keep the switch clear of snow. The heater tested was consuming 2000 w, and it is the opinion that a 3000-w unit is required to keep a switch clear in heavy snow or cold weather. The installation was made on a switch within an interlocking plant where its performance could be watched closely.

It is yet too early to determine the full merits of this heater for keeping switches clear of snow under severe conditions, but preliminary tests indicate that it is worth watching for future improvements.

6. Individual Gas Burners

Individual gas burners, introduced many years ago, are widely used by many railroads. These heaters consist of individual gas burner units attached to the base of the stock rail by spring clips. Usually one burner per tie space is used. These heaters burn commercial or natural gas.

This type of heater is used on switches at interlocking plant crossovers, spring switches, slip switches, and main-line switches in terminals. These heaters have been fairly effective in melting snow from switches, but they are difficult to maintain. Some of the troubles experienced have been broken clips and fuel pipes, cracked heater elements, and freezing of the heater elements in the tie cribs due to the accumulation of water. Also, difficulty has been experienced in keeping the burners lighted in windy locations. Another undesirable feature of these burners is that, being installed in the tie cribs, the ties must be protected with asbestos or metal plates to prevent the heaters from burning them.

So far as can be ascertained, these heaters are now obsolete and their use is gradually being discontinued due to high maintenance costs and uneconomical performance.

7. Long or Fixed Heaters (Gas Burning)

Long or fixed heaters of the rail-head type, attached directly to the stock rail, are generally conceded to be the best types of switch heaters in use at the present time, and their use is increasing on the railroads of both the United States and Canada. There are two makes of rail-head heaters generally in use. They are basically the same, except that one heater burns natural gas, commercial gas, or propane gas, while the other one burns propane gas only.

The type of heater designed to use natural, commercial and propane gas consists of an angular steel distributor containing brass pipe with orifices for emission of gas, which burns so that heat is directed downward along the web of the stock rail. This effectively heats the stock rail, base, switch plates, and the space between the running rails and moveable points. It is manually ignited.

The distributor is held rigidly in place by malleable iron brackets which fit around the base of the rail and make the heater a part of the rail structure, with which it may rise and fall during train passage, independent of the tightness of the spikes and ties. On puzzle or knuckle-easer rail assemblies of double slips, tie attachment brackets are employed.

As mentioned previously, this heater can be used with either commercial or natural gas, or propane. With propane the gas orifices in the inner brass pipe are spaced closer together than for commercial gas, because of the inertness of propane and its slower propagation of flame. Also, with propane, an inspirator admits about 65 to 70 percent of free air to provide a proper mix. To change from commercial to propane burning, or vice versa, the orifice spacing may be altered or different tubes inserted, and an inspirator added at gas intake for propane aeration.

This heater required only one gas intake for units up to 22 ft long, where commercial gas is used, or up to 18 ft long with propane. For longer heaters, up to 30 ft, 2 intakes per heater are required for the admission of sufficient gas. For 45-ft switches it is customary to use 2 heaters on each switch point, or 4 per switch with commercial gas. With propane it is the practice to use long heaters with 3 intakes.

The other type of rail head gas heater is for similar application, but it burns propane gas only. It is made up of 18-in cast iron sections threaded for screwing together into any required total length. Within the main round sections, approximately the diameter of 1¼-in pipe, is a secondary small diameter tube carrying the propane gas, which burns within the larger section and the hot gases are projected against the stock rail.

This heater is held by brackets attached to the ties. A separate gas inake with air inspirator is used for each 10 ft of heater length.

Rail-head-type gas heaters are used on switches in classification yard tracks, spring switches on main line, electrically operated switches in passenger terminals, at interlocking plants, and at outlying points.

The type of rail-head gas heater that burns either commercial or natural gas, or propane is reported to be the best gas burning heater available. With adequate vaporization and gas pressure this heater will melt snow from switches during moderate to heavy snow storm conditions at fairly low temperatures. It can be burned low for moderate snow and sleet storms, or opened wide to combat heavier storm conditions, and will keep the snow off the switch point for practically its entire length. Under ordinary conditions little trouble is experienced with water from melted snow freezing in the tie cribs as the radiation of heat from the heater and the heat from the hot rail evaporate most of the snow as it is melted. However, in cold climates it is advisable to provide drainage ditches from the tie cribs to eliminate the possibility of ice forming.

In areas where severe blizzard and windy conditions are likely to be encountered it is recommended that the heaters be shielded. Shields can be made of 18-gage sheet metal held to the ties with pins or nails through small holes to give a hinged effect, and about ¼ in above the top of the box, water does not drain into it. The wick chamber is packed with either asbestos or mineral wool and has a series of vertical slots, extending upward from the base, for the admission of the fuel. A sliding cover with thumb screw attachment permits regulation of the heat, and, in addition, may be used to seal the wick chamber against the accumulation of dirt when not in use. A flange on each side of the opening maintains the proper distance between the heater and the bottom of the switch point, and is intended to protect the ties.

In the top of the fuel chamber there is a small opening with a self-closing cap for filling. Since this opening is removed from the flame, there is no necessity for using a special filling can, even when the melter is burning. Experience has shown that it is better to place the combustion chamber directly underneath the running rail, rather than under the space between the running rail and the switch point.

Normally, these heaters burn kerosene. The proper fuel is a matter of great importance and only a good grade of oil should be used. To prevent the oil from boiling over due to heat expansion, the tank should be filled to within not more than ½ in of top. While there used to be a number of this type of switch heaters on the market, many of them have become obsolete and are no longer being used. The most popular of those in use today have the larger capacity box.

Pot heaters are used to best advantage under power-operated switches in classification yards, spring switches, or generally under switches where traffic is slow moving. Some railroads have used these heaters under switches on high-speed track, but with only a small degree of success; also in this case more heaters per switch must be used to provide greater heat.

Reports received indicate that a large number of railroads are still using pot heaters in territories where temperatures seldom go below zero and snow is light. Most railroads report that it is necessary to provide adequate drainage when using this type of heater in order to prevent ice forming in the tie cribs, which in some cases freezes the pot in so that it is difficult to remove. They also point out that ties have to be protected from burning by using metal shields on the sides of the ties.

It has also been found that when high winds prevail it is necessary to place a metal shield over the tops of the ties to act as a windbreak to prevent the flame from blowing out, and to protect the heater from drifting snow when the wind is blowing parallel to the track.

The number of heaters required per switch varies, but usually 12 are required—six to a side. These are placed in every second crib.

From a resumé of reports received from the different railroads which have been using pot heaters for many years, it appears that this type of heater will effect a small saving, and that its use is only fairly successful in territories where light snow is encountered with mild temperatures. In high winds, or drafts set up by fast trains, the heaters should be shielded. Maintenance on this heater is fairly high, particularly with regard to wick renewals and cleaning.

4. Long or Fixed Heaters (Oil Burning)

One type of oil burning switch heater was installed many years ago on a New England railroad. Thirteen installations in all were made of this type. Each installation consists of a large elevated tank having a capacity of 1000 to 2000 gal. from which oil is conveyed by gravity through main feed pipe lines to separate lines feeding two burner units, one on each switch point. These burner units are simply a section of pipe having openings 1/32 in. in diameter, spaced about 18 in apart. A pilot wick is located at the switch point and the operation of these burners is by manual control. The fuel used is hydrocarbon oil.

With these heaters it is the practice to light the igniter, then to flood the switch point with the hydrocarbon oil to melt out the snow. The flow of oil is immediately shut off as soon as the switch is flooded, the oil burning itself out and the snow being evaporated. This type of heater is still installed and being used. There appear to be objections to its use due to the large smokey flame it produces, and it is only efficient enough to handle light snow. Installation costs, as well as fuel consumption costs, are high. Care must be exercised in using this heater to prevent damage to the ties, etc. It is believed that this type of switch heater is now obsolete, and that it is not being used on any other railroad.

Another type of oil burning heater being used by some railroads uses compressed air to atomize the fuel. These are manually controlled. These heaters consist of tubular heat distributors up to about 20 ft in length, with cast iron center intake carrying atomizing burners. They are held rigidly in proper position by brackets attached to the base of the rail. Kerosene, distillate, or fuel oil is forced to the burners by a motor-driven pump located near the fuel storage. Compressed air is supplied at 60 to 80 psi for efficient operation. The burners use about 4 gal of fuel per hour and 6 cu ft per min of compressed air per switch. Usually compressed air is supplied from some central compressor station.

5. Electric Heaters

Many types of electric switch heaters have been used on the railroads during the past several years. These include the electric rail pad (radiation and contact type), the ballast pad (radiation type), and the tubular rail-head-contact type, which is a relatively new type. The most efficient of these, and the one most currently in use, is the tubular type, which has almost entirely superseded the older types of electric heaters.

The tubular electric rail-head-contact heater consists of a tubular heating element approximately the same length as the switch point. It is fastened under the head of the stock rail on the switch point side, and is held in place by clips bolted through the web of the rail. The element is flattened in section to provide clearance between the stock rail and the switch point. Two elements are required per switch. Power is furnished through a selector switch from either 440-v or 220-v ac circuit.

Power consumption varies according to the capacity of heating element required. The most popular unit, which has ample capacity to melt snow under most conditions, is the 220-v ac unit with a power consumption of 500 w per ft of heater element length. One railroad reports that to meet varying snow and temperature conditions the heaters have been connected to the 220-v line in series to give 110-v power, and that when connected in this way the heat output is reduced to one-half capacity for mild-temperature storms. For severe low-temperature storms the heaters have been connected in parallel to give 220-v power at full heat capacity.

Control leads are connected to an automatic double-throw switch, which is controlled by the operator in an interlocking tower. Many of these heaters are controlled remotely from stations and dispatching offices.

Electric switch heaters are used for melting snow in slip switches in passenger terminal yards, in track switches in classification yard tracks, and in spring switches at various locations.

Many railroads report that excellent results have been obtained from the tubular-element head-contact heater, even under severe storm conditions. It is also reported that laid against the top of the switch heater at an angle from the ties. They can then easily be swung back for inspection or maintenance of the heaters.

Cost of operation is reasonably low and maintenance costs are not high. Rail-head gas beaters will effect savings in manpower and will keep snow clear of switches that are impractical to clean by hand due to hazardous working conditions under frequent train movements during snowstorms and blizzards.

The same results can be expected from the similar type of heater that burns propane gas only, provided adequate vaporization and gas pressure are maintained.

In areas where low temperatures are encountered, viz., from + 16 deg F or lower, difficulty will be experienced in the operation of switch heaters using propane gas. Below + 16 deg F propane gas will shrink and pressure in the container will begin to drop with a corresponding loss in vaporization output. The lower the temperature drops, the worse the condition becomes. As the heaters continue to operate they draw off the heat in the propane and this action, coupled with low temperature, causes a refrigerating action which decreases pressure in the container until there is insufficient vapor and pressure left to maintain a pressure of 10 to 12 lb required for efficient operation of the heaters.

To counteract the refrigerating effect of propane being discharged at temperatures below + 16 deg F, it has been found necessary to apply sufficient heat to the propane container or tank to raise and maintain the temperature above + 16 deg F. The safest and most efficient method of heating the container appears to be by steam heating through the use of pipes installed in the container or tank, if it is a large installation, or steam coils can be installed underneath and part way up the outside of the tank. Steam can be furnished by a steam crane or whatever steam supply is available, or from a shop steam line if the installation is close to a shop. Another method is to install a small oil-fired steam boiler with automatic controls adjacent to the propane tank installation. In addition to the heat applied, it may be found necessary to lag and insulate the exterior of the tank, and the outer face of the steam pipes, with magnesia, to exclude the cold air in severe temperatures.

One railroad in Canada is using the steam heating method very successfully on a large propane gas heater installation. This installation consists of a 12,000-gal propane storage tank which supplies propane to operate 88 switch heaters for 44 switches in classification yard tracks. Temperatures range from 0 deg F to — 30 deg F. With steam heat applied, it was possible to operate the heaters for periods of 18 to 20 hr continuously, and excellent results have been obtained.

In the case of small installations, where small cylinders of propane are used, the cylinders could probably be covered with an insulating jacket and heated by either a small steam coil or by an electric heating pad, whichever source of heat is more readily available. With large or small installations it appears to require approximately 0.009 sq ft of pipe heat radiation per gallon of propane to produce the desired results at low temperatures. No type of open-flame heater is recommended as it would probably not pass state or provincial laws.

8. Remote Control for Gas Burning Heaters

Most of the rail-head type gas burning switch heaters in use are manually ignited. Recently, remote control has been made available for these heaters and is being used on some railroads. Remote control for switch heaters is of considerable interest because of the widely increasing installations of centralized traffic control. The railroads have spent large sums of money for the remote-control operation of signals and switches, only to find that snow, blocking switches, presents an operating problem.

Two types of remote control for gas-burning switch heaters are on the market. These differ slightly in design.

The requirements for such control include the electrical opening of the fuel supply line, ignition of the propane gas, discontinuance of the ignition current when heaters are lighted, provision for the re-ignition of the heaters if they are extinguished, and indication to the control station that the heaters are properly functioning. The equipment is operated from storage batteries near the switches protected, or from power lines along the right-of-way. They can be controlled on switch-signal control systems by carrier circuits, or on circuits for the switch heaters only.

Early attempts were made to use high-tension spark igniters, but results indicated preference for hot-coil elements. Solenoid valves must be attached to the propane storage, whether 100-lb cylinders or storage tanks, and must function to pass gas into the pipe lines when actuated from a remote station or tower.

One type of remote control uses two weather-tight, cast iron, rust-proofed boxes per switch, with adjustable pedestals to be driven into the ballast. These boxes contain the ignition controls. Attached to each box is a tube containing an elecric coil igniter, a pilot light, and a thermocouple. This tube is placed so that it is ½ in from the rail and ½ in below the heater, thus touching neither and not subject to rail vibration.

Within each box is a pressure regulator providing proper gas flow to the pilot light, a relay-switch actuated by 10 millivolt current from the thermocouple, which connects with a large relay in a battery house to control the flow of ignition current. Each igniter takes 7½ amp at 6 v for a few seconds to light the pilot. Each two igniters are in series on 12 v.

In operation, at a far-away tower or station, a switch is thrown on a traffic control panel, a carrier circuit, or on a special wire. This current passes through relays to the gas supply solenoid and to the ignition coils. The coils quickly heat, lighting the pilot which, in turn, lights the switch heaters. At the same time the pilot light heats the thermocouple, which actuates the relay-switch to cut off the igniter current and passes current into a circuit which lights a small lamp at the tower to indicate that the cycle has been completed and the switch heaters are burning.

The pilot light is included in this system because it has been found that a hot coil attached directly to the switch heater will not stand up under the rail vibration set up by passage of trains.

If the switch heater is extinguished by any cause, the pilot immediately relights it. If the pilot light goes out, the thermocouple cools at once and the relay-switch functions to turn out the indicator lamp at the tower and to turn on the igniter current. Elapsed time from extinguishing of pilot light, and consequent turning out of the indicator lamp at the tower, until the latter is relighted, is usually less than 15 to 20 sec.

The other type is quite similar, except that its hot-coil igniter is combined with the thermocouple and is attached directly to the switch heater. Experiments have been undertaken to use dry batteries with vacuum tubes at each switch to eliminate taking ignition current from a track-side battery house.

As far as can be ascertained, both types of remote control are giving satisfactory results and are constantly being improved.

Conclusions

From reports received from numerous railroads which have been using switch heaters for many years, it is the consensus that the most successful types are the electric tubular

(Text continued on page 697)

Fig. 1—Electric heater, tubular type.

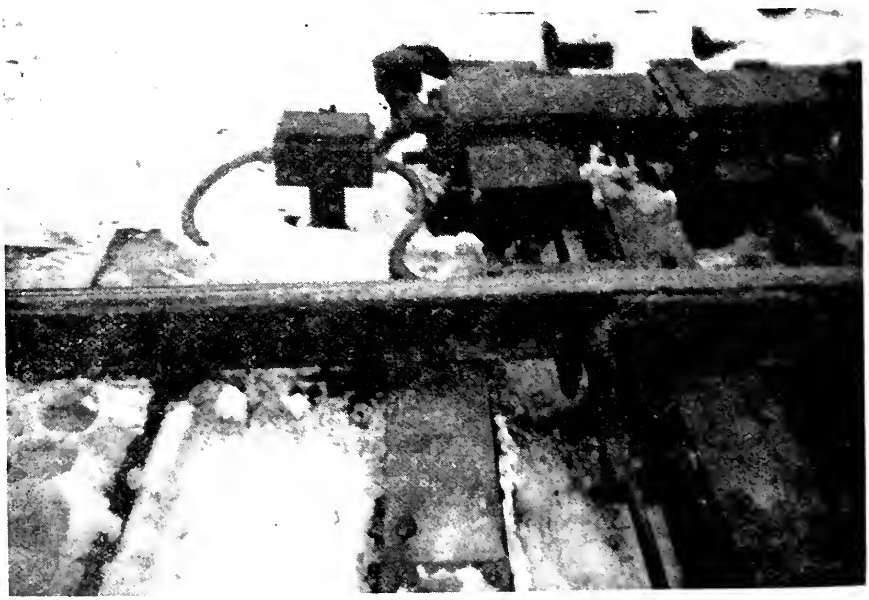


Fig. 2—Electric heater with timing device.

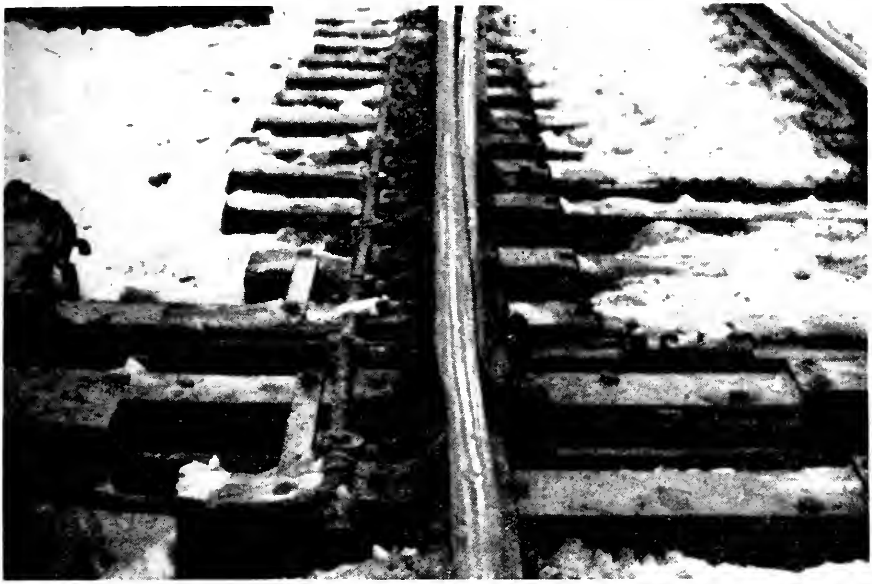


Fig. 3—Electric heater with timing device, showing conduit connections.

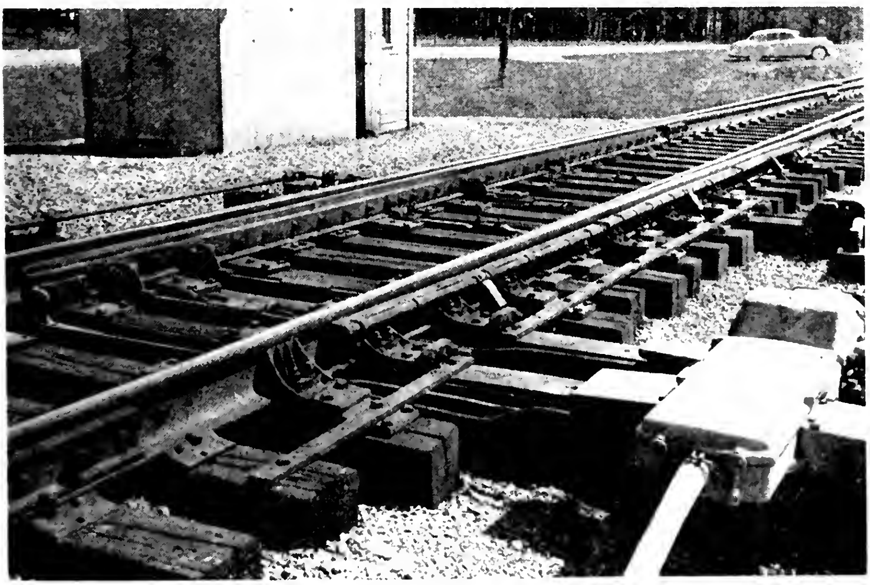


Fig. 4—Propane gas heater.

Fig. 5—End view of gas switch heater installation, which burns various types of gas, showing protecting shields.

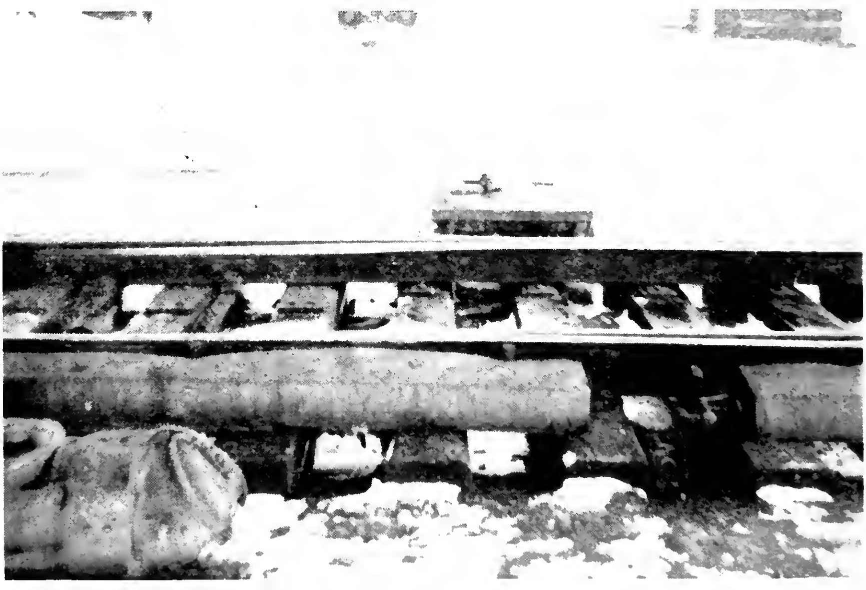


Fig. 6—Side view of heater designed to burn various types of gas, showing protecting shields in place.

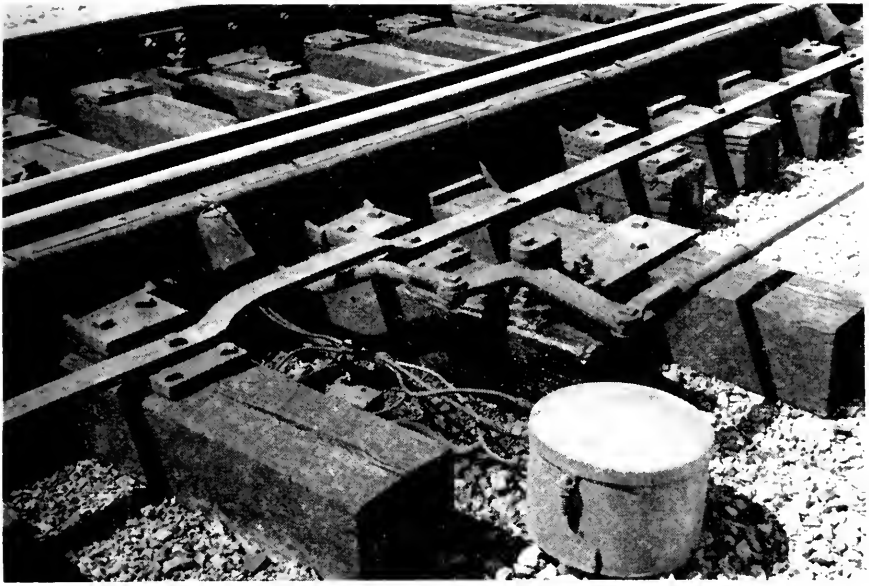


Fig. 7—Electric igniter, remote control, on propane gas heater.

type attached underneath the head of the rail, and the gas-burning, long or fixed rail-head type. The results obtained from switch heaters depend largely on the location of the system, and the climate. In climates where the temperatures rarely go below 0 deg F, and the ground is not frozen underneath the snow, the heaters are most successfully operated. In cold climates, where the ground is frozen, some trouble may be experienced in disposing of the melted snow water. Also, where the temperature drops to —40 deg F or —50 F some trouble is experienced with ice forming on the base of rail and in the tie cribs. In extremely cold climates, some advocate the use of electric ballast pad heaters to assist the rail-head heaters and eliminate the ice condition in the tie cribs. This raises the question of whether it is practical to install switch heaters to take care of all extreme conditions at switches so equipped. Possibly a good rule to follow is that in locations where the lowest anticipated temperature is —30 deg F, switch heaters can be installed and be expected to operate successfully. At lower temperatures the installation should first be studied to determine what auxiliary means of heat should be added to assist the switch heaters and overcome ice conditions, as well as to determine whether the operation would be economical.

Report on Assignment 9

Means of Conserving Labor and Materials, Including the Adaptation of Substitute Noncritical Materials, and Specifications for the Reclamation of Released Materials, Tools and Equipment

Collaborating with Committee 3–A, General Reclamation, Purchases and Stores Division, AAR

W. M. S. Dunn (chairman, subcommittee), C. T. Blume, E. L. Cloutier, R. E. Buss, L. E. Connor, C. L. Fero, N. W. Hutchison, Jack Largent, C. F. Lewis, V. W. Oswalt, Sr., P. G. Petri, J. W. Risk, R. S. Sabins, M. M. Stansbury, E. E. Turner, F. E. Yockey.

This is a progress report, submitted as information.

A report on this assignment was published as information in the Proceedings, Vol. 53, 1952, page 419.

Your committee has been unable to develop any further basic data in connection with this assignment since the publication of the report referred to. The information contained in the original report is of a specific nature, and it is the opinion of the committee that many of the practices recommended in that report are being used on many railroads which have efficient shops.

It is believed that most maintenance of way repair shops are salvage-minded because the utilization of used, usable material is part of their job. Further, the men in the shops are directly under the supervision of a superintendent, supervisor or foreman who has close daily contact with his men and materials, and is thereby able to produce greater uniformity of workmanship and better standardization of procedures.

Your committee feels that the misuse of equipment in the field can cause terrific waste, which an efficient shop organization can never overcome. This waste is caused by such things as:

1. Not providing proper protection against the elements.
2. Failure to lubricate properly.
3. Insufficient preventative field maintenance.
4. Inadequate protection against the weathering of repair parts held at field locations.
5. Operating a machine in need of minor adjustments or with a noticed minor defect.
6. Man-handling a machine on or off the track.
7. Failure to protect adequately against cold temperatures.
8. Use of improper lubricants, as well as the use of dirty containers when handling fuel and oil.
9. Insufficient blocking and rough handling in transit.

These seemingly insignificant details can and often do run into a major and unnecessary waste of material and manpower. Unnecessary shop repairs of equipment force the railroads to spend unnecessary labor hours and dollars for repair parts. The only corrective action is an educational program, being certain that this program adequately trains each machine operator so that he really knows how to use and care for his machine.

In field use, most equipment can produce either quality or quantity work. Certainly the goal is quantity with quality. To insist upon quantity without regard to quality is directly encouraging the waste of labor and material by producing a job which does not last as long as it should, or by doing a job in such a manner that material life is shortened.

Report of Committee 17—Wood Preservation

W. F. Dunn, Sr., *Chairman,*	L. C. Collister	A. J. Loom, *Vice Chairman,*
W. P. Arnold	G. H. Dayett, Jr.	A. L. Kammerer
W. W. Barger	R. F. Dreitzler	L. W. Kistler
J. A. Barnes	H. R. Duncan	G. L. P. Plow
A. S. Barr	T. H. Friedlin	R. R. Poux
R. S. Belcher	F. J. Fudge	M. H. Priddy
P. D. Brentlinger	W. H. Fulweiler	J. W. Reed
Walter Buehler	H. F. Gilzow	W. C. Reichow
C. M. Burpee	W. R. Goodwin	B. J. Richards
C. S. Burt	B. D. Howe	W. B. Stombock
G. L. Cain	M. S. Hudson	H. C. Todd, Jr.
G. B. Campbell	R. P. Hughes	H. von Schrenk
H. B. Carpenter	H. E. Hurst	C. H. Wakefield
	M. F. Jaeger	*Committee*

To the American Railway Engineering Association:

Your committee reports on the following subjects:

11. Means of conserving labor and materials, including the adaptation of substitute noncritical materials, and specifications for the reclamation of released materials, tools and equipment, collaborating with Committee 3–A, General Reclamation, Purchases and Stores Division, AAR.

No report.

THE COMMITTEE ON WOOD PRESERVATION,
W. F. DUNN, *Chairman*.

AREA Bulletin 505, December 1952.

Report on Assignment 1

Revision of Manual

C. S. Burt (chairman, subcommittee), W. P. Arnold, W. W. Barger, R. S. Belcher, Walter Buehler, G. B. Campbell, H. R. Duncan, A. J. Loom.

Your committee has made a comprehensive study of its entire chapter in the Manual and recommends the following deletions, additions, revisions and reapprovals:

In order to bring the following Manual material with respect to Wood Preserving Fundamentals, Wood Preserving Plant Practice, and Forms for Reporting Inspection of Wood Preserving Operations and Results, entirely up to date and to include references to five new preservatives, delete all three documents and substitute therefor, under the main heading "Wood Preserving", the material presented in Exhibit A.

Pages 17–1 and 17–2

WOOD PRESERVING FUNDAMENTALS

Page 17–51

WOOD PRESERVING PLANT PRACTICE

Pages 17–52 and 17–53

FORMS FOR REPORTING INSPECTION OF WOOD PRESERVING OPERATIONS AND RESULTS

Page 17–3

REQUISITIONING PRESERVATIVELY-TREATED WOOD

Delete Par (e) *Preservative,* and substitute therefor the following:

(e) *Preservative.* An impregnant which meets the requirements of one of the AREA specifications for preservatives in accordance with use requirements: i.e., creosote; creosote-coal tar solutions; creosote-petroleum solution; zinc chloride; chromated zinc chloride; copperized chromated zinc chloride; tanalith; pentachlorophenol; copper naphthenate; and acid copper chromate.

Delete Par (g) Retention of preservative, and substitute therefor:

(g) *Retention of preservative.* In accordance with applicable AREA specifications.

Pages 17–4 and 17–5

Delete Table 1—Minimum Net Retention of Preservative, which is to be revised and to become a part of revised Specifications for Treating Processes.

In order to bring the following two Manual documents up to date with respect to treatment processes, new preservatives and suggested retention of preservative, delete both of these documents and substitute the material shown in Exhibit B—Specifications for Treatment. Note that these new specifications include recast Table 1—Minimum Net Retention of Preservative, pages 17–4 and 17–5, under a new table heading "Specific Requirements for Preservative Treatment by Pressure Processes."

Pages 17–7 to 17–10, incl.

SPECIFICATIONS FOR TREATING PROCESSES

Pages 17–15 to 17–20, incl.

SPECIFICATIONS FOR THE PRESERVATIVE TREATMENT OF PACIFIC COAST DOUGLAS FIR

Pages 17–23 to 17–25, incl.

SPECIFICATIONS FOR PRESERVATIVES

In order to bring these specifications up to date, delete present specifications for Creosote-Petroleum Solutions; for Petroleum for Blending with Creosote; for Zinc Chloride; for Chromated Zinc Chloride; for Tanalith; and Methods of Tests, in their entirety and substitute revised specifications presented herewith as Exhibit C. Revised specifications for Creosote and for Creosote—Coal Tar Solutions are presented in the report on Assignment 8.

Pages 17–29 and 17–30

STANDARD VOLUME CORRECTION TABLE FOR CREOSOTE-PETROLEUM SOLUTIONS

Reapprove without change.

Pages 17--31 to 17–38, incl.

MEASURING AND SAMPLING CREOSOTE

Reapprove with following revision:
Page 17–33—Delete entire Section II—'Water in Creosote.'

Pages 17–43 to 17–46, incl.

TESTS RELATING TO ZINC CHLORIDE TREATMENT

Delete all of this material, pertinent parts of which are included in revised specifications for salt preservatives.

Your committee presents as Exhibit D, for adoption and publication in the Manual, Standard Abridged Volume Correction Tables for Petroleum Oils.

This information is comparable to that now shown in the Manual for Creosote, Creosote-Coal Tar Solutions, Creosote-Petroleum solutions and is useful for Petroleum Oils used with Pentachlorophenol and Copper Naphthenate.

Other recommendations with respect to the Manual appear in the reports on Assignments 6 and 8.

Exhibit A

WOOD PRESERVING

FUNDAMENTALS

All forest products exposed to decay or attack by wood-destroying organisms, if they are not naturally resistant to deterioration by such organisms, can be treated preservatively at a saving in annual cost. The largest saving is assured by most careful attention to quality of preservatives, details of treatment and protection of materials after treatment. Competent inspection is essential to assure proper treatment.

The heartwood of most naturally durable woods resists penetration by preservative, yet its life is generally extended by treatment, even though the depth of penetration is slight.

Preservative treatment will not restore any loss of strength resulting from defects of any kind; consequently, only wood free of defects which will render it unfit for use can be treated to advantage.

Wood needs to be conditioned for preservative treatment by a procedure which will render it receptive to penetration by preservative without reducing its strength. When circumstances permit, material should be air-seasoned. When there is not sufficient time for proper air seasoning, or in cases of large material, which in some localities during all seasons of the year will not air season successfully without deterioration, artificial conditioning should be used.

The conditioning of wood in steam is particularly adapted to kinds which do not check materially, split, or warp when subjected to high temperatures. Steaming is applied to Douglas fir and to hardwoods only when a salt is the preservative.

Heating wood in preservative at atmospheric pressure is undertaken to assure the penetration of some preservative under pressure when the removal of appreciable quantities of water is deemed unnecessary.

Heating in oil under a vacuum conditions Douglas fir and most hardwoods which do not check materially, split or warp when subjected to high temperatures, provided the treating equipment includes adequate condensors and measuring tanks.

Bark on wood to be treated prevents the penetration of preservative. Strips of inner bark, not more than ¾ in wide and 8 in long, may be permitted when separated by 1 in of clear surface between any 2 strips.

To avoid exposure of untreated wood by cutting into preserved parts, the complete manufacture in its final form before treatment is advisable. Preboring to accommodate fastening devices insures the introduction of preservative to the wood surrounding the holes.

Careless handling of treated wood is apt to expose areas not reached by the preservative; consequently, the use of pointed tools other than end hooks is objectionable.

Hot creosote will protect surfaces exposed by necessary adzing, boring or cutting of treated wood, if the holes are filled with the oil (preferably by means of portable pressure equipment) and the surfaces and cuts painted twice, followed by a coating of pitch sealing compound, flashing cement or other sealers. In the case of salt treated wood, a concentrated solution of toxic salt preservative may be used in place of creosote before application of the sealer. Tight fitting treated plugs should be driven into unused holes that were bored after treatment.

Pile cut-offs should be further protected. A suggested method is the application of two thicknesses of tar-saturated fabric over the cut-off and over-lapping the sides of the pile at least 2 in. The overlap should be folded down along the sides and glued in place with the sealing compound. The fabric should then be coated with a coating of the sealer. A satisfactory plastic compound for the protection of piles at cut-offs may be made with 10 to 20 percent of creosote and 80 to 90 percent pitch.

Treated piles should not be dapped in the field for sway bracing. Piles of uniform size should be selected for each bent and where necessary, pressure treated filler blocks used to fill in between piles or caps and sway bracing.

Adzing, boring and incising in accordance with AREA Specifications for Machining Cross Ties, Chapter 3, will not only provide a smooth and true bearing for the tie plates and greater resistance to spike pulling but will also assure the presence of preservative where it is most needed in the tie. Incising also assures most uniform penetration of preservative in lumber, timbers and other materials and is especially effective in obtaining desired penetration in the resistant heartwood of lumber when performed immediately prior to treatment.

PRESERVATIVES

Coal-tar creosote is the wood preservative generally used for all purposes where an odorless and paintable product is not required. It has a high degree of permanence and is highly toxic to fungi, insects and marine borers.

Creosote is often mixed with coal tar or petroleum to decrease the cost, increase the water-repelling properties and retard evaporation of the preservative. Where clean treatment is required, creosote-coal tar solutions are not suitable for poles nor are creosote-petroleum solutions to be used in marine borer infested waters.

Zinc chloride, chromated zinc chloride and tanalith are the preservatives generally used where a colorless, odorless and paintable product is required. They are highly toxic but less permanent than creosote under service conditions where the wood is in contact with water or subject to excessive wetting.

Wood treated with water-borne preservatives should be kiln dried or air dried after treatment and before installation, to prevent shrinkage.

Pentachlorophenol or copper naphthenate solutions in oil of suitable characteristics are suitable for specific applications. These preservatives are not recommended for protection against marine borer attack.

PLANT PRACTICE

Seasoning yards should be located where there is maximum exposure to the sun and to freely circulating air. Avoid low, humid situations. Arrange for effective drainage and keep the yard free of vegetation and debris, especially decaying wood.

Support all stacks of seasoning material on treated or other non-decaying sills, with at least 12 in of unenclosed air space beneath the lowest layer of material, but more space in warm humid localities.

Promote air circulation by providing, between the stacks of material in continuous lines across the seasoning yard, alleys not less than 3 ft wide in working spaces and 1 ft wide elsewhere, giving consideration to the direction of the prevailing wind.

Open stacking furthers the drying of wood, but satisfactory spacing of the pieces depends on their size and the mean relative humidity and temperature of the locality. In most sections satisfactory seasoning is accomplished by stacking cross ties in layers of 8 to 10 with 1 tie as a stringer at every other end. Timbers 5 in or more thick should be stacked with at least 2 in of air space between layers. Lumber less than 5 in thick and round material with at least 1 in between layers. Within each layer all pieces should be at least 2 in apart.

Stickers of preserved wood or areas of contact brushed with preservatives will reduce the likelihood of the decay called "stackburn".

The length of time required to adequately air dry wood in preparation for its preservative treatment varies with the kind, dimensions, and moisture content when stacked and climatic and site conditions; consequently, a specific seasoning period must be determined for each particular locality and care taken to assure the treatment of all material before it starts to deteriorate.

If anti-splitting devices are used, they should be applied on arrival of material at the treating plant or as soon as possible after stacking in the seasoning yard to the ends of ties and timbers of species which have a tendency to split during seasoning.

The railway company's representative or inspector shall have access to all parts and facilities of plants used in the conditioning and treating of its forest products and shall be present during the treating procedure to make sure that the process is being carried on as specified.

Plant equipment shall be checked frequently to determine its reliability. Any variation from accuracy which exceeds the following limits for the equipment listed shall cause the treating records to be corrected accordingly until the equipment is in acceptable, proper working order. Cylinders, tanks, or other equipment having temperature, pressure, or vacuum recording instruments shall be equipped with indicating thermometers or gages to check the accuracy of the recording instruments.

a. *Thermometers.* Compare with a thermometer certified by a manufacturer or testing laboratory and allow a variation not exceeding 2 deg of temperature.

b. *Pressure Gages.* Compare with a standard test gage or with other suitable gage-testing device and allow a variation not exceeding 2 percent of pressure.

c. *Vaccum Gages.* Compare with a mercury column and allow a variation not exceeding 1 in of vacuum.

d. *Working Tank Gages.* Compare the calculated tank volume with the readings on the indicator board or dial at three levels and allow a variation not exceeding 2 percent.

e. *Working Tank Scales.* Load with certified test weights when the tank is approximately empty, half full and full, and allow a variation not exceeding 1 percent. Where scales have been checked by recognized agencies, certificates of accuracy shall be accepted.

f. *Track Scales.* Test by certified weights or weight car and allow a variation not exceeding 1 percent. Where scales have been checked by recognized agencies, certificates of their accuracy should be accepted.

RECORDS OF TREATMENT AND REPORTS OF INSPECTION

The recording and reporting of the detailed procedure in the treatment of wood is desirable. Knowledge of what was done proves useful when seeking possible reasons for unsatisfactory results, provides information useful in developing treating methods and supplies a check on whether or not the plant operator is adhering to the process specification.

Forms should be provided to record the following details of treatment:

Name of Railroad

Name of Wood-preserving Plant Location of Wood-preserving Plant

Name of Inspector

Charge No.

Date

Type of material in charge

Number of pieces by sizes

Species

Degree of seasoning

Machinery*

Cubic feet

Preservative, description and analysis

Process

Steam conditioning

- Time required to reach maximum temperature
- Time steamed at maximum temperature
- Maximum temperature
- Initial vacuum period
- Maximum vacuum

Heating in oil

- Heating period
- Maximum vacuum
- Maximum temperature
- Total condensation
- Total absorption of preservative

Treatment

- Initial air pressure
- Initial air period
- Pressure period
- Maximum pressure
- Maximum temperature
- Average temperature
- Maximum final vacuum
- Final vacuum period

Working tank readings

Working tank temperatures

Injection under pressure

Net retention in pounds per cubic foot

Total time of treatment

Number of borings

Percent conforming

---

* Incised, un-incised, rough, surfaced, worked, etc.

Exhibit B

SPECIFICATIONS FOR TREATMENT

A. GENERAL REQUIREMENTS

The following requirements apply to each of the treatment processes. If these requirements are to be modified to meet special conditions, complete detailed instructions shall be given.

1. Plant Equipment

Treating plants shall be equipped with the thermometers and gages necessary to indicate and record accurately the conditions at all stages of treatment, and all equipment shall be maintained in acceptable, proper working condition. The apparatus and chemicals necessary for making the analyses and tests required by the purchaser shall also be provided by plant operators, and kept in condition for use at all times.

2. Conditioning

Material shall be conditioned by air seasoning, by kiln drying, by steaming, or by heating in the preservative either under vacuum or at atmospheric pressure, or by a combination of them as agreed upon, in such a manner as will not cause damage for the use intended.

When air seasoning is used, the material shall be treated before it begins to deteriorate.

When steam conditioning is used, the maximum temperature and the overall maximum duration of steaming shall be as prescribed for the species and type of material in Table 1. The maximum temperatures specified shall not be reached in less than 1 hr. Lower temperatures and shorter steaming periods may be used when agreed to by the purchaser.

The cylinder shall be provided with vents to relieve it of air and to insure proper distribution of steam. After steaming is completed, a vacuum of at least 22 in at sea level shall be drawn.

The cylinder shall be relieved continuously or frequently enough to prevent condensate from accumulating in sufficient quantity to reach the wood. Before preservative is introduced the cylinder shall be drained of condensate.

When steaming is used solely to preheat the material prior to treatment, the vacuum period may be waived.

When conditioning by heating in oil is used, the oil shall cover the material in the cylinder. If a vacuum is drawn during the conditioning period, it shall be of sufficient intensity to evaporate water from the material at the temperature of the oil. The intensity of the vacuum, or the temperature of the oil, or both, shall be adjusted so as to regulate the evaporation of water satisfactorily. The conditioning shall continue until the material is sufficiently heated and enough water removed to permit proper penetration. The oil shall be removed from the cylinder before an empty-cell process is applied.

3. Sorting and Spacing

Whenever it is practicable, the material in any charge shall consist of pieces similar in size, species, moisture content, and receptivity to treatment and so separated as to insure contact of treating medium with all surfaces.

4. Machining

All adzing, boring, chamfering, framing, gaining, incising, surfacing, trimming, etc., shall be done prior to treatment.

5. Incising

When incising is specified in Table 1, the material shall be incised prior to treatment on 4 sides, with incisor teeth not more than 7/32 in thick, to the pattern shown in Fig. 1. In pieces 5 in or more thick, the incisions shall be ¾ in deep. In pieces less than 5 but more than 2 in thick, they shall be ¾ in deep in the edges but only ½ in deep in the sides. Incising of pieces 2 in and thinner is not recommended. Patterns slightly different are not objectionable if machines constructed prior to 1940 are used.

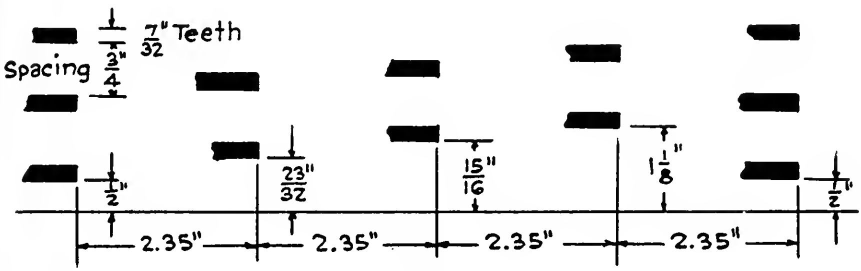


Fig. 1.

B. TREATMENT

Creosote-Type Preservatives

1. Manner of Treatment

Following the conditioning period, the material shall be treated by an empty-cell process whenever practicable, to obtain as deep and uniform penetration as possible with the retention of preservative stipulated. Material shall be treated by the full-cell process only when the maximum net retention is desired and when pressure is held to refusal, or when the stipulated retention is greater than can be obtained by the use of an empty-cell process. The ranges of pressure, temperature and time duration shall be controlled so as to obtain maximum penetration with the quantity of preservative injected.

2. Empty Cell—Lowry and Rueping*

Material shall be subjected to atmospheric air pressure or to a higher initial air pressure of the necessary intensity and duration. The preservative shall be introduced until the cylinder is filled, the air pressure being maintained constant during the filling operation. The pressure shall be raised to not more than that specified in Table 1. Material shall be held under pressure until there is obtained the largest practicable volumetric injection that can be reduced to the stipulated retention by ejection of surplus preservative from expansion of the air initially introduced and by a quick high vacuum.

The temperature of the preservative during the entire pressure period shall be not more than 220 deg F, but shall average at least 180 deg F.

* If the cylinder is filled at atmospheric air pressure, the process is known as Lowry. If initial air pressures higher than atmospheric are used, the process is known as Rueping.

After the pressure period is completed the cylinder shall be emptied speedily of preservative, and a vacuum of not less than 22 in at sea level created promptly and maintained until the wood can be removed from the cylinder free of dripping preservative.

An expansion bath may be applied after pressure of an oil treatment is completed and before removal of preservative from the cylinder, by quickly reheating the oil surrounding the material to the maximum temperature permitted by the individual species specification, either at atmospheric pressure or under vacuum, the steam to be turned off the heating coils immediately after the maximum temperature is reached. The cylinder shall then be emptied speedily of preservative and a vacuum of not less than 22 in at sea level created promptly and maintained until the wood can be removed from the cylinder free of dripping preservative.

At the completion of the treatment, material may be cleaned by final steaming as specified in Table 1 for the individual type of material or species.

3. Full Cell—Bethel

Material shall be subjected to a vacuum of not less than 22 in at sea level for not less than 30 min either before the cylinder is filled or during the period of heating in the preservative. If not already full, the cylinder shall then be filled without first breaking the vacuum. The pressure shall be raised to not more than that specified in Table 1. Material shall be held under pressure until there is obtained the volumetric injection that will insure the stipulated retention, or until the wood is treated to refusal.

The temperature of the preservative during the entire pressure period shall be not more than 220 deg F, but shall average at least 180 deg F.

After pressure is completed, the cylinder shall be emptied speedily of preservative and a vacuum of not less than 22 in at sea level created promptly and maintained until the wood can be removed from the cylinder free of dripping preservative.

Water-Borne Preservatives

4. Manner of Treatment

Following the conditioning* period, the material shall be treated by the full-cell process as described in Art. 3, Sec. B. The treating solution shall be of uniform concentration and no stronger than necessary to obtain the required retention of dry salt preservative with the largest volumetric absorption practicable. The ranges of pressure, temperature and time duration shall be controlled so as to obtain the maximum penetration by the quantity of preservative injected.

The temperature of the preservative during the entire pressure period shall not be more than 200 deg F in the case of zinc chloride, 160 deg F in the case of chromated zinc chloride, copperized chromated zinc chloride or tanalith, or 120 deg F for acid copper chromate.

Oil-Borne Preservatives

5. Manner of Treatment

Following the conditioning period* the material shall be treated by an empty-cell process as described in Art. 2, Sec. B, whenever practicable, to obtain as deep and uniform a penetration as possible with the retention of preservative stipulated. Material

* Heating in preservative is not practicable.

shall be treated by the full-cell process as described in Art. 3, Sec. B, only when the maximum net retention is desired and where pressure is held to refusal, or when the stipulated retention is greater than can be obtained by the use of an empty-cell process. The ranges of temperature, pressure and time duration shall be controlled so as to obtain maximum penetration with the quantity of preservative injected.

The temperature of the preservative during the entire treatment shall not be more than 210 deg F, but shall average at least 140 deg F.

After pressure is completed, the cylinder shall be emptied speedily of preservative solution and a vacuum of not less than 22 in at sea level created promptly and maintained until the wood can be removed from the cylinder free of dripping solution.

An expansion bath may be applied after pressure of an oil treatment is completed and before removal of preservative from the cylinder, by quickly reheating the oil surrounding the material to the maximum temperature permitted by the individual species specification, either at atmospheric pressure or under vacuum, the steam to be turned off the heating coils immediately after the maximum temperature is reached. The cylinder shall then be emptied speedily of preservative and a vacuum of not less than 22 in at sea level created promptly and maintained until the wood can be removed from the cylinder free of dripping preservative.

At the completion of treatment by an empty-cell process material may be cleaned by final steaming as specified in Table 1 for the individual type of material or species.

C. RESULTS OF TREATMENT

1. Retention of Preservative

The net retention in any charge shall be not less than 90 percent of the quantity of preservative that may be specified; but the average retention by the material treated under any contract or order and the average retention of any 5 consecutive charges shall be at least 100 percent of the quantity required, unless specified, and treated to refusal. The amount of preservative retained shall be calculated from reading of working-tank gages, or scales, or from weights before and after treatment of loaded trams on suitable track scales, with the necessary corrections for changes in moisture content. Recommended minimum retentions for various material for various uses are contained in Table 1.

The volume of creosote type preservatives shall be calculated on the basis of 100 deg F. Calculations of volume or weight shall be made by the use of temperature or specific gravity factors contained in the volume and specific gravity correction tables of the AREA.

The weight of water borne preservatives shall be based on the dry salt obtained by multiplying the net retention in pounds of solution per cubic foot by the strength ot the solution expressed as a decimal.

The volume of oil-borne preservatives shall be calculated on the basis of 100 deg F. Calculations of volume or weight shall be made by the use of temperature or specific gravity factors contained in the volume and specific gravity correction tables of the AREA.

The amount of preservative retained shall be in accordance with Table 1, unless modified by the purchaser.

The penetration of preservative shall be as specified in Table 1.

2. Plugging Penetration Test Holes

All holes made for determining penetration of preservative shall be filled with tight-fitting treated plugs.

D. PRESERVATIVES

The preservative used shall be whichever of the following specifications of the AREA is stipulated:

Creosote-Type Preservatives
- Creosote
- Creosote–Coal Tar Solutions
- Creosote–Petroleum Solutions

Water-Borne Preservatives
- Zinc Chloride
- Chromated Zinc Chloride
- Copperized Chromated Zinc Chloride
- Tanalith
- Acid Copper Chromate

Oil-Borne Preservatives
- Pentachlorophenol
- Copper Naphthenate

E. INSPECTION

Inspection for conformity to the requirements of this specification shall be as specified for the individual type of material or species as shown in Table 1 and as specified in Arts. 1, 2 and 3, of this Section.

1. Retention of Preservative

When maximum retention by full-cell process or treatment to refusal is specified, the pressure and temperature shall be maintained constant or increased within a range consistent with good practice for the material being treated until the quantity of preservative absorbed is not more than the following percentages of the amount already injected: All species except Douglas fir and oak—½ percent in any half hour; Douglas fir and oak—2 percent in each of any 2 consecutive half hours.

2. Penetration

After treatment, the inspector shall examine the charge and select representative material to be bored for determining penetration by the preservative. A boring shall be made by the inspector approximately midway between the ends of each selected piece, avoiding checks, knots, pitch pockets, shakes, and splits, except in red oak longer than 9 ft, when the boring shall be approximately 4 ft from either end of the piece.

3. Measurement of Penetration

Except in the case of red oak, cores shall be split smoothly, lengthwise with the grain, and depth of penetration and thickness of sapwood measured to the nearest 1/10 in. The depth of penetration shall be the distance from the outer end of the core to and including the summerwood of the innermost ring showing penetration in its summerwood, provided there are no untreated bands of one or more annual growth rings within the measured distance.

In the case of red oak, the number of annual growth rings in the core and the number of rings containing preservative shall be counted. The latter divided by the former will give the percentage of rings penetrated. When any ring appears on the core more than once each appearance shall be counted. Preservative in any pore or vessel of any annual ring of the core shall class that ring as penetrated. In case of doubt, the questionable ring shall be cut crosswise through the springwood and if any pore on the cut surface shows preservative for its length the ring shall be considered penetrated. The percentage of rings penetrated in any charge shall be determined by totaling the individual percentages and dividing their sum by the number of cores.

The depth of penetration in gum lumber and ties shall be the sum of all treated sections appearing on the core.

Penetration in material treated with water borne preservatives shall be determined in accordance with AWPA Standard A3, Standard Method for Determining Penetration of Preservatives.

F. RETREATMENT

Material not conforming to the stipulated minimum requirements may be retreated and may be reoffered for acceptance under the following conditions:

a. Material shall not be retreated more than twice.

b. When material is retreated in a charge with untreated material, the volume of the retreatable material shall not exceed 10 percent of the total volume of the charge, and in the computation of the required minimum net retention of preservative, all material in the charge shall be considered as untreated.

c. When a charge as a whole is retreated, the total retention as a result of all treatments shall be sufficient to satisfy the specified requirements for both net retention and penetration.

d. When a charge made up of pieces rejected for insufficient penetration only is retreated, the amount of preservative injected during retreatment shall be sufficient to produce the required penetration.

TABLE 1—SPECIFIC REQUIREMENTS FOR PRESERVATIVE TREATMENT BY PRESSURE PROCESSES

(Lumber, Timbers and Bridge Ties)

	Southern Pine Ponderosa Pine		Jack Pine / Lodgepole Pine Red Pine / Northern White Pine Sugar Pine / Western White Pine	
CONDITIONING	Air-seasoning or kiln drying, or steaming, or heating in the preservative or a combination.		Air-seasoning or kiln drying or steaming or heating in the preservative or a combination.	
Steaming				
Temp. - degrees F - Max.	259		240	
Duration - Hrs. Max.	15		6	
Vacuum				
Inches at sea level - Min.	22		22	
Heating in preservative				
Temp. - degrees F - Max.	220		220	
Incising	Not required		Required when thickness is greater than 3 inches	
TREATMENT				
Creosote type preservatives	Empty or Full-Cell		Empty or Full-Cell	
Water Borne preservatives	Full-Cell		Full-Cell	
Oil borne preservatives	Empty or Full-Cell		Empty or Full-Cell	
Pressure - psi - Max.	200		150	
Final steaming				
Temp. - degrees F - Max.	259		240	
Duration - hours - Max.	3		3	
RESULTS OF TREATMENT				
Retention - lb per cu ft -Min.				
Creosote type preservatives	General Use	Coastal Waters*	General Use	Coastal Waters*
Creosote	8	Ref. Min. 20	8	Refusal
Creosote-coal tar	8	Ref. min. 20	8	Refusal
Creosote-petroleum	8	Not recommended	8	Not recommended
Water borne preservatives**	Above Ground	Ground Contact	Above Ground	Ground Contact
Zinc chloride	1.00	1.25	1.00	1.25
Chromated zinc chloride	.75	1.00	.75	1.00
Tanalith	.35	.50	.35	.50
Oil borne preservatives				
Pentachlorophenol***	0.3	0.4	0.3	0.4
Copper naphthenate (Copper Metal)	0.05	0.1	0.05	0.1
Penetration in inches or percent of sapwood-Min.	3.0 or 85		Under 3" thick - 3/8 and 90. 3" and thicker and all marine structures - 1/2 and 90.	
Determination of penetration	A borer core shall be taken from 20 pieces in each charge If 90% of the cores meet the penetration requirements the charge shall be accepted.		A borer core shall be taken from 20 pieces in each charge. If 80% of the cores meet the penetration requirements the charge shall be accepted.	

*Subject to marine borer attack.
**Not recommended where leaching is a major consideration.
***Treating solution must contain approximately 5% Penta.; 0.4 lb/cu ft equals 8 lb of 5% Penta. solution.

TABLE 1 (CONT'D)—SPECIFIC REQUIREMENTS FOR PRESERVATIVE TREATMENT BY PRESSURE PROCESSES

(Lumber, Timbers and Bridge Ties, Cont'd)

	Pacific Coast Douglas Fir Intermountain Douglas Fir Western Hemlock Western Larch		Oaks	
CONDITIONING	Air-seasoning or kiln drying, or steaming, or heating in the preservative or a combination.		Air-seasoning or kiln drying, or heating in the preservative or a combination.	
Steaming Temp. - degrees F -Max. Duration - Hrs. Max.	220* 6		Not permitted	
Vacuum Inches at sea level - Min.	22			
Heating in preservative Temp. - degrees F - Max.	220		220	
Incising	Required when thickness over 3"		Not required	
TREATMENT				
Creosote type preservatives	Empty or Full-Cell		Empty or Full-Cell	
Water borne preservatives	Full-Cell		Full-Cell	
Oil borne preservatives	Empty or Full-Cell		Empty or Full-Cell	
Pressure - psi - Max.	150		200	
Final steaming Temp. - degrees F - Max. Duration - hours - Max.	240 3		240 3	
RESULTS OF TREATMENT				
Retention - lb per cu ft -Min.				
Creosote type preservatives	General Use**	Coastal Waters***	General Use	Coastal Waters***
Creosote	8	12 or refusal	6	Refusal Min. 10
Creosote-coal tar	8	12 or refusal	6	Refusal Min. 10
Creosote-petroleum	8	Not recommended	6	Not recommended
Water borne preservatives****	Above Ground	Ground Contact	Above Ground	Ground Contact
Zinc Chloride	1.00	1.25	1.00	1.25
Chromated zinc chloride	.75	1.00	.75	1.00
Tanalith	.35	.50	.35	.50
Oil borne preservatives				
Pentachlorophenol	0.3	0.4	0.3	0.4
Copper naphthenate(Copper Metal)	0.05	0.1	0.05	0.1
Penetration in inches or percent of sapwood-Min.	Under 3" thick 3/8 and 90. 3" and thicker and all marine structures 1/2 and 90.		White Oak - 95% of sapwood. Red Oak-65% of annual rings; charges of recalcitrant wood with less penetration may be accepted if wood is conditioned properly before treatment and treatment is continued to refusal.	
Determination of penetration	A borer core shall be taken from 20 pieces in each charge. If 80% of the cores meet the penetration requirements the charge shall be accepted.		A borer core shall be taken from 20 pieces in each charge. If the average penetration of the 20 cores meets the penetration requirements the charge shall be accepted.	

*See part (A) - Wood Preserving Fundamentals.

**8 lbs is general average retention. Thin material should have more than 8 lbs. Heavy timbers generally reach refusal with less.

***Subject to marine borer attack.

****Not recommended where leaching is a major consideration.

TABLE 1 (CONT'D)—SPECIFIC REQUIREMENTS FOR PRESERVATIVE TREATMENT BY PRESSURE PROCESSES

(Lumber, Timbers and Bridge Ties, Cont'd)

	Black Gum Red Gum	
CONDITIONING	Air-seasoning or kiln drying, or steaming, or heating in the preservative or a combination.	
Steaming		
Temp. - degrees F - Max.	240	
Duration - Hrs. Max.	6	
Vacuum		
Inches at sea level - Min	22	
Heating in preservative		
Temp. - degrees F - Max.	220	
Incising	Not required	
TREATMENT		
Creosote type preservatives	Empty or Full-Cell	
Water borne preservatives	Full-Cell	
Oil borne preservatives	Empty or Full-Cell	
Pressure - psi - Max.	200	
Final steaming		
Temp. - degrees F - Max.	240	
Duration - hours - Max.	3	
RESULTS OF TREATMENT		
Retention - lb per cu ft -Min.		
Creosote type preservatives	General Use	Coastal Waters*
Creosote	9	Refusal - Min. 12
Creosote-coal tar	9	Refusal - Min. 12
Creosote-petroleum	9	Not recommended
Water borne preservatives**	Above Ground	Ground Contact
Zinc chloride	1.00	1.25
Chromated zinc chloride	.75	1.00
Tanalith	.35	.50
Oil borne preservatives		
Pentachlorophenol	0.3	0.4
Copper naphthenate (Copper Metal)	0.05	0.1
Penetration in inches or per-cent of sapwood-Min.	1.5 or 85	
Determination of penetration	A borer core shall be taken from 20 pieces in each charge. If 80% of the cores meet the penetration requirements the charge shall be accepted.	

*Subject to marine borer attack.
**Not recommended where leaching is a major consideration.

TABLE 1 (CONT'D)—SPECIFIC REQUIREMENTS FOR PRESERVATIVE TREATMENT BY PRESSURE PROCESSES

(Piles)

	Southern Pine Ponderosa Pine	Pacific Coast Douglas Fir
CONDITIONING	Air-seasoning or steaming or heating in the preservative or a combination.	Air-seasoning or heating in the preservative or a combination.
Steaming Temp. - degrees F - Max. Duration - Hrs. Max.	 259 18	 Not permitted
Vacuum Inches at sea level - Min.	 22	
Heating in preservative Temp. - degrees F - Max.	 220	 220
TREATMENT		
Creosote type preservatives Water borne preservatives Oil borne preservatives	Empty or Full-Cell Not permitted Empty or Full-Cell	Empty or Full-Cell Not permitted Empty or Full-Cell
Pressure - psi - Max.	200	150
Final steaming		
Temp. - degrees F - Max. Duration - hours - Max.	Not permitted	Not permitted
RESULTS OF TREATMENT		
Retention - lb per cu ft - Min. Creosote type preservatives	 General Use - Coastal Waters*	 General Use - Coastal Waters*
Creosote	12 Ref. Min. 20	8 Refusal Min. 12
Creosote-coal tar	12 Ref. Min. 20	8 Refusal Min. 12
Creosote-petroleum	15 Not recommended	10 Not recommended
Penetration in inches or percent of sapwood-Min.	3.5 or 90 for 12 to 16 lbs retention 4.0 or 95 for 17 to 24 lbs retention	1 inch and 85% up to a Max. of 1.6 inches.
Determination of penetration	A borer core shall be taken mid-way between the butt and top of each pile in each charge. Only those piles meeting the penetration requirements shall be accepted.	A borer core shall be taken midway between the butt and top of each pile in each charge. Only those piles meeting the penetration requirements shall be accepted.

*Subject to marine borer attack.

TABLE 1 (CONT'D)—SPECIFIC REQUIREMENTS FOR PRESERVATIVE TREATMENT BY PRESSURE PROCESSES

(Piles, Cont'd)

	Oaks
CONDITIONING	Air-seasoning or heating in the preservative or a combination.
Steaming Temp. - degrees F - Max. Duration - Hrs. Max.	Not Permitted
Vacuum Inches at sea level - Min.	
Heating in preservative Temp. - degrees F - Max.	220
TREATMENT	
Creosote type preservatives Water borne preservatives Oil borne preservatives	Empty or Full-Cell Not Permitted Empty or Full-Cell
Pressure - psi - Max.	200
Final steaming Temp. - degrees F - Max. Duration - hours - Max.	Not Permitted
RESULTS OF TREATMENT	
Retention - lb per cu ft - Min. Creosote type preservatives Creosote Creosote-coal tar Creosote-Petroleum	General Use / Coastal Waters* Creosote: 10 / Refusal Full-Cell Creosote-coal tar: 10 / Refusal Full-Cell Creosote-Petroleum: — / Not Recommended (Above retentions apply to Red Oak only. White Oak to be treated to refusal for all uses.)
Penetration in inches or percent of sapwood-Min.	White Oak - 100% of sapwood Red Oak - 65% of annual rings; charges of recalcitrant wood with less penetration may be accepted if wood is conditioned properly before treatment and treatment is continued to refusal.
Determination of penetration	A borer core shall be taken approximately 4 ft from the butt end of each pile in each charge and only those piles meeting the penetration requirements shall be accepted.

*Subject to marine borer attack.

TABLE 1 (CONT'D)—SPECIFIC REQUIREMENTS FOR PRESERVATIVE TREATMENT BY PRESSURE PROCESSES

(Poles)

	Southern Pine Ponderosa Pine	Jack Pine Red Pine Lodgepole Pine
CONDITIONING	Air-seasoning or steaming or heating in the preservative or a combination.	Air seasoning or steaming or heating in the preservative or a combination
Steaming		
Temp. - degrees F - Max.	259	240
Duration - Hrs. Max.	18	6
Vacuum		
Inches at sea level - Min.	22	22
Heating in preservative		
Temp. - degrees F - Max.	220	220
TREATMENT		
Creosote type preservatives	Empty or Full-Cell	Empty or Full-Cell
Oil borne preservatives	Empty or Full-Cell	Empty or Full-Cell
Pressure - psi - Max.	200	150
Final steaming		
Temp. - degrees F - Max.	259	240
Duration - hours - Max.	3	3
RESULTS OF TREATMENT		
Retention - lb per cu ft -Min.		
Creosote type preservatives		
Creosote	8	8
Creosote-coal tar	8	8
Creosote-petroleum	10	8
Oil borne preservatives		
Pentachlorophenol*	0.4	0.4
Copper naphthenate (Copper Metal)	0.1	0.1
Penetration in inches or percent of sapwood-Min.	3.0 or 85	1.5 or 85% for Jack and Lodgepole Pine. 2.5 or 85% for Red Pine
Determination of penetration Group A—Poles whose 6 ft from butt circumference is less than 37.5 inches.	A borer core shall be taken midway between the butt and top of 20 poles in each charge. If 18 of the borings meet the penetration the Group A poles in the charge as a whole shall be accepted but the non-conforming poles in the sample shall be retreated. If 16 or 17 of the borings meet the requirements each Group A pole in the charge shall be bored and only those meeting the requirement shall be accepted. If less than 16 of the borings meet the requirements all Group A poles in the charge shall be rejected.	
Group B—Poles whose 6 ft from butt circumference is 37.5 inches or more.	A borer core shall be taken midway between the butt and the top of each pole and only those meeting the penetration requirement accepted.	

*Treating solution must contain approximately 5% Penta.; 0.4 lb/cu ft equals 8 lb of 5% Penta. solution.

TABLE 1 (CONT'D)—SPECIFIC REQUIREMENTS FOR PRESERVATIVE TREATMENT BY PRESSURE PROCESSES

(Poles, Cont'd)

	Pacific Coast Douglas Fir Intermountain Douglas Fir Western Larch
CONDITIONING	Air-seasoning or heating in the preservative or a combination.
Steaming Temp. - degrees F - Max. Duration - Hrs. Max.	Not Permitted
Vacuum Inches at sea level - Min.	
Heating in preservative Temp. - degrees F -Max.	220
TREATMENT	
Creosote type preservatives Water borne preservatives Oil borne preservatives	Empty or Full-Cell Not Recommended Empty or Full-Cell
Pressure - psi - Max.	150
Final Steaming Temp. - degrees F Max. Duration - hours - Max.	 240 3
RESULTS OF TREATMENT	
Retention - lb per cu ft - Min. Creosote type preservatives Creosote Creosote-coal tar Creosote-petroleum	 8 Not Recommended 10
Oil borne preservatives Pentachlorophenol* Copper naphthenate (Copper Metal)	 0.4 0.1
Penetration in inches or percent of sapwood - Min.	P. C. Douglas Fir - 1 inch Interm. Douglas Fir - ½ inch and 70 Western Larch ½ inch and 70
Determination of penetration Group A-poles whose 6 ft from butt circumference is less than 37.5 inches	A borer core shall be taken midway between the butt and top of 20 poles in each charge. If 18 of the borings meet the penetration the Group A poles in the charge as a whole shall be accepted, but the non-conforming poles in the sample shall be retreated. If 16 or 17 of the borings meet the requirements each group A pole in the charge shall be bored and only those meeting the requirement shall be accepted. If less than 16 of the borings meet the requirement all Group A poles in the charge shall be rejected.
Group B-poles whose 6 ft from butt circumference is 37.5 inches or more.	A borer core shall be taken midway between the butt and the top of each pole and only those meeting the penetration requirement accepted.

*Treating solution must contain approximately 5% Penta.; 0.4 lb/cu ft equals 8 lb of 5% Penta. solution.

Table 1 (Cont'd)—Specific Requirements for Preservative Treatment by Pressure Processes

(Posts)

	Southern Pine Ponderosa Pine	Jack Pine Red Pine Lodgepole Pine
CONDITIONING	Air-seasoning or steaming or heating in the preservative or a combination.	Air-seasoning or kiln drying or steaming or heating in the preservative or a combination.
Steaming		
Temp. - degrees F -Max.	259	240
Duration - Hrs. Max.	10	6
Vacuum		
Inches at sea level - Min.	22	22
Heating in Preservative		
Temp. - degrees F - Max.	220	220
TREATMENT		
Creosote type preservatives	Empty-Cell	Empty-Cell
Water borne preservatives	Full-Cell	Full-Cell
Oil borne preservatives	Empty-Cell	Empty-Cell
Pressure - psi - Max.	200	150
Final Steaming		
Temp. - degrees F - Max.	259	240
Duration - hours - Max.	3	3
RESULTS OF TREATMENT		
Retention - lb per cu ft -Min.		
Creosote type preservatives		
Creosote	6	6
Creosote-coal tar	6	6
Creosote-petroleum	7	7
Water borne preservatives*		
Zinc chloride	1.25	1.25
Chromated zinc chloride	1.00	1.00
Tanalith	.50	.50
Oil borne preservatives**		
Pentachlorophenol	0.4	0.4
Copper napthenate(Copper Metal)	0.1	0.1
Penetration in inches or percent of sapwood-Min.	2.5 or 85	L.P.Pine and Jack Pine 1½ or 85 Red Pine 2 or 85
Determination of penetration	Borings shall be made at the mid-section of at least 3 posts in each tram in each charge. Unless 90% meet the penetration requirements the charge shall be rejected.	

*Not recommended where leaching is a major consideration.
**Treating solution must contain approximately 5% Penta.; 0.4 lb/cu ft equals 8 lb of 5% Penta. solution.

TABLE 1 (CONT'D)—SPECIFIC REQUIREMENTS FOR PRESERVATIVE TREATMENT BY PRESSURE PROCESSES

(Cross Ties and Switch Ties)

	Southern Pine Ponderosa Pine	Jack Pine, Red Pine Lodgepole Pine
CONDITIONING	Air-seasoning or steaming, or heating in the preservative or a combination.	Air-seasoning or steaming or heating in the preservative or a combination.
Steaming		
Temp. - degrees F - Max.	259	240
Duration - Hrs. Max.	15	6
Vacuum		
Inches at sea level - Min.	22	22
Heating in preservative		
Temp. - degrees F - Max.	220	220
Incising	Not required	Required
TREATMENT		
Creosote type preservatives	Empty-Cell	Empty-Cell
Water borne preservatives	Not recommended	Full-Cell
Oil borne preservatives	Empty-Cell	Empty-Cell
Pressure - psi - Max.	200	150
RESULTS OF TREATMENT		
Retention - lb per cu ft -Min.		
Creosote type preservatives		
Creosote	8	6
Creosote-coal tar	8	6
Creosote-petroleum	8	7
Penetration in inches or percent of sapwood-Min.	3.0 or 85	1/2 and 90
Determination of penetration	A borer core shall be taken from the center of 20 ties in each charge. If 90% of the cores meet the penetration requirements the charge shall be accepted.	A borer core shall be taken from the center of 20 ties in each charge. If 80% of the cores meet the penetration requirements the charge shall be accepted.

TABLE 1 (CONT'D)—SPECIFIC REQUIREMENTS FOR PRESERVATIVE TREATMENT BY PRESSURE PROCESSES

(Cross Ties and Switch Ties, Cont'd)

	A.R.E.A. - To's Black Gum Red Gum	A.R.E.A. -Tc's Other than Black and Red Gum
CONDITIONING	Air-seasoning or steaming, or heating in the preservative or a combination.	Air-seasoning or heating in the preservative or a combination.
Steaming		Not permitted
Temp. - degrees F - Max.	240	
Duration - Hrs. Max.	6	
Vacuum		
Inches at sea level - Min.	22	
Heating in preservative		
Temp. - degrees F - Max.	220	
Incising	Not required	Not required
TREATMENT		
Creosote type preservatives	Empty-Cell	Empty-Cell
Water borne preservatives	Not recommended	Not recommended
Oil borne preservatives	Empty-Cell	Empty-Cell
Pressure - psi - Max.	200	200
RESULTS OF TREATMENT		
Retention - lb per cu ft -Min.		
Creosote type preservatives		
Creosote	9	Refusal
Creosote-coal tar	9	Refusal
Creosote-petroleum	9	Refusal
Penetration in inches or percent of sapwood-Min.	1.5 or 85	95% of sapwood
Determination of penetration	A borer core shall be taken from the center of 20 ties in each charge. If 80% of the cores meet the penetration requirements the charge shall be accepted.	A borer core shall be taken from the center of 20 ties in each charge. If 80% of the cores meet the penetration requirements the charge shall be accepted.

TABLE 1 (CONT'D)—SPECIFIC REQUIREMENTS FOR PRESERVATIVE TREATMENT BY PRESSURE PROCESSES

(Cross Ties and Switch Ties, Cont'd)

	Pacific Coast Douglas Fir Intermountain Douglas Fir Western Hemlock Western Larch	Oaks
CONDITIONING	Air-seasoning or steaming, or heating in the preservative or a combination.	Air-seasoning or heating in the preservative or a combination.
Steaming Temp. - degrees F - Max. Duration - Hrs. Max.	 220 6	 Not permitted
Vacuum Inches at sea level - Min.	 22	
Heating in preservative Temp. - degrees F -Max.	 220	 220
Incising	Required	Not required
TREATMENT		
Creosote type preservatives Water borne preservatives Oil borne preservatives	Empty or Full-Cell Not recommended Empty or Full-Cell	Empty or Full-Cell Not recommended Empty or Full-Cell
Pressure - psi - Max.	150	200
RESULTS OF TREATMENT		
Retention - lb per cu ft -Min. Creosote type preservatives Creosote Creosote-coal tar Creosote-petroleum	 8 or refusal 8 or refusal 8 or refusal	Red Oak / White Oak 6 / Refusal 6 / Refusal 6 / Refusal
Penetration in inches or percent of sapwood-Min.	1/2 and 90	White Oak - 95% of sapwood Red Oak - 65% of annual rings; charges of recalcitrant wood with less penetration may be accepted if wood is conditioned properly before treatment and treatment is continued to refusal.
Determination of Penetration	A borer core shall be taken from the center of 20 ties in each charge. If 80% of the cores meet the penetration requirements the charge shall be accepted.	A borer core shall be taken from the center of 20 ties in each charge. If the average penetration of the 20 cores meets the penetration requirements the charge shall be accepted.

Exhibit C

SPECIFICATIONS FOR PRESERVATIVES
CREOSOTE-PETROLEUM SOLUTION

Creosote-petroleum solution shall consist solely of a mixture of specified proportions of coal-tar creosote which meets AREA specifications for creosote and of petroleum which meets AREA specifications for petroleum for blending with creosote. No creosote-petroleum solution shall contain less than 50 percent by volume of such creosote.

PETROLEUM FOR BLENDING WITH CREOSOTE

Petroleum for blending with creosote shall conform to the following requirements:

Specific gravity at 60 deg F not less than 0.96 (not greater than 15.9 deg API) ASTM D 287.

Petroleum of lower specific gravity may be used provided experience or test shows the oil to be satisfactory.

Water and sediment BS&W, not more than 1 percent. ASTM D 96.

Flash point not less than 215 deg F as determined by the Pensky–Martens closed tester. ASTM D 93.

The viscosity shall be not less than 40 sec and preferably not more than 60 sec, although oils of higher viscosity may be used, provided that penetration requirements are met. The purchaser may specify the viscosity best suited to his requirements, allowing the supplier a tolerance of plus or minus 10 percent of the value specified. Viscosity shall be in terms of Saybolt Universal seconds at 210 deg F. ASTM D 88.

Tests to determine the foregoing requirements shall be made in accordance with the ASTM method as indicated. The ASTM standards referred to herein may be obtained from the American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa.

ZINC CHLORIDE

Zinc chloride in the dry form shall have the following properties:

It shall contain not less than 94 percent zinc chloride ($ZnCl_2$) calculated from the water-soluble zinc content.

The acid-soluble zinc content calculated as zinc chloride shall be not less than 96 percent.

The acid-soluble chloride content calculated as zinc chloride shall be not less than 96 percent.

It shall not contain more than 1.6 percent of water-insoluble matter.

It shall not contain more than 0.2 percent of iron and aluminum calculated as $Fe_2O_3 + Al_2O_3$.

A 50 percent solution of zinc chloride shall have the following properties:

It shall have a specific gravity not less than 1.547 and not more than 1.567 at 100 deg F.

It shall have a total zinc content equivalent to not less than 50 percent zinc chloride.

It shall have a total chloride content equivalent to not less than 50 percent zinc chloride.

It shall not contain more than 0.1 percent of iron and aluminum calculated as $Fe_2O_3 + Al_2O_3$.

A sample of the solution, when diluted with 12 times its volume of freshly boiled distilled water, shall test basic to methyl orange.

Tests to determine the foregoing requirements shall be made in accordance with AWPA Standard A2.

CHROMATED ZINC CHLORIDE

Chromated zinc chloride in the dry form shall have the following properties:

It shall contain not less than 77.5 percent of zinc chloride ($ZnCl_2$) calculated from the total soluble zinc content.

It shall contain hexavalent chromium equivalent to not less than 17.5 percent sodium dichromate dihydrate ($Na_2Cr_2O_7 . 2H_2O$). This may include chromium hydroxide sufficient to produce in a 3 percent solution of chromated zinc chloride a pH no lower than 3.0, as determined by a pH meter or pH paper of confirmed accuracy.

Chromated zinc chloride in concentrated solution or fresh working solution shall contain zinc calculated as zinc chloride and chromium calculated as sodium dichromate dihydrate in the proportion stated.

Samples of chromated zinc chloride treating solution taken from working tanks or treating cylinder may show a change in composition as a result of treating operations. Such changes shall not serve to cause rejection of the preservative, if they do not raise the ratio of zinc chloride to sodium dichromate dihydrate to more than 8 to 1, and if it can be shown that the original fresh preservative was of the specified composition.

Tests to determine the foregoing requirements shall be made in accordance with AWPA Standard A2.

TANALITH

Tanalith shall be composed of the following ingredients in the proportions given:

	Percent
Fluoride calculated as sodium fluoride (NaF)	25
Arsenate, calculated as disodium hydrogen arsenate (Na_2HAsO_4)	25
Chromate, calculated as sodium chromate (Na_2CrO_4)	37½
Dinitrophenol	12½

Subject to the following tolerances:

The minimum proportions may be, respectively, 22, 22, 34 and 5, but the preservative shall contain at least 95 percent of these active materials.

The pH of the treating solution shall be not less than 7.2 nor more than 7.8.

Tests to determine the foregoing requirements shall be made in accordance with AWPA Standard A2.

METHODS OF DETERMINING PENETRATION IN WOOD TREATED WITH PRESERVATIVES

1. Zinc Chloride
2. Chromated Zinc Chloride
3. Copperized Chromated Zinc Chloride
4. Tanalith
5. Pentachlorophenol
6. Copper Naphthenate
7. Acid Copper Chromate

Tests for penetration shall be in accordance with AWPA Standard A3.

Exhibit D

STANDARD ABRIDGED VOLUME CORRECTION TABLES FOR PETROLEUM OILS

The following abridged tables contain factors for reducing oil volumes to the basis of 60 deg F (Table 1) and 100 deg F (Table 2). The factors contained in Table 1 were taken from the Supplement to NBS Circular C410, issued July 20, 1937. The factors contained in Table 2 are computed values based on Table 1.

Only Group 0 and Group 1 oils were considered in the preparation of these tables. These groups, with the gravity ranges of each, follow:

Group Number	Range of Group: Degrees A.P.I.	Range of Group: Specific Gravity at 60-60° F
0............................	0 to 14.9	1.076 to 0.9665
1............................	15.0 to 34.9	0.9664 to 0.8504

To use the tables, multiply the volume at observed temperature by the factor corresponding to that temperature in the tables. Use Table 1 to reduce oil volumes to the basis of 60 deg F, and Table 2 to reduce oil volumes to the basis of 100 deg F.

TABLE 1 -FACTORS TO BE USED FOR DETERMINING THE VOLUME AT 60 DEG F OCCUPIED BY UNIT VOLUME AT TEMPERATURES RANGING FROM 30 DEG TO 220 DEG F.

Observed temp. deg F	Factors Group 0	Factors Group 1	Observed temp. deg F	Factors Group 0	Factors Group 1	Observed temp. deg F	Factors Group 0	Factors Group 1	Observed temp. deg F	Factors Group 0	Factors Group 1	Observed temp. deg F	Factors Group 0	Factors Group 1
30	1.0106	1.0120	70	0.9965	0.9960	110	0.9827	0.9803	150	0.9691	0.9647	190	0.9556	0.9494
31	1.0102	1.0116	71	.9962	.9956	111	.9823	.9799	151	.9687	.9643	191	.9553	.9490
32	1.0098	1.0112	72	.9958	.9952	112	.9820	.9795	152	.9684	.9639	192	.9549	.9487
33	1.0095	1.0108	73	.9955	.9948	113	.9816	.9791	153	.9680	.9636	193	.9546	.9483
34	1.0092	1.0104	74	.9952	.9944	114	.9813	.9787	154	.9677	.9632	194	.9543	.9480
35	1.0088	1.0100	75	.9948	.9940	115	.9809	.9783	155	.9674	.9628	195	.9539	.9476
36	1.0084	1.0096	76	.9944	.9936	116	.9806	.9779	156	.9670	.9624	196	.9536	.9472
37	1.0081	1.0092	77	.9941	.9932	117	.9802	.9775	157	.9667	.9620	197	.9533	.9468
38	1.0077	1.0088	78	.9938	.9929	118	.9799	.9771	158	.9664	.9616	198	.9530	.9465
39	1.0074	1.0084	79	.9934	.9925	119	.9795	.9767	159	.9660	.9612	199	.9527	.9461
40	1.0070	1.0080	80	.9931	.9921	120	.9792	.9763	160	.9657	.9608	200	.9523	.9457
41	1.0067	1.0076	81	.9927	.9917	121	.9789	.9759	161	.9654	.9604	201	.9520	.9453
42	1.0063	1.0072	82	.9924	.9913	122	.9785	.9755	162	.9650	.9601	202	.9517	.9449
43	1.0059	1.0068	83	.9920	.9909	123	.9782	.9752	163	.9647	.9597	203	.9513	.9446
44	1.0056	1.0064	84	.9917	.9905	124	.9779	.9748	164	.9643	.9594	204	.9510	.9442
45	1.0052	1.0060	85	.9914	.9901	125	.9775	.9744	165	.9640	.9590	205	.9507	.9438
46	1.0049	1.0056	86	.9910	.9897	126	.9772	.9740	166	.9637	.9586	206	.9504	.9434
47	1.0045	1.0052	87	.9907	.9893	127	.9768	.9736	167	.9633	.9582	207	.9500	.9430
48	1.0042	1.0048	88	.9903	.9889	128	.9765	.9732	168	.9630	.9578	208	.9497	.9427
49	1.0039	1.0044	89	.9900	.9885	129	.9762	.9728	169	.9627	.9574	209	.9494	.9423
50	1.0035	1.0040	90	.9896	.9881	130	.9758	.9724	170	.9623	.9570	210	.9490	.9419
51	1.0032	1.0036	91	.9892	.9877	131	.9755	.9720	171	.9620	.9566	211	.9487	.9415
52	1.0028	1.0032	92	.9889	.9873	132	.9751	.9716	172	.9616	.9562	212	.9484	.9412
53	1.0025	1.0028	93	.9886	.9869	133	.9748	.9713	173	.9613	.9559	213	.9481	.9408
54	1.0021	1.0024	94	.9882	.9865	134	.9745	.9709	174	.9610	.9555	214	.9477	.9405
55	1.0017	1.0020	95	.9879	.9861	135	.9741	.9705	175	.9606	.9551	215	.9474	.9401
56	1.0014	1.0016	96	.9876	.9857	136	.9738	.9701	176	.9603	.9547	216	.9471	.9397
57	1.0010	1.0012	97	.9872	.9853	137	.9735	.9697	177	.9600	.9543	217	.9468	.9393
58	1.0007	1.0008	98	.9869	.9849	138	.9731	.9694	178	.9596	.9540	218	.9464	.9390
59	1.0003	1.0004	99	.9865	.9845	139	.9728	.9690	179	.9593	.9536	219	.9461	.9386
60	1.0000	1.0000	100	.9862	.9841	140	.9724	.9686	180	.9590	.9532	220	.9458	.9382
61	0.9997	0.9996	101	.9858	.9837	141	.9721	.9682	181	.9586	.9528			
62	.9993	.9992	102	.9855	.9833	142	.9718	.9678	182	.9583	.9524			
63	.9990	.9988	103	.9852	.9830	143	.9714	.9675	183	.9580	.9521			
64	.9986	.9984	104	.9848	.9826	144	.9711	.9671	184	.9576	.9517			
65	.9982	.9980	105	.9844	.9822	145	.9707	.9667	185	.9573	.9513			
66	.9979	.9976	106	.9841	.9818	146	.9704	.9663	186	.9569	.9509			
67	.9976	.9972	107	.9837	.9814	147	.9701	.9659	187	.9566	.9505			
68	.9972	.9968	108	.9834	.9811	148	.9697	.9655	188	.9563	.9502			
69	.9969	.9964	109	.9831	.9807	149	.9694	.9651	189	.9559	.9498			

TAPLE 2 - FACTORS TO BE USED FOR DETERMINING THE VOLUME AT 100 DEG F OCCUPIED BY UNIT VOLUME AT TEMPERATURES RANGING FROM 30 DEG F TO 220 DEG F.

Observed temp. deg F	Factore Group 0	Factore Group 1	Observed temp. deg F	Factore Group 0	Factore Group 1	Observed temp. deg F	Factors Group 0	Factors Group 1	Observed temp. deg F	Factors Group 0	Factors Group 1	Observed temp. deg F	Factors Group 0	Factors Group 1
30	1.0247	1.0284	70	1.0104	1.0121	110	0.9965	0.9961	150	0.9827	0.9803	190	0.9690	0.9647
31	1.0243	1.0279	71	1.0101	1.0117	111	.9960	.9957	151	.9823	.9799	191	.9687	.9643
32	1.0239	1.0275	72	1.0097	1.0113	112	.9957	.9953	152	.9820	.9795	192	.9683	.9640
33	1.0236	1.0271	73	1.0094	1.0109	113	.9953	.9949	153	.9815	.9792	193	.9680	.9636
34	1.0233	1.0267	74	1.0091	1.0105	114	.9950	.9945	154	.9812	.9788	194	.9677	.9633
35	1.0229	1.0263	75	1.0087	1.0101	115	.9946	.9941	155	.9809	.9784	195	.9672	.9629
36	1.0225	1.0259	76	1.0083	1.0097	116	.9943	.9937	156	.9805	.9779	196	.9669	.9625
37	1.0222	1.0255	77	1.0080	1.0092	117	.9939	.9933	157	.9802	.9775	197	.9666	.9621
38	1.0218	1.0251	78	1.0077	1.0089	118	.9936	.9929	158	.9799	.9771	198	.9663	.9618
39	1.0215	1.0247	79	1.0073	1.0085	119	.9932	.9925	159	.9795	.9767	199	.9660	.9614
40	1.0211	1.0243	80	1.0070	1.0081	120	.9929	.9921	160	.9792	.9763	200	.9656	.9610
41	1.0208	1.0239	81	1.0066	1.0077	121	.9926	.9917	161	.9789	.9759	201	.9653	.9606
42	1.0204	1.0235	82	1.0063	1.0073	122	.9922	.9913	162	.9785	.9756	202	.9650	.9602
43	1.0200	1.0231	83	1.0059	1.0069	123	.9919	.9910	163	.9782	.9752	203	.9646	.9599
44	1.0197	1.0227	84	1.0056	1.0065	124	.9916	.9905	164	.9778	.9749	204	.9643	.9595
45	1.0193	1.0223	85	1.0053	1.0061	125	.9912	.9901	165	.9775	.9745	205	.9640	.9590
46	1.0190	1.0218	86	1.0049	1.0057	126	.9909	.9897	166	.9772	.9741	206	.9637	.9586
47	1.0186	1.0214	87	1.0046	1.0053	127	.9905	.9893	167	.9768	.9737	207	.9633	.9582
48	1.0183	1.0210	88	1.0042	1.0049	128	.9902	.9889	168	.9765	.9733	208	.9630	.9579
49	1.0179	1.0206	89	1.0039	1.0045	129	.9899	.9885	169	.9762	.9729	209	.9627	.9575
50	1.0175	1.0202	90	1.0034	1.0041	130	.9895	.9881	170	.9758	.9725	210	.9623	.9571
51	1.0172	1.0198	91	1.0030	1.0037	131	.9892	.9877	171	.9755	.9721	211	.9620	.9567
52	1.0168	1.0194	92	1.0027	1.0033	132	.9887	.9873	172	.9751	.9716	212	.9617	.9564
53	1.0165	1.0190	93	1.0024	1.0028	133	.9884	.9870	173	.9748	.9713	213	.9614	.9560
54	1.0161	1.0186	94	1.0020	1.0024	134	.9881	.9866	174	.9744	.9709	214	.9610	.9557
55	1.0157	1.0182	95	1.0017	1.0020	135	.9877	.9862	175	.9740	.9705	215	.9607	.9553
56	1.0154	1.0178	96	1.0014	1.0016	136	.9874	.9858	176	.9737	.9701	216	.9604	.9549
57	1.0150	1.0174	97	1.0010	1.0012	137	.9871	.9854	177	.9734	.9697	217	.9600	.9545
58	1.0147	1.0170	98	1.0007	1.0008	138	.9867	.9851	178	.9730	.9694	218	.9596	.9542
59	1.0143	1.0166	99	1.0003	1.0004	139	.9864	.9847	179	.9727	.9690	219	.9593	.9538
60	1.0140	1.0162	100	1.0000	1.0000	140	.9860	.9842	180	.9724	.9686	220	.9590	.9534
61	1.0137	1.0158	101	0.9996	0.9996	141	.9857	.9838	181	.9720	.9682			
62	1.0133	1.0153	102	.9993	.9992	142	.9854	.9834	182	.9717	.9678			
63	1.0130	1.0149	103	.9990	.9989	143	.9850	.9831	183	.9714	.9675			
64	1.0126	1.0145	104	.9986	.9985	144	.9847	.9827	184	.9710	.9671			
65	1.0122	1.0141	105	.9982	.9981	145	.9843	.9823	185	.9707	.9667			
66	1.0119	1.0137	106	.9979	.9977	146	.9840	.9819	186	.9703	.9663			
67	1.0116	1.0133	107	.9975	.9973	147	.9837	.9815	187	.9700	.9659			
68	1.0112	1.0129	108	.9972	.9970	148	.9833	.9811	188	.9697	.9656			
69	1.0108	1.0125	109	.9969	.9965	149	.9830	.9807	189	.9693	.9651			

Report on Assignment 2

Service Test Records of Treated Wood

A. J. Loom (chairman, subcommittee), G. H. Dayett, Jr., W. R. Goodwin, R. P. Hughes, L. W. Kistler, G. L. P. Plow, R. R. Poux, J. W. Reed, W. C. Reichow, W. B. Stomback.

The following progress report is submitted as information.

Baltimore & Ohio Railroad report on 1951 inspection of experimental ties in Germantown–Barnesville, Md., test track.

Erie Railroad report on 1949 inspection of experimental ties in Ravenna, Ohio, test track.

Northern Pacific Railway report on 1952 inspection of experimental ties in test tracks near Duluth, Minn., and Plateau, Mont.

Santa Fe reports on October 1952 inspection of cross ties in service at five different locations. Treated with creosote-petroleum solution and placed in track 1926, 1927 and 1928.

Baltimore and Ohio Railroad Tie Tests at Germantown–Barnesville, Md.

Length of Test—23 Years

Report for 1951 Renewals Installed Summer—1928

Treatment		*Ties Placed*	*In Test*	*Removed to Date*		*Avg. Life to Date*	*Condition*
				No.	*Per-cent*		
Red Oak							
8 lb. Creo-Petroleum	50–50	300	68	232	77	19.0	good, splits and decay
9 lb. Creo-Petroleum	50–50	900	448	452	50	21.7	splits and decay
9 lb. Creo-Coal Tar	50–50	900	408	492	55	20.8	fair, some decay
10 lb. Creo-Coal Tar	60–40	900	134	766	85	20.1	good
8 lb. Water Gas Tar	100%	900	3	897	100	17.2	
9 lb. Creo-Pet-W.G. Tar	30–30–40	900	151	749	83	18.5	splits
8 lb. Creosote	100%	900	87	813	90	20.0	fair, splits and rail cut
8 lb. Creo-Water Gas Tar	50–50	900	142	758	84	20.5	splits and decay
9 lb. Creo-Water Gas Tar	40–60	900	21	879	98	19.9	splits and decay
10 lb. Creo-Water Gas Tar	30–70	900	10	890	99	20.9	rail cut
8 lb. Creo-Pet-W.G. Tar	30–50–20	900	422	478	53	20.2	fair condition
10 lb. Creo-Pet-W.G. Tar	40–30–30	900	42	858	95	21.0	poor, decay
6 lb. Creosote	100%	900	56	844	94	20.6	splits, decay
0.47 lb. Zinc-3.75 lb. Petroleum		600	0	600	100	15.6	
0.32 lb. Zinc-4.70 lb. Petroleum		600	0	600	100	16.1	
10 lb. Creo-Coal Tar	80–20	900	319	581	65	21.7	good
9 lb. Creo-Coal Tar	70–30	900	240	660	73	21.5	splits, rail cut
9 lb. Creo-Petroleum	40–60	900	40	860	96	21.1	bad splits, decay
Total		15000	2591	12409	83	20.0	
White Oak							
5 lb. Creosote-Coal Tar	50–50	300	147	153	51	20.9	much decay
7 lb. Creosote-Coal Tar	60–40	300	99	201	67	20.2	some splits, decay
7 lb. Water Gas Tar	100%	300	3	297	99	19.9	
7 lb. Creo-Pet-W.G. Tar	30–30–40	300	134	166	55	19.8	splits, spike killed
6 lb. Creosote	100%	300	34	266	89	19.4	some checked
8 lb. Creosote	100%	300	64	236	79	20.6	some decay, splits
8 lb. Creo-Water Gas Tar	50–50	300	65	235	78	20.6	good
7 lb. Creo-Water Gas Tar	40–60	300	30	270	90	20.7	some decay
8 lb. Creo-Water Gas Tar	30–70	300	49	251	84	21.3	some rail cut
5 lb. Creo-Pet-W.G. Tar	30–50–20	300	129	171	57	19.6	fair—rail cut
7 lb. Creo-Pet-W.G. Tar	40–30–30	300	55	245	82	21.4	good
0.41 lb. Zinc-2.82 lb. Petroleum		300	0	300	100	19.0	
7 lb. Creo-Coal Tar	80–20	300	51	249	83	21.3	fair
8 lb. Creo-Coal Tar	70–30	300	127	173	58	21.8	good, rail cut
7 lb. Creo-Petroleum	50–50	300	37	263	88	21.2	fair, rail and decay
7 lb. Creo-Petroleum	40–60	300	29	271	90	21.2	very good
Total		4800	1053	3747	78	20.6	
Mixed Woods							
9 lb. Creo-Coal Tar	50–50	300	241	59	20	22.2	good
8 lb. Creo-Coal Tar	60–40	300	235	65	22	22.1	good, splits
9 lb. Water Gas Tar	100%	300	8	292	97	20.2	some decay
10 lb. Creo-Pet-W.G. Tar	30–30–40	300	186	114	38	20.8	some splits, decay
8 lb. Creosote	100%	300	88	212	71	19.6	good
8 lb. Creosote	100%	300	140	160	51	21.4	good
8 lb. Creo-Water Gas Tar	50–50	294	70	224	76	20.7	good, some decay
10 lb. Creo-Water Gas Tar	40–60	300	77	223	74	21.5	good, some decay
10 lb. Creo-Water Gas Tar	30–70	300	46	254	85	21.3	rail cut
9 lb. Creo-Pet-W.G. Tar	30–50–20	300	204	96	32	22.0	good, a few splits
10 lb. Creo-Pet-W.G. Tar	40–30–30	300	62	238	79	21.4	very good, rail cut
9 lb. Creo-Coal Tar	80–20	300	160	140	47	22.1	good
8 lb. Creo-Coal Tar	70–30	300	145	155	52	22.0	some splits
8 lb. Creo-Petroleum	50–50	300	137	163	54	21.9	some rail cut, good
9 lb. Creo-Petroleum	40–60	300	112	188	63	21.8	very good, some checks
Total		4494	1911	2583	57	21.4	
GRAND TOTALS		24294	5555	18739	77.1	20.36	

Summary—Erie Railroad Tie Tests at Ravenna, Ohio
Status as of January 1949

Four hundred ties originally in tests. One hundred ties in each as follows. Creosote-coal tar solution.

1. Air seasoned gum from Brunswick, Ga. All hewn ties. Treated by Lowry process. Avg. 6.43 lb per cu ft. Treated in 1930. Installed in 1931. No S–irons used.

Removals	*Reason for removals*
17	Decay caused by checks through treated shell.

2. Air-seasoned gum from Metropolis, Ill. Ties 1–15 hewn and 15–100 sawed. Treated by Rueping process. Avg. 7.15 lb per cu ft. Treated in 1930. Installed in 1931. S–irons used.

Removals	*Reason for removals*
4	Decay caused by checks through treated shell.
1	End splits.
1	Burned.
1	Shattered.
2	End splits and spike killed.

3. Air-seasoned oak from Metropolis, Ill. Ties 1–52 sawed and 52–100 hewn. Treated by Rueping process. Avg. 7.57 lb per cu ft. Treated in 1931. Installed in 1931. S-irons used.

Removals	*Reason for removals*
2	Spike kill or end splits.
1	Decay.

4. Air-seasoned oak from Orrville, Ohio. All sawed ties. Treated by Rueping process. Avg. 8.41 lb per cu ft. Treated in 1930–1931. Installed in 1931. S–irons used.

Removals	*Reason for removals*
4	Burned.

Considering ties burned as removed from test, because the loss is not related to effectiveness of treatment, the removals are as follows:

		Percent
Decay	22	78.6
Spike killed and end split	4	14.3
End split	1	3.6
Shattered	1	3.6
	28	

The total removals of 33 ties, including those burned, do not allow an accurate estimate of total service to be made at the present stage of the test.

To date, only 8.25 percent of the ties have been removed, for all reasons, in the 19 years of the test.

Northern Pacific Railway Company

Tie Record Test Track

Grassy Point, Duluth Superior Terminal. Third Sub-Division MP 2+3267.5 to MP 2+4490.1.

Six hundred hardwood ties treated at Brainerd in 1922 and placed in track in 1922. Treatment by Lowry process. Two hundred ninety-nine with straight creosote, 6.25 lb. per cu ft, and 301 with 50-50 creosote-petroleum solution, 7 lb. per cu ft.

One hundred untreated white oak. Total 700 ties.

Year	*Summary of Ties by Species*							
	W. Oak Untrtd.	*Birch Str. Creo.*	*Birch Solution*	*H. Maple Str. Creo.*	*H. Maple Solution*	*Red Oak Str. Creo.*	*Red Oak Solution*	*Total*
1922	100	98	101	101	100	100	100	700
				Renewals				
1929	3							3
1930	2							2
1932	5							5
1933	19							19
1934	7							7
1935	1							1
1936	6							6
1937	21							21
1938	12							12
1939	4				3			7
1940	3				3			6
1942	5			3	8			16
1943	5			1	6			12
1948	7			3	3			13
1949			2	18	22		1	43
1952		4	1	6	6	2	2	21
Total	100	4	3	31	51	2	3	194
% Renewed	100%	4%	3%	31%	51%	2%	3%	
Avg. Yrs. Per Tie	14.9	30.0	28.0	26.6	24.4	30.0	29.0	

15.67% renewals of treated ties in 30 years.
Average life of treated ties replaced—25.73 years.
Estimated total life treated ties based on Tie-Life Curve of the U. S. Forest Products Laboratory—43 years.

Causes for Removal of 194 ties renewed to date:

Decayed account not treated	100 Ties
Decayed account plate cut and mechanical wear	88 Ties
Split and Decayed	6 Ties
TOTAL	194 Ties

Analysis of Preservatives Used in Treatment of Ties in Northern Pacific Tests at Duluth, Minn., and Plateau, Mont.

	Straight Creosote	*50–50 Creosote-Petroleum Solution*
Sp Gr at 38 Deg C.	1.055	1.027
Water	Trace	3.0
210 Deg C	4.5	8.6
235 Deg C	22.5	3.0
270 Deg C	24.5	18.6
315 Deg C	16.4	11.2
355 Deg C	14.0	17.6
Residue	17.0	37.8

Northern Pacific Railway Company

Tie Record Test Track

Phileman Line Change. Fifth Sub-Rocky Mountain Division MP 156+5198 to MP 157+1259
Six hundred fifty-two hardwood ties treated at Brainerd in 1922 and placed in track 1923. Treatment by Lowry process. Three hundred two with straight creosote 6.25 lb. per cu ft and 350 with 50–50 creosote-petroleum solution, 7 lb. per cu ft.
One hundred twenty-one Untreated white oak. Total 773 Ties.

Year	*Summary of Ties by Species*								
	W. Oak Untrtd.	*Birch Str. Creo.*	*Birch Solution*	*H. Maple Str. Creo.*	*H. Maple Solution*	*Red Oak Str. Creo.*	*Red Oak Solution*	*R. Elm Solution*	*Total*
1923	121	101	100	101	101	100	99	50	773
	Renewals								
1931	22								22
1932	5								5
1933	21								21
1934	30								30
1935	43								43
1937					10				10
1943					11				11
1945			7	2	8	8	17	7	49
1948				13	63	66	62		204
1949			3		1	1		5	10
1950					1	1			2
1952									0
Total	121	0	10	15	94	76	79	12	407
% Renewed	100%	0	10%	15%	94%	76%	80%	24%	
Avg. Yrs. Per Tie	10.5		23.2	24.6	23.0	24.7	24.4	23.7	

44.01% Renewals of treated ties on 29 years.
Average life of treated ties replaced—23.96 years.
Estimated total life treated ties based on Tie-Life Curve of the U. S. Forest Products Laboratory—32 years.

Causes for Removeal of 407 ties renewed to date:

Decayed account not treated	121 Ties
Decayed account plate cut and mechanical wear	120 Ties
Split, shattered and crushed	34 Ties
Broken	8 Ties
Removed without apparent cause	124 Ties
TOTAL	407 Ties

Santa Fe Reports on October 1952 Inspection of Cross Ties In Service at Five Different Locations

Presented in the following tables are reports on inspection of cross ties in service in second track construction at five different locations on the Santa Fe. These cross ties were treated with creosote-petroleum solution and placed in track 1926, 1927 and 1928.

These reports are submitted as information.

Summary of Count of Original Ties and Renewals in Second Track Construction in 1926, 1927 and 1928 - Count Made October, 1952, by R. P. Hughes and N. C. Hawley, Inspectors.

Location	Date Inserted	Original Ties Remaining In Track - 1952: Hn.Sou. Pine 50/50 M.	Sn.Sou. Pine 50/50 M.	Hn.West. Pine 45/55 M.	Sn.West. Pine 45/55 M.	Hewn Gum 50/50 M.	Sawn Gum 50/50 M.	Sawn D.Fir 45/55 M.	Sn.West. Pine Zn. 1/2 lb.fol.by .5 lbs.30/70 M.	Total Original Ties	Renewals By Years: 1930	1931	1935	1937	1938	1939	1940	1941
Plains Divn.-3d Dist. Amarillo-Canyon MP 556-561	1927	9,870			5,825		38			15,733							4	
Plains Divn.-2d Dist. St. Francis-Folsom MP 541-546	1927	7,143		543	6,940				3	14,629	1					1	2	
Albuq. Divn.-2d Dist. Defiance-Lupton MP 167-172	1927			66	26		193	13,053		13,338		1	2	1	2		14	46
Middle Divn.-2d Dist. Cicero-Wellington EB MP 232-237	1926	15,360					192			15,552								8
Middle Divn.-2nd Dist. Near Mulvane, Ks. EB MP 216-221	1927-1928	14,057	211			1				14,269				1				
Grand Total		46,430	211	609	12,791	1	423	13,053	3	73,521	1	1	2	2	2	1	20	54

Renewals By Years Continued

Location	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951	1952	Total Renewals	Total Ties in 5 Miles	Percent Re-moved	Percent Re-maining	Average Life	Estimated Expected Life
Plains Divn.-3d Dist. Amarillo-Canyon MP 556-561		71			20	2	13	150	232	33		530	16,263	3.26	96.74	24.89	
Plains Divn.-2d Dist. St. Francis-Folsom MP 541-546	15	2	79		43	13		897	281			1,334	15,963	8.36	91.64	24.72	
Albuq. Divn.-2d Dist. Defiance-Lupton MP 167-172	222	36		2308	19		29	561	736	23	119	4,119	17,457	23.60	76.40	23.69	33.33
Middle Divn.-2d Dist. Cicero-Wellington EB MP 232-237			43	65	3	77	57	66	157	89	151	716	16,268	4.40	95.60	25.87	
Middle Divn.-2d Dist. Near Mulvane,Ks.EB MP 216-221	4		1	14	31	33	1	425	674	119	345	1,648	15,917	10.35	89.65	24.60	39.68
Grand Total	241	109	123	2387	116	125	105	2099	2080	264	615	8,347	81,868	10.20	89.80	24.74	

Office Manager Treating Plants, System,
Topeka, Kansas, October 10, 1952.

Count of Original Ties and Renewals in Second Track Constructed in 1927 Between MP 167 and MP 172 -
Second District - Albuquerque Division - Between Defiance and Lupton
Count Made October 1-2, 1952 - R. P. Hughes - Inspector.

Location	Original Ties Remaining In Track - 1952					Renewals By Years														
Mile	Sn.D.Fir 45/55 Mix 1927	Hn.W.Pine 45/55 Mix 1927	Sn.W.Pine 45/55 Mix 1927	Sn.Gum 50/50 Mix 1927	Total Original Ties	1931	1935	1937	1938	1940	1941	1942	1943	1945	1946	1948	1949	1950	1951	1952
167-168 WB	2,150	65	24		2,239	1				12		29	36	734		29	213	103		
168-169 WB	2,080		1		2,081		2			2		94		876			181	306		
*169-170 EB-WB	2,393	1		193	2,587				2		21	72		424	19		163	120		34
170-171 EB	3,322		1		3,323							5		197				24		58
171-172 EB	3,108				3,108			1			25	22		77			4	183	23	27
Grand Total	13,053	66	26	193	13,338	1	2	1	2	14	46	222	36	2308	19	29	561	736	23	119

* 1670' E of MP-170 track thrown over at time of construction and second track becomes eastward track.

Location	Total	Total Ties in	Percent		Average	Estimated Expected
Mile	Renewals	Mile	Removed	Remaining	Life	Life
167-168 WB	1,157	3,396	34.07	65.93	22.97	30.86
168-169 WB	1,461	3,542	41.25	58.75	22.66	29.07
*169-170 EB-WB	855	3,442	24.84	75.16	23.61	32.89
170-171 EB	284	3,607	7.87	92.13	24.59	
171-172 EB	362	3,470	10.43	89.57	24.58	39.68
Grand Total	4,119	17,457	23.60	76.40	23.69	33.33

Office Manager Treating Plants, System,
Topeka, Kansas, October 10, 1952.

Count of Original Ties and Renewals in Second Track Constructed in 1927 Between MP 556 and MP 561 - Third District - Plains Division - Between Amarillo and Canyon

Count Made October 6, 1952 - R. P. Hughes - M. C. Hawley, Inspectors.

Location Mile	Original Ties Remaining in Track - 1952: Hn.Sou.Pine 50/50 Mix 1927	Sn.West.Pine 45/55 Mix 1927	Sn. Gum 50/50 Mix 1927	Total Original Ties	Renewals By Years: 1940	1943	1946	1947	1948	1949	1950	1951	Total Renewals	Total Ties in Mile	Percent Re-moved	Percent Re-maining	Average Life	Estimated Expected Life
556-557 WB	1,128	2,270		3,398	4						7		11	3,409	0.32	99.68	24.98	
557-558 WB	1,284	1,843		3,127			13			35	81	7	136	3,263	4.17	95.83	24.89	
558-559 WB	1,241	1,712		2,953		71	5	2	18	92	93	2	273	3,226	8.46	91.54	24.63	
559-560 WB	3,108		10	3,118			1			20	10	9	40	3,158	1.27	98.73	24.97	
560-561 WB	3,109		28	3,137			1			3	51	15	70	3,207	2.18	97.82	24.96	
Grand Total	9,870	5,825	38	15,733	4	71	20	2	13	150	232	33	530	16,263	3.26	96.74	24.89	

Office Manager Treating Plants, System,
Topeka, Kansas, October 10, 1952.

Count of Original Ties and Renewals in Second Track Constructed in 1927 Between MP 541 and MP 546 -
Second District - Plains Division - Between St. Francis and Folsom
Count Made October 6-7, 1952 - R. P. Hughes - N. J. Hawley, Inspectors.

Location Mile	Original Ties Remaining In Track - 1952: Hn.Sou.Pine 50/50 Mix 1927	Hn.West.Pine 45/55 Mix 1927	Sn.West.Pine 45/55 Mix 1927	Sn.West.Pine Zn. 1/2 lb. fol. by 5 lbs. 30/70 Mix 1927	Total Original Ties	Renewals By Years: 1930	1939	1940	1942	1943	1944	1946	1947	1949	1950
541-542 WB	2,372	543			2,915			1					6	281	8
542-543 WB	2,816				2,816							3		224	113
543-544 WB	1,832		1,137		2,969				15				4	172	35
544-545 WB			3,118		3,118		1					20		34	58
545-546 WB	123		2,685	3	2,811	1		1		2	79	20	3	186	67
Grand Total	7,143	543	6,940	3	14,629	1	1	2	15	2	79	43	13	897	281

Location Mile	Total Renewals	Total Ties in Mile	Percent Removed	Percent Remaining	Average Life	Estimated Expected Life
541-542 WB	296	3,211	9.22	90.78	24.72	
542-543 WB	340	3,156	10.77	89.23	24.71	39.06
543-544 WB	226	3,195	7.07	92.93	24.73	
544-545 WB	113	3,231	3.50	96.50	24.89	
545-546 WB	359	3,170	11.32	88.68	24.52	39.06
Grand Total	1,334	15,963	8.36	91.64	24.72	

Office Manager Treating Plants, System,
Topeka, Kansas, October 10, 1952.

Count of Original Ties and Renewals in Second Track Constructed in 1926 Between MP 232 and MP 237 EB
Second District - Middle Division - Between Cicero and Wellington, Kansas
Count Made October 9, 1952 - R. P. Hughes - M. C. Hawley, Inspectors.

Location Mile	Original Ties Remaining In Track - 1952: Hn.Sou.Pine 50/50 Mix 1926	Sn.Gum 50/50 Mix 1926	Total Original Ties	Renewals By Years: 1941	1944	1945	1946	1947	1948	1949	1950	1951	1952	Total Renewals	Total Ties in Mile	Percent Removed	Percent Remaining	Average Life	Estimated Expected Life
232-233 EB	3,188		3,188	8					8	8	21			45	3,233	1.39	98.61	25.94	
233-234 EB	3,089		3,089						16		4	53	54	127	3,216	3.95	96.05	25.96	
234-235 EB	3,141		3,141		15			34			13		35	97	3,238	3.00	97.00	25.90	
235-236 EB	3,104		3,104		4			24	11		17		48	104	3,208	3.24	96.76	25.93	
236-237 EB	2,838	192	3,030		24	65	3	19	22	58	102	36	14	343	3,373	10.17	89.83	25.63	41.27
Grand Total	15,360	192	15,552	8	43	65	3	77	57	66	157	89	151	716	16,268	4.40	95.60	25.87	

Office Manager Treating Plants, System,
Topeka, Kansas, October 10, 1952.

Count of Original Ties and Renewals in Second Track Constructed in 1927 and 1928 Between MP 216 and MP 221 EB -
Second District - Middle Division - East Jct. and West Jct. near Mulvane, Kansas.
Count Made October 8, 1952 - R. P. Hughes - [illegible] Hawley, Inspectors.

Location	Original Ties Remaining In Track - 1952						Renewals By Years										
Mile	Hn.Sou.Pine 50/50 Mix 1927	Hn.Sou.Pine 50/50 Mix 1928	Sn.Sou.Pine 50/50 Mix 1927	Sn.Sou.Pine 50/50 Mix 1928	Hn.Gum 50/50 Mix 1927	Total Original Ties	1937	1942	1944	1945	1946	1947	1948	1949	1950	1951	1952
216-217	2,760					2,760	1				4	4	1	21	205	39	71
217-218	3,034		53		1	3,088		4							126		
218-219	1,402	1,656				3,058						12		44	76		37
219-220		2,774		35		2,809				14	20	17		41	219		
220-221	1,148	1,283	75	48		2,554			1		7			319	48	80	237
Grand Total	8,344	5,713	128	83	1	14,269	1	4	1	14	31	33	1	425	674	119	345

Location Mile	Total Renewals	Total Ties in Mile	Percent Removed	Percent Remaining	Average Life	Estimated Expected Life
216-217	346	3,106	11.14	88.86	24.81	39.06
217-218	130	3,218	4.04	95.96	24.91	
218-219	169	3,227	5.24	94.76	24.89	
219-220	311	3,120	9.97	90.03	23.72	38.10
220-221	692	3,246	21.32	78.68	24.64	34.25
Grand Total	1,648	15,917	10.35	89.65	24.60	39.08

Office Manager Treating Plants, System,
Topeka, Kansas, October 10, 1952.

Report on Assignment 5

Destruction by Wood-Destroying Insects; Methods of Prevention

Collaborating with Committees 6 and 7

B. D. Howe (chairman, subcommittee), Walter Buehler, F. J. Fudge, W. H. Fulweiler, H. F. Gilzow, M. F. Jaeger, H. C. Todd, Jr.

The following report is submitted as information.

It is felt that a final report on the soil poisoning tests at Florissant, Mo., will be of value and it is the purpose of the subcommittee to make such a report as soon as conditions permit an inspection at the site.

Report on Assignment 6

New Impregnants and Procedures for Increasing the Life and Serviceability of Forest Products

M. S. Hudson (chairman, subcommittee), W. P. Arnold, J. A. Barnes, R. S. Belcher, P. D. Brentlinger, H. B. Carpenter, H. E. Hurst, R. R. Poux, J. W. Reed, B. J. Richards.

The committee submits herein information on and specifications for two new oil-borne preservatives and recommends that these specifications be adopted for publication in the Manual.

NEW IMPREGNANTS—OIL-BORNE PRESERVATIVES

Pentachlorophenol

This preservative was approved by the American Wood-Preservers' Association as a standard in 1949. Information on pentachlorophenol was presented in the AREA Proceedings under Assignment 6 in 1949, at which time a specification was included, but was submitted as information only. This specification, together with appended comment, presented in the following, is now offered for adoption and publication in the Manual.

SPECIFICATION FOR PENTACHLOROPHENOL

Pentachlorophenol shall contain not less than 95 percent of chlorinated phenols as determined by titration of hydroxyl and calculated as pentachlorophenol.

It shall contain not more than 1 percent of matter insoluble N/1 aqueous sodium hydroxide solution.

It shall have a freezing point of not less than 174 deg C.

Solvents used to prepare solutions of pentachlorophenols shall comply with the standards of the AWPA.

Tests to establish conformity with the foregoing requirements shall be made in accordance with the standard methods of the AWPA (see AWPA Manual Sec. A5).

Comment

Wood treated with pentachlorophenol is suitable for use in exposure to all types of wood-destroying organisms, except those of marine origin, such as teredo, limnoria, etc.

For general use, the following retentions of pentachlorophenol are recommended:

For use in contact with the ground, not less than 0.4 lb/cu ft of dry pentachlorophenol. For use above ground, not less than 0.3 lb/cu ft of dry pentachlorophenol.

Copper Naphthenate

Copper naphthenate was approved as a standard of the AWPA in 1949. Data on this preservative and a specification for it was presented as information by AREA Committee 17 in 1949. This specification, together with appended comment, presented in the following, is now offered for adoption and publication in the Manual.

SPECIFICATION FOR COPPER NAPHTHENATE

The naphthenic acid used in the manufacture of copper naphthenate shall be of the group of cyclopentane carboxylic acids occurring in petroleum and shall have an acid number of not less than 180 on an oil-free basis.

The copper naphthenate concentrate used to prepare wood-preserving solutions shall contain not less than 6 percent nor more than 8 percent copper in the form of copper naphthenate.

All of the copper present in the concentrate shall be combined as copper naphthenate.

Copper naphthenate concentrate shall not contain more than 0.5 percent water.

Solvents used to prepare solutions of copper naphthenate shall conform to the standards of the AWPA.

The foregoing tests shall be made in accordance with the standard methods of the AWPA (see AWPA Manual, Sec. A5).

Comment

Copper naphthenate is recommended for preservation of all types of wood except marine piling.

For general use the following retentions of copper naphthenate are recommended:

For use in contact with the ground, not less than 0.1 lb/cu ft of metallic copper present as copper naphthenate. For use above ground, not less than 0.05 lb/cu ft of metallic copper present as copper naphthenate.

NEW IMPREGNANTS—WATER-BORNE PRESERVATIVES

Within recent years several new water-soluble preservatives have been approved as tentative standards by the AWPA. These are chromated zinc arsenate, acid copper chromate, ammoniacal copper arsenite, copperized chromated zinc chloride, and chromated copper arsenate. The committee submits herein information and specifications for these five new water-borne preservatives and recommends that the specifications for chromated zinc arsenate, acid copper chromate, and copperized chromated zinc chloride be adopted and published in the Manual.

Chromated Zinc Arsenate

This salt has been used extensively in Sweden and other Scandinavian countries, and since World War II has been introduced to a number of European countries as well as South America and the United States. It has shown up well in test stations in various parts of the world as is indicated on pages 34 and 35 of the AWPA Proceedings for 1949. It is covered by U. S. Patent No. 2,139,747, issued December 13, 1938, to Bror Hager, but is available for use in the wood preserving industry for a nominal royalty.

Chromated zinc arsenate presents no particular health hazard although workers handling concentrated solutions should be protected by suitable safety equipment ordinarily employed with arsenic and chromium compounds. It is practically non-corrosive, imparts some fire retardance to the treated wood, and apparently has no marked effect on the strength of wood. To prevent sludging in treating solutions, the treating temperature should not exceed 120 deg F.

The following specification was approved as a tentative standard of the AWPA in 1951, and is hereby recommended for adoption and publication in the AREA Manual, along with the appended comment.

SPECIFICATIONS FOR CHROMATED ZINC ARSENATE

Chromated zinc arsenate shall be composed of the following ingredients in the proportions given:

Arsenate calculated as arsenic acid (H_3AsO_4) 35 percent

Arsenate calculated as sodium arsenate (Na_2HAsO_4) 36 percent

Hexavalent chromium calculated as sodium dichromate dihydrate ($Na_2Cr_2O_7 \cdot 2H_2O$) 29 percent

Concentration of chemicals in the treating solution shall be maintained within the following limits:

	Max Percent	*Min Percent*
Arsenic acid	37	33
Sodium arsenate	38	34
Sodium dichromate dihydrate	31	27

The ratio of arsenic acid to sodium arsenate shall be deemed to fall within the prescribed limits if the percentage of total arsenic as (As_2O_5) lies between 47.7 and 53.5 percent, and the pH of the solution containing 100 g per liter of the dry salts, measured at 25 deg C, lies between 2.80 and 3.40.

Zinc Sulphate ($ZnSO_4 \cdot 7H_2O$)

The zinc sulphate shall be acid free and contain at least 98 percent zinc sulphate septahydrate ($ZnSO_4 \cdot 7H_2O$). It shall contain not more than 0.2 percent of iron and aluminum calculated as (Fe_2O_3) plus (Al_2O_3).

An equivalent amount of zinc sulphate pentahydrate ($ZnSO_4 \cdot 5H_2O$) may be used in place of ($ZnSO_4 \cdot 7H_2O$).

Concentration of chemicals in the treating solution shall be maintained within the following limits:

	Max Percent	*Min Percent*
Arsenic acid	22	18
Sodium arsenate	23	19
Sodium dichromate dihydrate	18	14
Zinc sulphate septahydrate	45	41

The ratio of arsenic acid to sodium arsenate shall be deemed to fall within the prescribed limits if the percentage of total arsenic as (As_2O_5) in the salts in solution lies between 26.4 and 32.1 percent, and the pH of a solution containing 25 g per liter of the dry salts, measured at 25 deg C, lies between 2.90 and 3.50.

The preservative shall contain at least 95 percent of the active ingredients listed above.

The foregoing tests shall be made in accordance with the standard methods of the AWPA. (See AWPA Manual A2).

Comment

Chromated zinc arsenate is recommended for preservative treatment of all classes of wood except marine piling. However, salt treatments as a general rule have not been found entirely satisfactory for cross ties because they do not help to protect the wood mechanically as do oily type preservatives.

For general use where leaching is not an important factor, the following retentions of chromated zinc arsenate are recommended:

For use in contact with the ground not less than 1.0 lb/cu ft, for use above ground not less than 0.5 lb/cu ft.

Acid Copper Chromate

This preservative was developed in the early 20's by Gilbert Gunn, an Englishman, and was patented in the U. S. in September 1928. The patent has now expired. This preservative consists of an acid solution of copper sulphate and sodium dichromate. It has been in extensive use in the United States since the 30's. By 1940 the amount used had become sufficient to justify reporting it as a separate item in the AWPA Proceedings. It has shown good performance in tests in the United States and in the International Termite Exposure tests published by Hunt and Snyder.

Acid copper chromate involves no particular health hazard and is less corrosive than zinc chloride, and apparently has no effect on the strength of the wood. It presents no fire hazard, although wood treated with 1 lb per cu ft will continue glowing until consumed if the ignition goes beyond charring and is severe, just as is the case with chromated copper arsenate. With acid copper chromate there is no need for special handling equipment or procedures other than those commonly employed with salt preservatives. The temperature of the preservative solution should be kept below 120 deg F in order to prevent sludge formation, which is likely to occur at higher temperatures. The following specification for acid copper chromate, together with appended comment, is recommended for adoption and publication in the Manual.

SPECIFICATIONS FOR ACID COPPER CHROMATE

Acid copper chromate shall be composed of the following ingredients in the proportions given:

Copper calculated as copper sulphate ($CuSO_4 . 5H_2O$) 50 percent

Hexavalent chromium calculated as sodium dichromate dihydrate ($Na_2Cr_2O_7 . H_2O$)[1] 47.5 percent

Chromic acid ($CrO_3$1.68 percent) calculated equivalence as sodium dichromate dihydrate[2] 2.5 percent

[1] Potassium dichromate may be used in the place of sodium dichromate.
[2] 0.25 percent acetic acid may be used in place of chromic acid.

The proportions of the ingredients of the dry salt or chemicals in treating solution may vary within the following limits:

	Max Percent	*Min Percent*
Copper sulphate	55	45
Sodium dichromate	55	45

The pH of the treating solution shall be maintained below 4.2.

Acidifying Agent

The preservative shall contain at least 95 percent of the active ingredients listed above.

The foregoing tests shall be made in accordance with the standard methods of the AWPA. (See AWPA Manual, Sec. A2).

Comment

Acid copper chromate is recommended for preservative treatment of all classes of timber except marine piling. Attention is called to the note regarding salt treatment of cross ties in the comment on chromated zinc arsenate above. It applies to acid copper chromate also.

For general use where leaching is not an important factor, the following retentions of acid copper chromate are recommended:

For use in contact with the ground, not less than 1 lb/cu ft. For use above ground 0.5 lb/cu ft.

Ammoniacal Copper Arsenite

A patent on ammoniacal copper arsenite—U. S. No. 2,149,284, was issued in March 1939 to Gordon. The preservative is being licensed in the wood-preserving industry on a nominal royalty basis. Detailed information on ammoniacal copper arsenite will be found in the AWPA Proceedings for 1949, page 32. Ammoniacal copper arsenite has been used extensively on the West Coast and has given good service both in test plots and commercial installations. It poses no particular health hazard except in the treating plant where the usual care must be exercised in handling arsenic compounds. It is no more corrosive to metal than zinc chloride, does not constitute a fire hazard, and ordinarily does not reduce materially the strength of the wood, in normally recommended quantities.

Ammoniacal copper arsenite may be used in standard treating equipment, except that any brass or bronze fittings must be excluded. Treating solutions should not be used at temperatures higher than 212 deg F, and the treated wood should be subjected to seasoning after treatment to insure evaporation of the ammonia.

The committee presents the following specifications for ammoniacal copper arsenite as information only.

SPECIFICATIONS FOR AMMONIACAL COPPER ARSENITE

Ammoniacal copper arsenite shall be composed of the following ingredients in the proportions given:

Copper calculated as cupric hydroxide ($Cu(OH)_2$), not less than 57.7 percent.

Arsenite calculated as arsenic trioxide (As_2O_3), not less than 40.7 percent.

Acetic acid ($C_2H_4O_2$) 1.6 percent.

The above shall be dissolved in a solution of ammonia in water of sufficient strength to make the weight of ammonia contained in the treating solution from 1.5 to 2.0 times the weight of copper hydroxide contained.

The proportions of the chemicals in the treating solution may vary within the following limits:

	Max Percent	*Min Percent*
Cupric hydroxide	59.7	55.7
Arsenic trioxide	42.7	38.7

The preservative shall contain at least 95 percent of the active ingredients listed above.

The foregoing tests shall be made in accordance with the standard methods of the AWPA (See AWPA Manual, Sec. A2).

Comment

Ammoniacal copper arsenite is recommended for preservative treatment of all classes of timber except marine piling. However, attention is called to the fact that salt treatments are not entirely satisfactory for the treatment of cross ties since they leave no oily materials in the wood which from past experience appear to be necessary in order to obtain optimum mechanical life.

For general use where leaching is not an important factor, the following retentions of ammoniacal copper arsenite are recommended.

For use in contact with ground 0.50 lb/cu ft. For use not in contact with the ground 0.3 lb/cu ft.

Copperized Chromated Zinc Chloride

This preservative as its name implies, is chromated zinc chloride to which about 7 percent copper chloride and a small additional quantity of sodium dichromate have been added. A specification for chromated zinc chloride was approved by the AREA in 1949. Complete information on copperized chromated zinc chloride was published in the AWPA Proceedings for 1950, page 38. It was approved as a tentative standard of the AWPA in 1951. The preservative is now used extensively in the United States and in test plots has shown itself to be equal or superior to chromated zinc chloride. Its properties as to health hazard, corrosiveness, fire hazard, and effect on strength of wood are very much like those of chromated zinc chloride. There is no need for special equipment for handling it. Copperized chromated zinc chloride is not patented and is, therefore, available for use in the wood-preserving industry without royalty charge.

The committee offers the following specification for copperized chromated zinc chloride, together with appended comment, for publication in the Manual.

SPECIFICATIONS FOR COPPERIZED CHROMATED ZINC CHLORIDE

1. Dry Salt

Copperized chromated zinc chloride in the dry form shall be composed of the following ingredients in the proportions given:

Zinc calculated as zinc chloride ($ZnCl_2$): Not less than 73 percent.

Hexavalent chromium calculated as sodium dichromate dihydrate ($Na_2Cr_2O_7 \cdot 2H_2O$): Not less than 20 percent.

Copper calculated as cupric chloride dihydrate ($CuCl_2 . 2H_2O$): Not less than 7 percent.

Subject to the following tolerances; the minimum proportions may be: Not less than 68.6 percent.

Acid soluble zinc calculated as zinc chloride: Not less than 18.8 percent.

Hexavalent chromium calculated as sodium dichromate dihydrate cupric chloride dihydrate: Not less than 6.6 percent.

2. Solutions

Fifty percent concentrated solution shall have a specific gravity at 100 deg F of 1.515 to 1.538.

Samples of copperized chromated zinc chloride treating solution taken from the working tanks or treating cylinders may show a change in composition as a result of treating operations. Such changes shall not serve to cause rejection of the preservative if they do not raise the ratio of zinc chloride to sodium dichromate dihydrate to more than 8 to 1, and the ratio of zinc chloride to copper chloride dihydrate to more than 25 to 1, provided it can be shown that the original fresh preservative was of the specified composition.

The preservative shall contain at least 95 percent of the actual ingredients listed above.

The foregoing tests shall be made in accordance with the standard methods of the AWPA (See AWPA Manual, Sec. A2).

Comment

Recommended retentions of copperized chromated zinc chloride, where leaching is not an important factor, are: ground contact 1 lb/cu ft. For use not in contact with the ground 0.75 lb/cu ft. The preservative is not recommended for use in marine piling.

Chromated Copper Arsenate

This preservative was developed by Sonti Kamesam of the Indian Forest Service, and was patented in the United States in February 1938. It is a mixture of copper, chromium, and arsenic compounds, which has shown excellent performance in test plots and commercial installations. Large numbers of poles have been treated with this preservative for the Bell Telephone System. These have been in service for about 12 years and have given excellent performance. A detailed discussion of chromated copper arsenate will be found in the AWPA Proceedings for 1949, page 29. Wood treated with chromated copper arsenate presents no health hazard, but in handling concentrated solutions of the chemicals in the treating plant care must be exercised to prevent contact with the arsenic and chromium compounds present in it. The material is less corrosive to metals than zinc chloride. It presents no fire hazard. However, dry wood treated with 1 lb/cu ft of chromated copper arsenate will continue glowing until consumed if ignition goes beyond charring and is severe. It does not ordinarily reduce the strength of the treated wood materially when used in the quantities normally recommended. No special treating equipment is required for handling this preservative and the only treating limitation is that of temperature, which should not be allowed to exceed 120 deg F, because of the tendency of the preservative to undergo sludging at higher temperatures.

Chromated copper arsenate is patented but is available to the wood-preserving industry for a nominal royalty.

The committee presents the following specification for chromated copper arsenate as information only.

SPECIFICATIONS FOR CHROMATED COPPER ARSENATE

Chromated copper arsenate shall be composed of the following ingredients in the proportions given.

Hexavalent chromium calculated as potassium dichromate[1] $K_2Cr_2O_7$: 56 percent.

Copper calculated as copper sulphate $CuSO_4 . 5H_2O$: 33 percent.

Arsenic calculated as arsenic pentoxide $As_2O_52H_2O$: 11 percent.

Concentration of chemicals in the treating solution shall be maintained within the following proportions:

	Max	*Min*
Potassium dichromate: copper sulphate	5.5:3.0	4.5:3.0
Potassium dichromate: arsenic acid	5.5:1.0	4.5:1.0
Copper sulphate: arsenic acid	3.3:1.0	2.7:1.0

The preservative shall contain at least 95 percent of the active ingredients listed above:

The foregoing tests shall be made in accordance with the standard methods of the AWPA (See AWPA Manual, Sec. A2).

Comment

The retentions recommended for this preservative in exposure where leaching is not an important factor are 0.75 lb/cu ft for use in contact with the ground, and 0.5 lb/cu ft for use above ground. It is not recommended for use in marine piling.

NEW OIL-TYPE PRESERVATIVES

The following data on new oil type preservatives is presented for information only.

Lignite Tar Creosote

Lignite tar creosote is obtained by distillation of tar produced by low temperature carbonization of lignite or brown coal, large quantities of which are available in the Dakotas and parts of Canada. Creosote produced from this source is low in specific gravity. The specific gravity is usually about the same as that of water. It contains little benzol insoluble and coke residue, and generally has a low distillation residue above 355 deg C. Lignite tar creosotes are very high in tar acids; ranging from approximately 25 percent to as high as 50 percent. Tests conducted by the U. S. Forest Products and Canadian Forest Laboratories indicate that this material has value as a wood preservative. It has been used by the Northern Pacific Railway for a number of years, usually in admixture with the regular coal-tar creosote and petroleum oil. The Canadian National Railways has also used some of the material in tests. Northern Wood Preservers, Ltd., of Port Arthur, Canada, have been using a 50:50 solution for the treatment of poles and fence posts. More detailed information on this material will be found in the AWPA Proceedings for 1949, page 62.

[1] Sodium dichromate dihydrate may be used in the place of potassium dichromate.

Wood Preserving Oil

A wood-preserving oil, manufactured by a Pacific Coast company, is produced by high-temperature pyrolysis of residual fuel oil and is similar in physical properties to coal-tar creosote, in that it has a specific gravity above 1.03. The benzol insoluble, coke residue, and distillation pattern is also similar to coal-tar creosote. However, it is completely devoid of tar acids. A paper on this material was published in 1940 by Glenn Vorhees of Oregon State College, entitled Oil Tar Creosote for Wood Preservation. Members of the wood-preserving industry during the past year have been widely circularized with a brochure, published in March 1952, describing this product. The present recommendation of the sponsors for this material is as a pentachlorophenol carrier, rather than a straight preservative in its own right, inasmuch as the specification which they recommend requires the addition of 2 percent pentachlorophenol. About one million gallons of this product are produced annually.

NEW PROCESSES

Vapor-Cleaning and Solvent Recovery

A new process has been recently developed for cleaning the surface of wood treated with copper naphthenate and pentachlorophenol so that it can be painted immediately after treatment without having to wait for the long period currently recommended by the sponsors of such preservatives before painting. This waiting period before painting, in many cases, of species such as Douglas fir and heartwood of pine, is still not adequate to insure satisfactory paintability.

The newly developed method utilizes a modification of the vapor-drying process to effect removal of high concentrations of preservative from the surface of wood after impregnation with solutions of copper naphthenate or pentachlorophenol. When wood is treated with these preservatives dissolved in heavy oil, it is subsequently exposed to the vapor of petroleum solvents, such as mineral spirits. The vapor condenses on the surface of the wood and extracts the excess preservative. A vacuum is afterward employed to remove the solvent. When the wood is impregnated with solutions of the preservatives in volatile solvents, such as mineral spirits, the vapor operation is carried out in the same manner as for vapor cleaning, but since during the vacuum periods that follow vapor exposure, the mineral spirits are evaporated from the wood and recovered at the condenser, this operation is called vapor solvent recovery. Normally, when wood is treated with these preservatives in light solvents, it is then stored in open piles to allow the solvent to evaporate into the air before the wood is used. By means of the vapor solvent recovery process this solvent is reclaimed, and thus a saving of several dollars per thousand board feet of lumber processed, is effected.

A program of experimental work on this process was carried out on copper naphthenate treated lumber during 1949 and 1950, and a similar project was carried out with pentachlorophenol in 1951–1952. The first commercial plant employing the process began operation in August 1952.

The new process insures the immediate availability of lumber treated with the non-leachable preservatives, copper naphthenate and pentachlorophenol. In addition, it assures that the lumber can be painted without experiencing the difficulties of bleed-through and discoloration of paint that have attended the use of those preservatives heretofore. The process also promises to be of value in cleaning up of creosoted wood after impregnation to prevent objectionable bleeding of this preservative onto the surface.

Report on Assignment 7

Incising Forest Products

W. P. Arnold (chairman, subcommittee), Walter Buehler, B. D. Howe, R. P. Hughes, A. J. Loom, C. H. Wakefield.

This is a progress report, presented as information.

Erie Railroad

In 1950, the Erie Railroad started an incising test which has been described previously. These ties were treated in 1951 and have now been installed in track near Burbank, Ohio. The committee hopes to be able to report inspection data on this test next year.

Wheeling & Lake Erie Division, Nickel Plate Railroad

This test of incised ties reported previously is still in progress. An inspection was made in September 1952 and results after 11 years' service are given in Table 1.

Report on Assignment 8

Review the Specifications for Creosote, Particularly with Respect to Limitation of Residue Above 355 Deg C and Other Revisions Resulting from Changes in Processes of Manufacture

W. W. Barger (chairman, subcommittee), R. S. Belcher, Walter Buehler, C. M. Burpee, W. H. Fulweiler, W. R. Goodwin, M. S. Hudson, A. L. Kammerer, B. J. Richards.

This is a final report presenting information and submitting revised specifications for Creosote and Creosote–Coal Tar Solutions for adoption and publication in the Manual under the general heading of Specifications for Preservatives.

The revised Creosote specification is as follows:

CREOSOTE

1. The creosote shall be a distillate derived entirely from tar produced by the carbonization of bituminous coal.

2. It shall contain not more than 3 percent water.

3. It shall contain not more than 0.5 percent matter insoluble in benzol. (See Note 1).

4. The specific gravity of the creosote at 38 deg C, compared with water at 15.5 deg C shall be not less than 1.03.

5. The distillate, based on water-free creosote, shall be within the following limits (See Note 1).

Up to 210 deg C not more than 5 percent.
Up to 235 deg C not more than 25 percent nor less than 5 percent.
Up to 270 deg C not less than 20 percent.
Up to 355 deg C not more than 85 percent nor less than 60 percent.

6. The specific gravity of fraction between 235 deg C and 315 deg C shall be not less than 1.025, and the fraction between 315 deg C and 355 deg C not less than 1.085 at 38 deg C, compared with water at 15.5 deg C.

(Continued on page 750)

Table 1—Results of Inspection September 15, 1952

Species	Actual	Percent	GROUP 1 (Checks 1/8" or no checks) No.	GROUP 1 Percent of Species	GROUP 1 Percent of Group	GROUP 2 (Checks and/or splits between 1/8 and 3/8") No.	GROUP 2 Percent of Species	GROUP 2 Percent of Group	GROUP 3 (Checks and/or splits 3/8" and over) No.	GROUP 3 Percent of Species	GROUP 3 Percent of Group
Incised											
Maple	86	55.1	31	36.0	51.6	45	52.4	64.3	10	11.6	38.5
Elm	34	21.8	3	8.8	5.0	15	44.1	21.5	16	47.1	61.5
Gum	23	14.7	19	82.6	31.6	4	17.4	5.7			
Cherry	7	4.5	6	85.7	10	1	14.3	1.4			
Ash	4	2.5	1	25.0	1.7	3	75.0	4.3			
Sassafras	1	.7				1	100.	1.4			
Hickory	1	.7				1	100.	1.4			
Totals	156	100.0	60		100.0	70		100.0	26		100.0
Percent			38.5			44.9			16.6		
Unincised											
Maple	81	51.9	7	8.7	53.8	47	58.0	55.9	27	33.3	45.8
Elm	42	26.9	2	4.8	15.4	10	23.8	11.9	30	71.4	50.8
Gum	23	14.7	3	13.0	23.1	20	87.0	23.8	0		
Cherry	5	3.2	1	20.0	7.7	3	60.0	3.6	1	20	1.7
Ash	2	1.3				1	50.0	1.2	1	50.0	1.7
Sassafras	2	1.3				2	100.0	2.4	0		
Hickory	1	.7				1	100.0	1.2	0		
Totals	156	100.0	13		100.0	84		100.0	59		100.0
Percent			8.3			53.9			37.8		

7. The creosote shall yield not more than 2 percent of coke residue. (See Note 1).

8. The foregoing shall be determined in accordance with AWPA Standard A1.

Note 1—Samples of used creosote may show increases in matter insoluble in benzol and in coke residue, and decreases in percentages of distillate, due to treating operations. If neither the matter insoluble in benzol nor the coke residue exceeds the specification limits by more than 1 percent, and if the percentages of distillate are not lower than the specification minimum limits by more than 3 percent, and it can be shown that the original creosote was of specified quality, the used creosote shall be regarded as conforming to the specification.

Committee Comment

You will note that Par. 1 of the Specification has been changed, omitting all reference to the method of production of tar used in making the creosote. Par. 6 will tend to exclude creosote distilled from tars produced by methods other than high-temperature carbonization of coal.

Par. 2 and 3 have only minor editorial changes.

There has been no change made in Par. 4.

In Par. 5 the distillation range of the creosote has been more closely restricted than it is in the present specification. The permissible amounts distilling to 210 deg C and 235 deg C remain the same, but minimum requirements on distillate to 235 deg C and 270 deg C have been added. Also minimum and maximum requirements on distillate to 355 deg C have been added. The minimum requirements of distillate to 235 deg C and 270 deg C will tend to assure liquidity at relatively low temperatures and thus reduce difficulties of handling oreosote during cold weather. A further object is to describe more closely the type of creosote which has been found by experience to be effective. Practically all of our service records are based on creosote having appreciable amounts distilling up to 270 deg C.

The specific gravity of fractions, which in footnote No. 1 of the present specification is one of three optional purity tests, has been placed in the body of the proposed specification under Par. 6. This changes it to a fixed requirement. The main purpose of this requirement is to prevent the gross adulteration of creosote with petroleum oils.

Par. 7 of the proposed specification is the same as Par. 6 of the present specification and remains unchanged.

Par. 8 of the proposed specification takes the place of Par. 7 of the present specification. The new Par. 8 requires that the foregoing determinations shall be made in accordance with the AWPA Standard A1, instead of in accordance with the ASTM methods.

Footnote No. 2 of the present specification has been changed to footnote No. 1 of the proposed specification and revised to also take care of increases in coke residue up to 1 percent and changes in distillation fractions up to 3 percent due to treating operations.

The revised Creosote–Coal Tar Solutions Specifications are as follows:

CREOSOTE–COAL TAR SOLUTIONS

The material shall be a pure coal-tar product obtained by the carbonization of bituminous coal. It may be either a coal-tar distillate oil or a solution of coal tar in distillate oil. It shall comply with the following requirements for the grades below:

Grade	A		B		C		D	
	Not more than	*Not less than*	*Not more than*	*Not less than*	*Not more than*	*Not less than*	*Not more than*	*Not less thon*
1. Composition: Coal-tar distillate, percent by volume	------	80	------	70	------	60	------	50
2. Water: percent by volume	3.0	------	3.0	------	3.0	------	3.0	------
3. Material insoluble in benzol (See Note 1); percent by weight	2.0	------	3.0	------	3.5	------	4.0	------
4. Coke residue (See Note 1); percent by weight	5.0	------	7.0	------	9.0	------	11.0	------
5. Specific gravity at 38 deg C compared with water at 15.57 deg C	1.11	1.06	1.12	1.07	1.13	1.08	1.14	1.09
6. Distillation: On a water-free basis the distillate shall be within the following percents by weight:								
Up to 210 deg C	5	------	5	------	5	------	5	------
Up to 235 deg C	25	5	25	5	25	5	25	5
Up to 315 deg C	------	36	------	34	------	32	------	30
Up to 355 deg C	------	60	------	56	------	52	------	48

7. The specific gravity of fractions between 235 deg C and 315 deg C shall be not less than 1.025, and the fraction between 315 deg C and 355 deg C not less than 1.085 at 38 deg C, compared with water at 15.5 deg C.

8. The foregoing shall be determined in accordance with AWPA Standard A1.

Note 1—Samples of used creosote–coal tar solutions may show increases in matter insoluble in benzol and coke residue as a result of treating operations. Such increases, provided they do not exceed by 1 percent the specification limits, should not cause rejection of the solution if it can be shown that the original fresh solution was of specified quality.

Committee Comment

The proposed specifications for Creosote–Coal Tar Solutions have not been changed except to add the specific gravity of fractions as Par. 7 to the body of the present specifications. The specific gravity of fractions heretofore has been one of three optional purity tests under Note No. 1.

Par. 8 has been added requiring determinations be made in accordance with AWPA Standard A1.

Notes Nos. 2 and 3 have been consolidated as Note No. 1 in the proposed specifications.

Report on Assignment 10

Artificial Seasoning of Forest Products Prior to Treatment

W. P. Arnold (chairman, subcommittee), R. S. Belcher, P. D. Brentlinger, C. M. Burpee, L. C. Collister, R. F. Dreitzler, H. R. Duncan, B. D. Howe, M. S. Hudson, R. R. Poux, M. H. Priddy.

This is a progress report, presented as information.

Controlled Air Seasoning

Last year your committee reported on the controlled air seasoning of southern yellow pine poles. This same method of seasoning is now being experimentally applied to cross ties. The committee hopes to be in a position to submit information on this subject next year.

Timber Engineering Company One-Step Seasoning and Creosoting Process

Last year preliminary information was reported on this process. Recently pilot plant tests of the process were run at the Santa Fe Railway Experimental Plant in Albuquerque, N. M. A report dated October 7, 1952 was prepared by the Timber Engineering Company, Washington, D. C., describing the results of this pilot test work. Your committee feels this report contains some controversial information and therefore has decided not to republish this report until all of the data can be compiled.

Report of Committee 22—Economics of Railway Labor

R. J. Gammie, *Chairman*,
Lem Adams
A. D. Alderson
M. B. Allen
H. C. Archibald
B. V. Bodie
E. J. Brown
J. A. Bunjer
F. G. Campbell
R. H. Carpenter
G. E. Chambers
M. W. Clark
P. A. Cosgrove
A. T. Danver
C. G. Davis
M. H. Dick
W. W. Edwards
J. P. Ensign
H. J. Fast
J. L. Fergus
L. C. Gilbert, *Secretary*,
C. G. Grove
C. T. Gunsallus
W. H. Hamilton
K. H. Hanger
G. L. Harris
W. H. Hoar
G. W. Hunt
T. B. Hutcheson
J. E. Inman
Claude Johnston
H. W. Kellogg
G. A. Kellow
N. M. Kelly
W. I. King
H. E. Kirby
Roy Lumpkin
J. S. McBride
E. H. McIlheran
D. E. Rudisill, *Vice Chairman*,
W. H. Miesse
H. C. Minteer
C. R. Montgomery
J. P. Morrissey
G. M. O'Rourke
L. F. Racine
R. B. Radkey
A. G. Reese
C. W. Reeve
G. L. Sitton*
J. S. Snyder
E. C. Vandenburgh
H. J. Weccheider
J. G. West, Jr.
H. M. Williamson
F. R. Woolford
C. R. Wright
Committee

* Died April 2, 1952.

To the American Railway Engineering Association:

Your committee reports on the following subjects:

8. Means of increasing or conserving labor supply for the duration of the emergency advising the secretary currently of recommendations or practices that merit emergency publication by the AREA.

   No report.

THE COMMITTEE ON ECONOMICS OF RAILWAY LABOR
R. J. GAMMIE, *Chairman*.

AREA Bulletin 505, December 1952.

MEMOIR

George Loyall Sitton

With a unanimous expression of sorrow, Committee 22 records the passing of George Loyall Sitton on April 2, 1952. Our committee has sustained a grievious loss.

As a member and vice chairman, he contributed unsparingly of his time and energy to the work of the committee. A man of clear perception and high courage, Mr. Sitton instinctively applied soundest principles in his counsel. His intellectual honesty unfailingly impressed those who were privileged to be associated with him.

A more complete memoir, which more fully expresses the feeling of our committee with respect to Mr. Sitton, appears on page 1179, AREA Proceedings, Vol. 53, 1952—this memoir having been prepared by a special committee appointed by the president of the Association.

Report on Assignment 1

Revision of Manual

C. G. Grove (chairman, subcommittee), Lem Adams, M. B. Allen, R. H. Carpenter, A. T. Danver, M. H. Dick, K. H. Hanger, G. W. Hunt, G. A. Kellow, J. S. McBride, G. M. O'Rourke, L. F. Racine, E. C. Vandenburgh, C. R. Wright.

During the past year your committee, upon the request of the Board of Direction, has presented to the secretary's office a new Table of Contents for Chapter 22 in the Manual as to be reprinted in 1953, which Table of Contents incorporates a desirable rearrangement of the present material in the chapter in order to better correlate related material.

In connection with this rearrangement of material, the committee has continued its work of the last two years in reviewing specific documents, and as a result thereof recommends the reapproval of all of the material in Chapter 22 with the following revisions, deletions and additions.

Page 22–1 to 22–5, incl.

ECONOMICS OF RAILWAY LABOR

Change this heading to "Recruiting, Training and Welfare."

Page 22–1. Change center heading "B. Supervisory" to "Recruiting and Training."

Pages 22–1 and 22–2. Combine the material under "A. Personnel" with that under "C. Employees" under a new general heading "Welfare."

Pages 22–2 and 22–3. Under the heading "D. Mechanical Equipment" delete the first two paragraphs and substitute the new material presented herewith as Statement A.

This revised material is to be presented under a new general heading "Track" in the reprinted Manual. The purpose of this recommendation is to bring the information up to date and place it under the proper headings.

Under the heading "D. Mechanical Equipment", delete the third paragraph, and substitute the material submitted herewith, designated Statement B. This revised material is to be presented under a new general heading "Bridge and Building" in the reprinted Manual. The purpose of this recommendation is to bring the information up to date and place it under the proper heading.

Page 22-3. E. ANNUAL TRACK INSPECTION AND PRIZE AWARDS

Delete the word "Track" in this heading.

Pages 22-3 and 22-4. In the first line, first paragraph, under "G. Programming Work", add the word "track" between the words "way" and "work".

Combine all the material under "F. Diversion of Traffic" and "G. Programming Work" under new general heading "Programming Work and Diversion of Traffic."

Page 22-5. Delete the entire material under the heading "I. Vegetation Control" and substitute the material herewith designated as Statement C. The proposed new material involves revision of and additions to the existing material in order to bring the information up to date and keep the Manual material current with new developments.

Pages 22-5 to 22-9, incl.

PROGRAMMING OF BRIDGE AND BUILDING WORK

In the first paragraph, third line under this heading, delete the words "see Manual, this Chapter, Part I, Section G."

Page 22-9

COMBINED OR SEPARATE BRIDGE AND BUILDING GANGS

Change this heading to "Relative Economy of Combined and Separate Gangs".

Pages 22-10 to 22-14, incl.

OUTFIT CARS FOR HOUSING MAINTENANCE OF WAY EMPLOYEES

Change heading to "Outfit Cars for Housing."

Page 22-15

EQUATED TRACK VALUES FOR LABOR DISTRIBUTION

Delete the word "Track" in this heading.

Statement A

MECHANICAL EQUIPMENT

The use of mechanical equipment in connection with track work has resulted in substantial reductions in labor required to maintain track. The development of such equipment has made it feasible to organize special gangs with equipment suitable to handle heavy out-of-face repairs to track. The use of some power tools can be extended in a degree to small gangs and result in increases in productive work.

Special gangs organized to relay rail out-of-face make good use of spike pullers, adzers, cranes, bolt machines, spike drivers, creosote sprayers, and power rail saws and drills. For raising track, power jacks with unit or multiple tamping machines increase production and promote uniformity of work. In ballast renewal work more economical use of labor is possible if coordinated with cribbing machinery, ballast cleaners, power jacks, power tampers and ballast dressing machines. Labor required for tie renewals has been reduced by using tie saws and tie pullers, and at times power spike pullers and spike drivers.

Smaller section or district gangs can sometimes be permanently furnished with power equipment adapted for use with one or two laborers. Occasionally it is economical to assign larger pieces of equipment to these forces temporarily for special work of short duration.

Many types of grading machines are available for roadway work. Off-track equipment for this type of work has been developed extensively in recent years and its effectiveness in reducing costs has been well demonstrated. Pressure grouting equipment for stabilizing roadbeds has received considerable attention and in many instances a substantial reduction of labor required for subsequent track maintenance has resulted.

Statement B

MECHANICAL EQUIPMENT

The development and use of mechanical equipment for bridge and building construction and maintenance work has resulted in definite labor economies. Each railroad considering the use of power tools for this work must consider its own needs based on its particular problems and method of organizing forces.

Experience has shown that some types of power tools can well be used by nearly all types of bridge and building crews. Such tools include power saws, drills, impact wrenches, and grinders. Many crews can use push cars equipped with derricks, either power or hand-operated, to good advantage.

Crews handling specialized work can utilize additional equipment. For steel bridge work, cleaning equipment, including flame cleaners, power chipping tools and brushes, or sand blasting equipment, will save hours of hand labor. Concrete crews can use concrete mixers, paving breakers, portable pumps, and in some instances pressure grouting machinery. Water service crews should have available power hoists, portable pumps, power cutting and threading tools, and at times can use small trenching machines to good advantage. When programs call for considerable painting, hand brush work can be reduced with paint spray equipment.

Many of the machines mentioned are available, powered either by gasoline, compressed air, or electricity. The type of power best adapted to the existing facilities or needs of each railroad should be obtained.

In connection with larger mechanical equipment used in the construction or maintenance of bridges and buildings, progress in the design of cranes is noteworthy. Modern steam, gas, diesel or diesel-electric cranes are readily converted for various types of service. A steam generator, fully automatic, may be used to supply steam for steam crane and steam pile hammer operation. Where steam is not available a self-contained diesel-operated pile hammer may be used.

Statement C

VEGETATION CONTROL

The elimination of vegetation within the ballasted area is essential to the economical maintenance of track. Within this area the elimination of vegetation facilitates drainage, increases the life of ties, and reduces the fouling of ballast, thereby decreasing the cost of track maintenance.

The control of objectionable types of vegetation on the right-of-way, outside of the ballasted area, facilitates proper policing, improves the view, facilitates operation and maintenance activities, reduces the fire hazard and accumulation of snow, and improves the appearance of railway property.

Objectionable types of vegetation should be destroyed at that period in their growth that is most effective in preventing regrowth or reproduction. Generally, this period is in the early part of the seeding stage of the vegetation concerned.

The greatest economy in vegetation control is effected by reducing to the minimum the amount of manual labor through the use of (1) mechanical equipment, (2) oil burners, (3) chemicals, or (4) oil, the relative economy of which depends upon the character and density of the vegetation concerned, and on local conditions.

Economy of maintenance may be promoted frequently by smoothing the right-of-way to the extent practicable to permit the use of power-operated mowing machines. Also, it is economical to plant and maintain grass on the right-of-way outside of the roadbed shoulders to retard the growth of objectionable types of vegetation and to minimize soil erosion; this grass to be of a variety adapted to the locality involved.

Since 1949 there has been great impetus in the matter of vegetation and brush control. Many new chemicals and much new equipment to apply them economically have been introduced. The methods and cost are being closely followed by Committee 22—Economics of Railway Labor, collaborating with Committee 1—Roadway and Ballast.

Report on Assignment 2

Analysis of Operations of Railways That Have Substantially Reduced the Cost of Labor Required in Maintenance of Way Work

G. A. Kellow (chairman, subcommittee), B. V. Bodie, E. J. Brown, F. G. Campbell, W. W. Edwards, H. J. Fast, J. L. Fergus, C. T. Gunsallus, G. L. Harris, W. H. Hoar, T. B. Hutcheson, C. Johnston, N. M. Kelly, H. E. Kirby, E. H. McIlheran, H. C. Minteer, G. M. O'Rourke, A. G. Reese, C. W. Reeve.

This report is submitted as information.

Your committee is reporting on a comprehensive system of programming roadway maintenance work developed by the Delaware Lackawanna and Western Railroad. The system involves working out, in complete detail at the beginning of each year, a program of work for the entire year. All concerned have a definite goal to achieve and know that nothing short of a major reversal will change this program.

In order to observe some the operations and to have a first hand view of the results of several years of programming as it affected the standard of maintenance, Committee 22 made an inspection trip, on August 6, 1952, over the Lackawanna main line between Buffalo, N. Y., and Hoboken, N. J.

The main line is primarily a double-track railroad, with some stretches of three and four-track territory over the Allegheny mountain range and in the congested eastern territory. Between Denville, N. J., and Hoboken, in the suburban territory of the Lackawanna, four mains are in use, two for passenger service and two for freight service.

The Lackawanna has a total trackage of 2379 miles to maintain, divided as follows:

Miles of road	949
Miles of second main	482
Miles of other main	113
Miles of yards and sidings	835
Total	2,379

Volume of traffic on the main lines and secondary mains is indicated in the tabulation below:

Hoboken to Binghamton, N. Y.	3,800,400 Thousand Gross Ton Miles Annually
Binghamton to Buffalo	5,920,700 " " " " "
Syracuse branch (Oswego, N. Y. to Binghamton) / Utica branch (Utica, N. Y. to Binghamton)	722,000 " " " " "
Bloomsburg branch (Northumberland, Pa., to Scranton)	240,724 " " " " "

Speed of trains is generally limited to a maximum of 80 mph in passenger service and 50 mph in freight service.

Main line track construction consists of 132-lb rail with 6-hole head-free joint bars, double-shoulder "waffle-bottom" tie plates, and 24 creosoted ties per 39-ft rail panel. The ballast generally conforms to AREA specification No. 3, and is trap rock on the eastern half of the road and limestone on the western half. Grade 4 and 5 treated oak, gum and pine ties are used in main track. In general, oak ties are used in sharper curves, gum in lighter curves, and pine in tangent track. A few grade 3 ties are used on branch lines, and the grade 1 and 2 ties, necessary to purchase along with the larger ties, are used in new industry tracks.

The 949 miles of road operated is divided for track maintenance purposes into seven divisions, six of them between Buffalo and Hoboken, including supplemental branch lines, and the seventh covering the two secondary main lines known as the Syracuse branch and the Utica branch. Each main line section is assigned about 15 miles of double track, or its equivalent in three or four-track territory. Branch line sections have 15 to 30 miles of single-track main to maintain. The number of laborers in section gangs is held nearly constant throughout the year, the 1952 winter section force averaging 300 laborers, and the summer force 359 laborers. Work of section gangs is confined mainly to spotting, policing and miscellaneous work.

All heavy out-of-face maintenance work is handled by extra gangs, and work is generally confined to about a seven-month working period each year. The Lackawanna's maintenance program is geared almost entirely to its surfacing program, which may be explained briefly as follows:

1. Once every 6 years track is worked over completely, ballast is cleaned, all ties with remaining life of less than 6 years are renewed, and the track is raised about 3½ in with X-type tampers.
2. One, and sometimes 2 years after the above operation, track is raised out-of-face about 1½ in and tamped with Y-type tampers.

3. About 3 years after the operation described under 1, the track is raised out-of-face again, with a light lift of approximately 1½ in, this being the final operation until the 6-year cycle is completed.

Almost all other track work, including most out-of-face rail renewals, is coordinated with this general policy of surfacing track. With such an established policy the Lackawanna prepares and follows a rigid annual program of maintenance work.

About the first of November each year the roadmasters meet with the engineer maintenance of way to set up programs for the following year's work. Ninety-five percent of the programs follow the regular cycle of surfacing outlined above. If a roadmaster requests work that is not within this cycle a field inspection of the track is made to determine if the request is justified. After this preliminary meeting, the engineer maintenance of way works up preliminary programs to cover the necessary work, submits them to the chief engineer for approval of the management, and receives a maintenance of way money allotment for the entire year. On the basis of the allotment final programs are completed and, barring major upsets in earnings, it is understood that the annual allotment will not be changed.

The complete work on each division is set up in a Program book, which then becomes the season's work sheets for all involved in carrying out the schedules. The Program book for 1952 included a total of 71 pages and covered the following items of track work for each division:

Winter Force Allotment
Summer Force Allotment
Ballast Cleaning
Pennsylvania Grinding Train
Scarifying of Track
Cribbing Machines
Total Track Raising
Extra Gang Work Schedules
Tamping Schedules—light raise
Tamping Schedules—heavy raise
New Rail Program
Relayer Rail Program
Application of Joint Bars
Turnout Renewals
Tie Plate Renewals
Track Stabilization (Grouting)
Chemical Brush and Weed Control
Application of Tie Pads and Preservative to Bridge Ties
Assignment and Storage of Cinders
New Switch Tie Allotments
New Cross Tie Allotments
Stone Ballast Allotments

Programs for the above work are complete in detail, including limits of work, dates work to be done, quantities of material needed, and in some instances quantities and type of materials released. In some programs instructions are included to explain how materials are to be used and applied. All materials required for the maintenance of way program work are ordered and charged out by the engineer maintenance of way. An inventory is maintained by the engineer maintenance of way only for rail and ties. The last two pages in the program book are devoted to the General Track Work Methods and Standards of the Lackawanna.

The detailed planning involved may be illustrated in part by the six sample pages taken from the Lackawanna's 1952 Program book and included at the end of this report. These pages, altered to eliminate names of machines, were selected to show some of the work programmed on Division 5, covering about 100 miles of double-track mains from Binghamton to Bath, N. Y., and the branch line from Owego to Ithaca, N. Y.

Exhibits 1 and 2 are the winter and summer allotment of supervisors and laborers for both section and extra gangs on Division 5. It is interesting to note that, with a heavy program of work, section force laborers increase from 31 in the winter to 43 in the summer, while extra gang laborers increase from 14 to an average of 87.

Exhibit 3 outlines by tracks and mile post limits the total track raising scheduled for Division 5. Under the column headed "Tamper X" is shown the miles to be machine tamped, working under the Lackawanna "detour" method, which was described in the report of Committee 22 in the Proceedings, Vol. 50, 1951, pages 226–228. There is shown a total of 19.2 miles of track where tie renewals, on a 6-year cycle, are to be made and track raised about 3½ in as described under item 1 earlier in this report, while the 79.1 miles of track to be covered under the column headed "Tamper Y" will be covered as outlined in items 2 and 3, previously described.

Extra-gang programs are set up around the operation of three Y-type and two X-type tamping machines. The Y-type machines are worked separately, while the X-type tampers are worked both singly and in tandem. Exhibits 4 and 5 outline the season's work for one Y-type machine and the two X-type tampers working in tandem. Similar programs are prepared for the other two Y-type tampers and for each of the X-type machines when working separately.

Exhibit 6 covers the extra-gang work schedule for Division 5 for the full year 1952. Extra gangs are identified 5 x 1, 5 x 2, etc., indicating extra gang 1—Division 5, extra gang 2—Division 5. Where, on the program for Division 5, a gang apparently finishes its work in the middle of the season, this gang will then appear on another division's program. To illustrate how the division force allotment fits into the program for the machines, your attention is directed to the line on exhibit 4, "Program for Tamper Y No. 9001," covering M.P. 254.4 to 263.1 from July 14 to August 4. The gang assignments for this work as shown on exhibit 4 are 5 x 6, 5 x 8 and 23, or extra gangs 6 and 8 and section 23 on Division 5. Going to exhibit 2, summer force, and exhibit 6, extra-gang work schedule for the same dates, we find the following:

Exhibit 6—5 x 6	1 Foreman	3 Asst. Foremen	19 Laborers
5 x 8	1 "		12 "
Exhibit 4—Section 23	1 "		6 "
add 7–14 to 8–4		1 Asst. Foreman	9 "
Total	3 Foremen	4 Asst. Foremen	46 Laborers

If it were possible to include all the information shown in the Lackawanna's Program book, there would be shown a page entitled "Force Set-Up Tamper Y" which would show a total force of 3 Foremen, 4 assistant foremen and 46 laborers, and just what each man was assigned to do. It can be also seen, and it is common practice, that section forces work constructively with extra gangs when work is programmed on their section.

Space does not permit illustration or discussion of the completeness of all phases of the programming done by the DL&W. This railroad, at the beginning of a working season, has a clear picture of the work ahead, knows with a practical degree of certainty that authorizations will not be changed, and can work in a straight-forward manner toward accomplishing its goal.

The programming of maintenance of way work started on this railroad in 1934 and enlarged about 1946. Automatic power-tamping equipment was used to a small extent in 1949, and in 1950 practically all main-track tamping was accomplished with the automatic machines. A comparison of the program of track raising with the actual accomplishments for the six years 1946 to 1951, incl., is shown in Table 1:

TABLE 1—DELAWARE, LACKAWANNA & WESTERN RAILROAD PROGRAM AND PROGRESS REPORT 1946–1951 TRACK RAISING

Year	*Tie Renewal Raise—3"*			*Surface Raise 1½"*			*Total Raising*		
	Miles		*% of Prog*	*Miles*		*% of Prog.*	*Miles*		*% of Prog.*
	Prog.	*Actual*		*Prog.*	*Actual*		*Prog.*	*Actual*	
1946	282.7	238.3	84	217.1	171.2	79	499.8	409.5	82
1947	266.1	233.5	88	247.5	242.9	98	513.6	476.4	93
1948	260.8	256.7	99	170.2	123.8	73	431.0	380.5	88
1949	221.1	217.3	98	175.2	141.9	81	396.3	359.2	91
1950	236.4	222.8	94	241.9	246.5	102	478.3	469.3	98
1951	198.1	207.9	105	247.5	269.6	109	445.6	477.5	107
AVG.	244.2	229.4	94	216.6	199.3	92	460.8	428.7	93

In 1952 a total of 433 track miles was set up in the track-raising program. As of August 6, when the committee made its inspection, all raising gangs were either on schedule or within one or two days of their schedule.

Direct responsibility for the quality of work and the progress of extra gangs is delegated to the roadmasters on whose territory the gangs are working. At the close of each working day the roadmasters telephone a summary of the day's gang activities to the engineer maintenance of way, reporting mile post limits, number of rails covered, total men in gang, number of productive hours, and delays because of traffic conditions or machinery failures. If the gang is ahead of schedule on a roadmaster's territory the roadmaster may do other constructive work so long as program schedules are maintained. As indicated in Table 1, 93 percent of the work programmed in the past 6 years has been completed, and in the last 2 years the completed work equalled or exceeded expectations.

The value of any system of organizing forces is measured by the amount of work accomplished as compared with the cost of doing such work. Table 2 is set up to make such a comparison on the Lackawanna for the 7-year period from 1945 to 1951, incl.

Col. 4 in Table 2 shows that, except for 1949, every year since 1945 the maintenance of way ratio of expenses to revenue has decreased. Col. 13, average hourly rate of pay for track labor, shows an increase from $0.65 to $1.422, or 118 percent, in the 7 years covered. Railroad Construction Indices as published by the Engineering Section of the Interstate Commerce Commission's Bureau of Valuation form the basis for Table 3.

TABLE 2

DELAWARE, LACKAWANNA & WESTERN RAILROAD
WORK PROGRESS COMPARED TO EXPENDITURES - 1945 - 1951

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)			(13)
											TOTAL TRACK RAISED (MILES)			
YEAR	TOTAL OPERATING REVENUE	TOTAL M.W.& S. EXPENSES	RATIO TO REVENUES	MONEY OUTLAY M.W.& S. EXPENSE (See Note)	RATIO TO REVENUES	M. W. & S. EXPENSE IN MAJOR TRACK ACCOUNTS (See Note)	RATIO TO REVENUES	STONE BALLAST USED (Tons)	NEW RAIL LAID (Gross) Tons	NEW TIES USED	TIE RENEWAL 3 IN	SURFACE RAISE 1 1/2 IN	TOTAL RAISING	AVG. RATE OF TRACK LABOR (Pr.Hr.)
1945	$72,245,847	$9,391,991	13.00	$7,451,669	10.31	$3,951,019	5.47	166,774	8,249	156,818	Not Avail.	Not Avail.	Not Avail.	$ .65
1946	69,481,551	8,716,282	12.54	6,875,808	9.90	4,144,329	5.96	119,620	8,588	170,605	238.3	171.2	409.5	.825
1947	81,154,430	10,116,053	12.47	8,158,024	10.05	4,734,161	5.83	171,806	8,122	188,528	233.5	242.9	476.4	.887
1948	91,426,345	10,662,748	11.66	8,959,411	9.79	5,123,185	5.60	180,350	7,698	217,750	256.7	123.8	380.5	.99
1949	80,476,508	10,316,315	12.82	8,607,048	10.69	5,259,262	6.54	129,475	8,055	197,212	217.3	141.9	359.2	1.079
1950	82,343,567	9,333,483	11.33	7,653,627	9.29	4,536,071	5.51	212,019	5,166	171,281	222.8	246.5	469.3	1.258
1951	89,621,240	9,957,661	11.11	8,113,094	9.05	4,376,380	4.88	183,691	4,742	148,456	207.9	269.6	477.5	1.422
AVG.	80,964,213	9,784,933	12.09	7,974,097	9.85	4,589,201	5.67	166,248	7,231	178,664	229.4	199.3	428.7	

NOTES - Column (7) includes expenses chargeable to A/c 202-Roadway Maintenance, A/c 212-Ties, A/c 214-Rails, A/c 216-Other Track Material, A/c 218-Ballast, and A/c 220-Track Laying and Surfacing.

Column (5) Exclusive of depreciation and retirements.

TABLE 3—RAILROAD CONSTRUCTION INDICES

Year	ICC Road Account					Weighted Avg.
	8	9	10	11	12	
1945	241	152	176	181	273	198
1946	252	165	190	194	298	212
1947	270	210	217	207	336	242
1948	298	244	266	235	366	275
1949	302	245	278	254	366	282
1950	306	264	278	258	364	289
1951	344	278	301	268	386	310

(1910–1914 costs equals 100)

Total expense reported in Col. 7, Table 2, covering the major track accounts for 1951, shows an increase of approximately 5 percent over 1946. At the same time more miles of track were raised. The increase of only 5 percent in expenses was accomplished in spite of an average increase in costs, including labor, of over 45 percent in the same period, as indicated by the weighted average indices in Table 3.

It would not be proper to allocate the entire savings accomplished in the past years to the Lackawanna's programming methods. This railroad, particularly since 1949, has extended its use of work equipment as fully as possible, and full credit must be given to the mechanization of track work. Likewise, equal credit must be given to the programming methods for maximum utilization of this railroad's investment in modern machinery, and it is this feature, along with the judicious use of the labor necessary for full production, that makes programming most attractive.

The DL&W and your committee feel that their policy of programming work on a 6-year cycle basis has led to economies other than labor. By maintaining a good surface on track the life of rail has been extended. Also, a better joint condition has followed, and the life of joint bars and other track fastenings has been improved.

The Lackawanna's plan of renewing ties on a 6-year cycle has caused much comment. Following such a plan, all the renewals are made on "dead" track under the "detour" method in connection with a substantial track raise, and no soft ties are left in track to be replaced later by digging in new ties, thus disturbing the track surface. On more than half the railroad scrap ties cannot be burned where they are removed because of local fire restrictions, but must be picked up and transported to other locations for disposition. Usable second-hand ties are systematically stacked, mechanically picked up on dead track, and reinstalled by gangs in conjunction with a surfacing raise in side tracks. It is estimated that less than 1000 ties a year are dug in on this railroad. In the 5-year period from 1947 to 1951, incl., this railroad renewed less than 3 percent of its ties annually, indicating an average tie life of almost 35 years.

Conclusion

The Lackawanna has been able to reduce the labor required for maintenance of way work by means of the detour method, the increased use of labor-saving equipment, and detailed annual programming of work. It is not possible to separate the labor saving among the three items. However, the detailed annual programming has resulted in:

1. More efficient and constructive use of labor.
2. Greater utilization of labor-saving equipment.

EXHIBIT 1

PROGRAM 1952

Winter Force

Division No. 5

(Effective 1-1-52 to 3-31-52 & 11-3-52 to 12-31-52 Except as noted)

Gang	Foremen	Asst. Foremen	M. of W. Laborers	Other Dept. Laborers	Total Laborers	Remarks
19	1		3		3	
20	1		3		3	
21	1		3		3	Add 1 A-F & 12 Lab. 11-3 to 11-7
22	1	1	8	2	10	Add 4 Laborers 11-3 to 11-7
23	1		4		4	
24	1		4		4	
25	1	1	4		4	
74	1	2	2		2	
Total Section	8		31	2	33	
5X1 Owego	1		10		10	
5X9 Elmira	1		4		4	Add 6 Lab. 1-1 to 4-1
Total X-Gang	2		14		14	
Grand Total	10	2	45	2	47	

EXHIBIT 2

PROGRAM 1952

Summer Force

Division No 5

(Effective 4-1-52 to 10-31-52 except as noted)

Gang	Foremen	Asst. Foremen	M of W laborers	Other Dept Laborers	Total Laborers	Remarks
19	1		5		5	Add 7 Laborers 6-19 to 6-26 Add 1 AF & 10 laborers 8-11 to 8-25
20	1		6		6	Add 6 laborers 8-11 " 9-11
21	1		6		6	Add 1 A.F. & 9 lab. 8-26 - 10-3
22	1	1	6	2	8	Add 1 AF & 9 lab. 4-21 " 5-16 Add 6 laborers 9-12 " 10-3
23	1		6		6	Add 1 AF & 9 Lab. 7-14 " 8-4
24	1		6		6	Add 1 AF & 9 Lab. 7-8 " 8-19
25	1	1	5		5	Add 10 Laborers 6-27 " 7-7 " 10 " 8-5 " 8-8
74	1		3		3	
Total Section	8	2	43	2	45	
5X1 Owego	See work schedule for force allotment					1-1 to 11-30
5X2 Elmira	" " " " " "					3-17 " 5-16
5X3 "	" " " " " "					3-20 " 5-16
5X4 "	" " " " " "					3-20 " 5-16
5X5 "	" " " " " "					4-2 " 5-16
5X6 Bath	" " " " " "					4-21 " 8-8
5X7 "	" " " " " "					5-19 " 8-19
5X8 "	" " " " " "					5-19 - 8-8
5X9 Elmira	" " " " " "					1-1 - 12-31
5X10 Bath	" " " " " "					5-19 - 8-19
5X11 Owego	" " " " " "					5-19 - 8-8
Total X-gang	5	6	87	-	87	*Average force 4-1 to 10-31
Grand Total	13	8	130	2	132	* " " 4-1 " 10-31

* Includes extra asst. foremen and laborers added to sections as noted under "Remarks"

EXHIBIT 3

PROGRAM 1952

Total Track Raising

Division No. 5

Branch	M.P. Location From	M.P. Location To	Track No.	Miles Shovel Tamping: By Hand	Miles Shovel Tamping: Tamper & Detur	Miles Shovel Tamping: Total	Miles Machine Tamping: Air Comp.	Miles Machine Tamping: Tamper	Miles Machine Tamping: Total	Total Miles
Main	195.7	212.5	1					16.8	16.8	16.8
"	195.7	199.8	2					4.1	4.1	4.1
"	224.3	225.7	1					1.4	1.4	1.4
"	225.8	228.0	1	2.2		2.2				2.2
"	230.8	231.9	1	1.1		1.1				1.1
"	230.8	235.8	2					5.0	5.0	5.0
"	232.0	236.4	1					4.4	4.4	4.4
"	239.4	247.3	1					7.9	7.9	7.9
"	240.0	242.5	2					2.5	2.5	2.5
"	248.4	254.4	1		6.0	6.0				6.0
"	248.4	248.7	2	0.3		0.3				0.3
"	248.4	248.7	4	0.3		0.3				0.3
"	248.7	254.5	2					5.8	5.8	5.8
"	254.4	263.1	1					8.7	8.7	8.7
"	267.3	270.9	2		3.6	3.6				3.6
"	273.5	284.4	1					10.9	10.9	10.9
"	275.9	287.5	2					11.6	11.6	11.6
"	284.4	294.0	1		9.6	9.6				9.6
Total Main Line				3.9	19.2	23.1		79.1	79.1	102.2
Ithaca	216.8	221.0		4.2		4.2				4.2
Total Branch Line				4.2		4.2				4.2
Grand Total				8.1	19.2	27.3		79.1	79.1	106.4

EXHIBIT 4

PROGRAM 1952

Tamper Y, No. 9001

Branch	Trk Nº	MP Location From	MP Location To	Miles	Days	Dates From	Dates To	Gang Assignments #1	Gang Assignments #2	Gang Assignments #3	Location Machine Operator's Living Car
Boon	2	22.0	34.0	*12.0	22	4-1	4-30	1X1	1X2	5	Denville
"	2	34.0	38.0	*4.0	7	5-1	5-9	1X1	1X2	5	"
"	1	34.0	38.0	*4.0	7	5-12	5-20	1X1	1X2	5	"
Main	2	82.3	91.1	8.8	18	5-21	6-16	2X3	9	–	Stroudsburg
"	2	94.9	97.0	2.1	4	6-17	6-20	2X3	9	–	Cresco
"	2	168.9	175.7	6.8	14	6-23	7-11	4X3	4X4	17	New Milford
"	1	254.4	263.1	8.7	16	7-14	8-4	5X6	5X8	23	Big Flats
"	2	285.3	287.5	2.2	4	8-5	8-8	5X6	5X8	25	Bath
"	1	210.7	212.5	1.8	3	8-11	8-13	5X1	20	19	Owego
"	2	195.7	199.8	4.1	8	8-14	8-25	5X1	20	19	Vestal
"	1	224.3	225.7	1.4	3	8-26	8-28	5X1	20	21	Waverly
"	2	230.8	235.8	5.0	9	8-29	9-11	5X1	20	21	"
"	1	232.0	236.4	4.4	9	9-12	9-24	5X1	22	21	"
"	1	239.4	243.1	3.7	7	9-25	10-3	5X1	22	21	"
Morris	1	28.2	36.0	7.8	20	10-6	10-31	1X1	1X2	–	Denville
			Total	76.8	151						

* To be done under detour

Operator's.

Repairman - W. Luther Headquarters Harrison, N.J.

Crane operator - A. Velocci Headquarters Harrison, N.J.

EXHIBIT 5

PROGRAM 1952

Tampers X, Nos. 9003 & 9004

(Working in Tamden)

(Set-up "A")

Branch	Trk. Nº	MP Location From	MP Location To	Miles	Days	Dates From	Dates To	Gang Assignments 1-A	2-A	3-A	4-A	5-A	Location Machine Operator's, Living Cars
Main	2	161.8	168.9	7.1	10	4-14	4-25	4X2	4X3	4X4	4X1	16	New Milford
"	2	177.3	187.7	10.4	15	4-28	5-16	4X2	4X3	4X4	4X1	17	" "
"	2	267.3	270.9	3.6	5	5-19	5-23	5X6	5X7	5X8	5X10	24	Bath
"	1	284.4	294.0	9.6	14	5-26	6-13	5X6	5X7	5X8	5X10	25	"
"	1	306.5	312.8	6.3	9	6-16	6-26	6X2	6X3	6X1	6X5	26	Wayland
"	2	314.0	321.4	7.4	11	6-27	7-14	6X2	6X3	6X1	6X5	27	"
"	2	334.0	344.0	10.0	13	7-15	7-31	6X8	6X9	6X4	6X10	29	Mt Morris
"	2	344.0	354.0	10.0	13	8-1	8-19	6X12	6X13	6X4	6X14	29	E. Bethany
"	2	383.0	388.9	5.9	8	8-20	8-29	6X15	6X16	6X6	6X17	31	Lancaster
(See sheets 42 & 43)					-	9-2	9-12	-	-	-	-	-	-
Main	2	60.8	74.3	13.5	18	9-15	10-8	2X2	2X4	2X3	2X5	8	Blairstown
"	1	60.8	81.5	20.7	27	10-9	11-14	2X2	2X4	2X3	2X5	8	"
(See sheets 42 – & 43)					-	11-17	11-28	–	–				–
			Total	104.5	143.0								

See sheets 42 & 43 for operators

EXHIBIT 6

PROGRAM 1952
Extra Gang Work Schedule
Division No. 5

Gang	Headquarters	Start Time	Consist F.	Consist A.F.	Consist Lab.	Work		Dates From	Dates To
5x1	Owego (Local)	7:00	1		10	Misc. work Div. #5		1.1	2.29
						Install tie plates	212.0 to 231.9	3.3	3.14
						" splices #1	195.7 " 207.7	3.17	3.31
						Misc Work Train & Shoulders etc.		4.1	4.11
			1	1	26	Cribbing Machine and Platform		4.14	4.18
						Fork #1	230.8 to 231.9	4.21	4.28
						" #1	225.8 " 228.0	4.29	5.13
						Install Detour X-over	228.0 & 235.0	5.14	5.16
			1	3	19	Gang #1 Tamper Y #1	195.7 to 210.7	5.19	6.26
			1	1	26	Clean up #1	195.7 " 210.7	6.27	7.11
						Shovel Ithaca -S-	219.0 to 221.0	7.14	8.8
			1	3	19	Gang #1 Tamper Y #1	210.7 " 212.5	8.11	8.13
						" #1 " #2	195.7 " 199.8	8.14	8.25
						" #1 " #1	224.3 " 225.7	8.26	8.28
						" #1 " #2	230.8 " 235.8	8.29	9.11
						" #1 " #1	232.0 " 236.4	9.12	9.24
						" #1 " #1	239.4 " 243.1	9.25	10.3
			1	1	36	Lay Rail Track #2	240.0 " 242.4	10.6	10.14
						Shovel Ithaca -S-	217.5 " 219.0	10.15	10.31
			1	3	19	Gang #1 Tamper Y #2	240.0 " 242.5	11.3	11.7
			1	1	20	Remove X-overs	228.0 " 235.0	11.10	11.12
						Shovel Ithaca -S-	216.8 " 217.5	11.13	11.18
			1		10	Lay Rail Ithaca -S-	216.8 " 220.5	11.19	11.28
5x2	Elmira (Local)	6:00	1	1	24	Install Temp. X-overs	250.3 to 254.4	3.13	3.13
						Rail & Switches #1	249.6 " 250.6	3.14	3.19
						" " " #1	248.4 " 248.8	3.20	3.25
			1	2	18	Gang 1-B Tamper X #1	248.4 " 254.4	3.26	4.11
			1	1	21	With gang 5x3		4.14	4.18
			1	3	19	Gang #1 Tamper Y #1	243.1 to 247.3	4.21	4.30
						" #1 " #2	248.7 " 254.5	5.1	5.16
5x3	Elmira (Local)	6:00	1	1	24	With gang 5x2		3.13	3.25
			1	3	26	Gang 2-B Tamper X #1	248.4 " 254.4	3.26	4.11
			1	1	25	Rail and Switches 2-3 & 4	248.4 " 248.8	4.14	5.9
						" " " 2 & 3	249.6 " 249.8	5.12	5.16
5x4	Elmira (Local)	7:00	1	1	18	With gang 5x2		3.13	3.25
			1	3	16	Gang 3-B Tamper X #1	248.4 to 254.4	3.26	4.11
			1	1	18	With gang 5x3		4.14	4.18
			1	1	18	Cribbing Machine		4.21	5.2
						Remove Temp X-overs	250.3 " 254.4	5.5	5.6
			1	1	15	Fork #2 & #4	248.4 " 248.7	5.7	5.16
5x5	Elmira (Local)	7:30	1		11	Gang 4-B Tamper X #1	248.4 to 254.4	3.26	4.11
			1		12	With gang 5x3		4.14	4.18
			1		12	Gang #2 Tamper Y (see Sched 5x2)		4.21	5.16
5x6	Bath (Local)	6:00	1	1	20	Install Switches #2	275.9 to 287.5	4.21	5.2
						" Temp. X-overs	264.5-280.3 & 284.4-289.6	5.5	5.16
			1	2	19	Gang 1-A Tamper X #2	267.3 to 270.9	5.19	5.23
						" " " #1	284.4 " 294.0	5.26	6.13
			1	1	20	Lay Rail #2	275.9 " 287.5	6.16	6.26
						Crib & Air Tamp Avoca Crossings #2		6.27	7.3
						Rem. Temp. X-overs	264.5-280.3 & 284.4-289.6	7.7	7.11
			1	3	19	Gang #1 Tamper Y #1	254.4 to 263.1	7.14	8.4
						" #1 " #2	285.3 " 287.5	8.5	8.8
5x7	Bath (Local)	6:00	1	3	28	Gang 2-A Tamper X (see Sched. 5x6)		5.19	6.13
			1	2	29	Lay Rail #2	275.9 to 287.5	6.16	6.26
			1	3	19	Gang #1 Tamper Y #1	280.3 to 284.4	6.27	7.7
						" #1 " #1	273.5 " 280.3	7.8	7.25
						" #1 " #2	275.9 " 285.3	7.28	8.19
5x8	Bath (Local)	7:00	1	3	20	Gang 3-A Tamper X (see Sched. 5x6)		5.19	6.13
			1	1	22	With gang 5x6		6.16	7.11
			1		12	Gang #2 Tamper Y (see Sched. 5x6)		7.14	8.8
5x9	Elmira (Local)	7:00	1		10	Work Trains & Shoulder work		1.1	4.1
			1		4	Work Trains		4.2	12.31
5x10	Bath (Local)	7:30	1		12	Gang 4-A Tamper X (see Sched. 5x6)		5.19	6.13
						Lay Rail #2	275.9 to 287.5	6.16	6.26
						Gang #2 Tamper Y (see Sched. 5x7)		6.27	8.19
5x11	Owego (Local)	7:00	1		6	Grouting		5.19	8.8

Report on Assignment 3

Organization of Forces for Track Maintenance Operations

H. C. Archibald (chairman, subcommittee), A. D. Alderson, J. A. Bunjer, F. G. Campbell, G. E. Chambers, J. P. Ensign, H. J. Fast, C. T. Gunsallus, K. H. Hanger, G. L. Harris, W. H. Hoar, T. B. Hutcheson, N. M. Kelly, C. R. Montgomery, R. B. Radkey, J. T. Snyder, H. J. Weccheider, F. R. Woolford.

This is a final report, presented as information.

Your committee has assembled and presents in tabular form certain information received from the Class I railroads in response to a questionnaire sent out in 1951. Owing to the large volume of data received and the scope of the questions, the subject was carried over for report at this time.

The committee endeavored to find out in some detail the organizations used by each railroad in the maintenance of tracks; also the methods used for track inspection, the length of sections, the strength of section and extra-gang forces assigned, together with information as to labor-saving machinery available, etc.

In compiling the data it seemed desirable to make various groupings of railroads, so that anyone referring to the tables would find roads listed which are of similar classification as to traffic, speed, single or multiple-track systems, etc. Also, northern railroads subject to frost action in ballast and roadbed have entirely different problems than roads which are frost-free, that is, the roads which are required to do little or no shimming. Hence, a grouping was made as between northern and southern roads.

Finally, a tabulation has been made showing organization for terminal yard maintenance, and on the same tabulation the "chain of supervision", from section foreman up to chief engineer, is given.

TABLE 1

SUMMARY OF REPLIES TO QUESTIONNAIRES
TRACK MAINTENANCE ORGANIZATION

NORTHERN Railroads
MULTIPLE Track Lines
HEAVY Traffic

Name of Railroad	Maximum Speed Allowed Pass.	Frt.	Est. Annual Gross Tons Over Track (1000's)	Wt. of Rail	Type of Ballast	Are Section Gangs Supplemented By Small Ex.Gang	Large Ex.Gang	Trk. Inspection By Whom	How Often Per Week	Average Length Section (ST Mi.)	Heavy Maintenance Done by Special Gangs Rail Syst.	Resur. (Div)	Ties	Other Oper'tns	Track Laborers Per Mile of Main Track Section W	S	Ex.Crew W	S	Type of Trans-port-ation	Extent of Labor Saving Tools and Equipment	Remarks
B&LE	50	40	32,700	130 155	Lime-stone	Yes	-	Sect. Fore.	2 - 3 Times	14.4	No	Yes	No	-	0.49	0.58	0.17	0.23	Motor Car, Bus	50% Power	
B&M	70	45	36,000	112 130	Rock	Yes	Yes	Mo.Car Patrol	Daily	11.23	Yes (Div)	Yes	Yes	No	0.39	0.42	0.09	0.15	Motor Car	Portable Tampers	Small Ex.Gangs in Camp Cars.
CNR	80	60	26,000	130	Rock	Yes	Yes	Asst. Rdmstr.	Daily	8.00 12.00	Yes (Dist)	Yes	No	-	0.50	0.60	Varies		Motor Car	Lg.Gangs Mechanized	Extra Gangs in Camp Cars.
CPR	90	50	23,000	100	Rock	No	No	Asst. Rdmstr.	Daily	8.05	Yes (Dist)	Yes	Yes	Yes	0.37	0.50	Varies		Hand or Mo. Car	None directly assigned	Extra Gangs in Camp Cars
CB&Q	90	65	Heavy	112 129	Slag, Rock	No	Yes	Supvr.	Daily ex. Sunday	10.00 12.00	Yes	Yes	Yes	Grout'g.	0.20	0.33	-	-	Mo.Car Truck	Portable Tampers	
CNW	90	60	11,238	110 115	Slag Gravel	Yes	No	Tk.Supv. Sec.Gang	5 Times 1 "	14.1	Yes	Yes	No	No	0.18	0.30	0.10	0.15	Mo.Car Truck	Supplied as needed	
DL&W	80	60	20,000	132	Rock	Yes	Yes	Tk.Pat.	3 Times	30.0	No	Yes	Yes	Yes	0.13	0.20	0.13	0.50	Mo.Car Truck	As comp. as possible	Ex.Gangs not responsible for mtce.
DM&IR	55	35	35,000	115	Rock	No	Yes	Insp.	Daily	15.0	Yes	Yes	No	-	0.20	0.60	-	-	Mo.Car	Port.Tamps.	
ERIE	Over 60		Heavy			Yes	Yes	Tk.Supv. Fore.	Daily	8.00 16.00	No	Yes	Yes	Yes	0.25	0.25	Varies		Mo.Car Truck		Large Gangs for heavy work
GN	79	50	Heavy	115 .131	Rock	Yes	Yes	Tk.Insp.	Daily	18.35	Yes (Div)	Yes	Yes	Yes	0.16	0.27	Varies		Mo.Car Truck	Portable Tampers	Spec.Gangs for welding, grout'g, etc.
IC (Chicago to Gilman)	79	60	60,000	115 132	Slag	Yes	Yes	Tk.Insp.	Daily	12.00 16.00	No	Yes	When Surf.	-	.53 Aver.		Varies		Mo.Car Truck	Gangs Mech.	
Monongahela	40	30	25,000	112 132	Slag	No	No	Supv. Fore.	Weekly 2-3 Times	12.00	Yes	Yes	Yes	No	0.46	0.56	0.20	0.30	Motor Car	Tampers on Secs.	Gangs combined for heavy maintenance
NC&St.L	70	60	Heavy	112 115	Lime Stone	Yes	No	Supv. Sec.Fo.	2-3 Times	15.00	Yes	Yes	Yes	-	0.40	0.40	-	0.70	Truck Mo.Car	Moved from Gang to Gang.	
NYC	80 85	55 60	Heavy	127	Rock	Yes	Yes	Patrol	3 Times	20.00	No	Yes	Yes	-	Varies		Varies		Mo.Car Truck	Hvy.work mechanized	Lg.Gangs for rail, surfacing, etc.
NH	70	50	Heavy	132	Rock	No	Sect.Gangs	Truck Walker	5 Times	16.0	Div. Gangs	Yes	Yes	-	0.41	-	0.41	-	Truck	Completely	Wholly maintained by Lg. Truck Crews plus seasonal gangs as required.
NP	75	50	15,000	100 132	Gravel Rock	No	Yes	Tk.Supv.	3 Times	16.0 22.0	Yes	Yes	No	Yes	0.17	0.33	Varies		Motor Car	Portable Tampers	Lg.Crews for special jobs
Penn.Sys. (N.Y.Div.)	80	50	192,000	140 155	Rock	Yes	Yes	Tk.W'ker	Daily	9.40	Yes	Yes	Yes	Yes	0.53	0.75	0.15	1.16	Truck Bus	80%	20 Men Gangs 20 Mile Radius

TABLE 1 (CONT'D)

SUMMARY OF REPLIES TO QUESTIONNAIRES
TRACK MAINTENANCE ORGANIZATION

Name of Railroad	Maximum Speed Allowed Pass.	Frt.	Est. Annual Gross Tons Over Track (1000's)	Wt. of Rail	Type of Ballast	Are Section Gangs Supplemented By Small Ex. Gang	Large Ex. Gang	Trk. Inspection By Whom	How Often Per Week	Average Length Section (ST Mi.)	Heavy Maintenance Done by Special Gangs Rail Syst.	Resur. (Div)	Ties	Other Oper'tns	Track Laborers Per Mile of Main Track Section W	S	Ex. Crew W	S	Type of Trans-portation	Extent of Labor Saving Tools and Equipment	Remarks
Penn.Sys. (Pitts.Div.)	70	50	25,000 98,000	130 155	Rock	Yes	Yes	Fore.& Laborers	3-5 Times	8.00 16.00	Yes	Yes	Yes	Yes	0.31	0.35	0.40	0.82	Mo.Car Truck	Little on Sections	24 Men Gangs 14 Mile Radius
Penn.Sys. (Ft.Wayne)	75	50	28,000	131 133	Rock	Yes	Yes	Tk.W'ker & Patr.	Daily 3 Times	12.00	Yes	No	No	-	0.40	0.40	0.00	1.00	Truck Bus	Fullest extent	Large Gangs for special purposes
Penn.Sys. (Mary.Div.)	80	50	60,000	155	Rock	No	Yes	Tk.W'ker	3 Times	12.57	Yes	Yes	Yes	Yes	0.64	0.80	0.37	1.10	Truck Train	Assigned Supv.Dist.	
Penn.Sys. (Pan.Div.)	70	50	40,000	133 152	Rock	Yes	Yes	Laborers & Fore.	3-5 Times	12.00	Yes	Yes	Yes	Yes	0.33	0.38	0.44	0.80	Tr.Bus Mo.Car	Lg.Gangs equipped	Special Gangs for heavy work.
Penn.Sys. (Mid.Div.)	70	50	103,000	155	Rock	No	Yes	Tk.W'ker	5 Times	16.00	Yes	Yes	No	No	0.50	0.50	0.1	0.9	Truck Bus	Much as practical	
P&LE	70	40	Heavy	115 132	Slag	Yes	Yes	Tk.W'ker & Patr.	Daily	9.20	Yes	Yes	Yes	Yes	Va-ries	0.80	Va-ries	1.17	Mo.Car Truck	Sm.Gangs as req'd.	Lg.Gangs for heavy work
UP	80	50	Heavy	133	Rock	Yes	Yes	Track Walker	3 Times	10.00	Yes	No	No	-	0.40	0.60	-	0.50	Truck Mo.Car	Power Wrenches	Lg.Gangs for heavy work

TABLE 2

NORTHERN — Railroads
MULTIPLE — Track Lines
MEDIUM — Traffic

Name of Railroad	Maximum Speed Allowed Pass.	Frt.	Est. Annual Gross Tons Over Track (1000's)	Wt. of Rail	Type of Ballast	Small Ex. Gang	Large Ex. Gang	By Whom	How Often Per Week	Average Length Section (ST Mi.)	Rail Syst.	Resur. (Div)	Ties	Other Oper'tns	Section W	S	Ex. Crew W	S	Type of Trans-portation	Extent of Labor Saving Tools and Equipment	Remarks
B&Ar.	55	44	Medium	80 115	Gravel	No	No	Fore.	Daily	16.00	Yes	No	No	Yes	0.19	0.63	-	-	Motor Car	None on Sections	
B&M	70	45	Medium	100 115	Rock	Yes	Yes	Mo.Car Patrol	Daily	11.23	Yes (Div.)	Yes	Yes	No	0.39	0.42	0.09	0.15	Motor Car	Portable Tampers	
CMSP&P	90	60	Medium	115 132	Gravel	Yes	Yes	Fore.	As Req'd.	17.00	Yes	Yes	Yes	-	0.13	0.13	Varies		Motor Car	Supplied as needed	Ex.Gangs for summer work.
DRGW	65	50	Medium	115	Slag	Yes	Yes	Sec. Gang	Daily	12.00	Yes	Yes	Yes	-	0.20	0.40		0.40	Motor Car	Lg.Gangs equipped	Ex. Gangs for special work.
GTW	75	60	Medium	100 131	Lime. Gravel	No	Yes	Tk.Pat. Sec.Fo.	5 Times 1 "	24.00	Yes	Yes (Sys)	Yes	No	0.30	0.40	0	0.20	Motor Car	Tamps.Lg gangs fully	Ex.Gangs for Summer work
MeC.	60	40	Medium	100 115	Gravel	Yes	Yes	Tk.Pat. Sec.Fo.	5 Days 1 "	10.00	No	Yes	No	Yes	0.30	0.40	-	-	Motor Car	Portable Tampers	Gangs combined for heavy work.
NYS&W	60	40	Medium	100 112	Rock	Yes	No	Sec. Fore.	Daily	6.39	No	No	No	No	0.50	1.20	-	-	Hand or Mo.Car	Slight	Gangs combined for heavy work.
Penn.Sys. (Col.Div.)	75	50	12,000	133	Stone	Seldom	Yes	Tk. Walker	3 Times	13.00	Yes	Yes	No	Yes	0.40	0.40	-	0.70	Tr.Bus Mo.Car	Pow.Tools available	Extra gangs for special work.
Penn.Sys. (So.W.Div.)	75	50	6,000	133	Gravel	Yes	Yes	Patr. Tk.W'ker	5 Times	12.00	Yes	-	-	-	0.30	0.50	-	0.50	Truck Mo.Car	As Req'd.	Special Gangs for special work.

TABLE 3

SUMMARY OF REPLIES TO QUESTIONNAIRES
TRACK MAINTENANCE ORGANIZATION

NORTHERN Railroads
SINGLE Track Lines
HEAVY Traffic

Name of Railroad	Maximum Speed Allowed Pass.	Maximum Speed Allowed Frt.	Est. Annual Gross Tons Over Track (1000's)	Wt. of Rail	Type of Ballast	Are Section Gangs Supplemented By Small Ex. Gang	Are Section Gangs Supplemented By Large Ex. Gang	Trk. Inspection By Whom	Trk. Inspection How Often Per Week	Average Length Section (ST Mi.)	Heavy Maintenance Done by Special Gangs Rail Syst.	Heavy Maintenance Done by Special Gangs Resur. (Div)	Heavy Maintenance Done by Special Gangs Ties	Heavy Maintenance Done by Special Gangs Other Oper'tns	Track Laborers Per Mile of Main Track Section W	Track Laborers Per Mile of Main Track Section S	Track Laborers Per Mile of Main Track Ex. Crew W	Track Laborers Per Mile of Main Track Ex. Crew S	Type of Transportation	Extent of Labor Saving Tools and Equipment	Remarks
CNR	75	60	10 to 20,000	100 115	Gravel Rock	Yes	Yes	Asst. Rdmstr.	6 Times	6.2 to 7.5	Yes (Dist)	Yes	Yes	Yes	0.50	0.60	Varies		Motor Car	Lg. Gangs equipped	
CPR	90	50	12,000	100	Rock	No	No	Asst. Rdmstr.	6 Times	6.00	Yes	Yes	Yes	Yes	0.50	0.67	Varies		Hand or Mo. Car	None on Sections	
CB&Q	70	50	Heavy	112 129	Gravel Rock	No	Yes	Track Supv.	6 Times	12.00	Yes	Yes	Yes	Grout'g	0.20	0.33	-	-	Truck Mo. Car	Portable Tampers	
CNW	95	50	Heavy	100 115	Gravel	Yes	No	Tk. Supv. Sec. Fo.	5 Times 1 "	13.2	Yes	Yes	No	No	0.18	0.27	0.05	0.42	Truck Mo. Car	Equipment rotated.	
DRGW	65	50	Heavy	115 133	Slag	Yes	Yes	Sec. Gang	Daily	14.0	Yes	Yes	Yes	-	0.20	0.40	-	-	Motor Car	Very little.	
ERIE	Over 60		Heavy			Yes	Yes	Tk. Supv. Fore.	Daily	8.00 to 12.00	No	Yes	Yes	Yes	0.25	0.25	Depends on Prog.		Truck Mo. Car		Large gangs for heavy work.
GN	79	50	Heavy	115	Rock	Yes	Yes	Tk. Insp.	Daily	13.62	Yes	Yes	Yes	Yes	0.29	0.36	0.15	0.50	Bus Truck Mo. Car	Fully equipped	Special gangs for welding, grouting, etc.
IC (Edgewood to Bloford)	50	50	35,000.	112 100	Stone	Yes		Tk. Insp.	Daily	7.00 9.00	No	Yes	Yes	-	0.53	Aver.	Varies		Mo. Car	Rail & Sur. Gangs Mech.	
MeC	60	45	Heavy	85 115	Gravel	Yes	No	Tk. Patr. Sec. Gang	5 Times 1 "	8.00	No	Yes	No	No	0.35	0.45	Varies		Mo. Car	Portable Tampers	Gangs combined for heavy work.
NP	75	50	25,000	100 132	Gravel Rock	No		Tk. Supv.	Daily	15.00 19.00	Yes	Yes	No	Ballast	0.17	0.33	Varies		Mo. Car	Portable Tampers	Large gangs for special work.
Soo	65	55	10,500	100	Gravel	No	No	Sec. Fo.	6 Times	10.00	Yes	Yes	No	No	0.40	0.60	Varies		Mo. Car	As assigned.	
Penn. Sys. (North. Div.)	50	45	22,000	131	Slag	No	No	Tk. W'ker	2 Times	8.00	Yes	No	No	No	0.50	0.65	-	-	Mo. Car	Very little in Sections.	
Monongahela	40	30	25,000	112 132	Slag	No	No	Supv. Sec. Fo.	3 Times	12.00	Yes	Yes	Yes	No	0.46	0.56	0.20	0.30	Motor Car	Portable Tampers	1 Lg. Gang to supplement sections.

TABLE 4

SUMMARY OF REPLIES TO QUESTIONNAIRES
TRACK MAINTENANCE ORGANIZATION

NORTHERN ——— Railroads
SINGLE ——— Track Lines
MEDIUM ——— Traffic

Name of Railroad	Maximum Speed Allowed Pass.	Maximum Speed Allowed Frt.	Est. Annual Gross Tons Over Track (1000's)	Wt. of Rail	Type of Ballast	Are Section Gangs Supplemented By Small Ex.Gang	Are Section Gangs Supplemented By Large Ex.Gang	Trk. Inspection By Whom	Trk. Inspection How Often Per Week	Average Length Section (ST Mi.)	Heavy Maintenance Done by Special Gangs Rail Syst.	Heavy Maintenance Done by Special Gangs Resur. (Div)	Heavy Maintenance Done by Special Gangs Ties	Heavy Maintenance Done by Special Gangs Other Oper'tns	Track Laborers Per Mile of Main Track Section W	Track Laborers Per Mile of Main Track Section S	Track Laborers Per Mile of Main Track Ex.Crew W	Track Laborers Per Mile of Main Track Ex.Crew S	Type of Transportation	Extent Of Labor Saving Tools and Equipment	Remarks
B&Ar.	55	44	Medium	80 to 115	Gravel	In emergency	No	Section Foreman	Daily	6.00	Yes	No	No	Ballast	0.33	0.67	-	-	Motor Car	None on Sections	Ex.Gang for heavy work.
B&M	60	45	Medium	112	Gravel Stone	Yes	-	Track Patrol	Daily	10.44	Yes	Yes	Yes	-	0.36	0.39	0.07	0.07	Motor Car	Portable Tampers	Gangs combined for heavy work.
CV	55	35	9,600	100	Rock	No	Yes	Sec.Fo. Tk.Patr.	2 Times 5 "	8.00	Yes	Yes	No	No	0.38	0.50	0.0	0.70	Motor Car	Portable Tampers	
CI&L	75	50	7,000	115	Rock	No	No	Section Foreman	3 Times	10.00	Yes	No	Yes	No	0.30	0.60	0.0	0.30	Truck Mo.Car	Portable Tampers	
CMSP&P	90	60	Medium	115 132	Gravel	Yes	Yes	Section Foreman	As required	13.00	Yes	Yes	Yes	-	0.20	0.20	Varies		Motor Car	Furnished as req'd.	Ex.Gangs for summer work.
DL&W	60	50	8,000	118	Cinder	Yes	-	Section Gang	Once Week	16.00	No	Yes	Yes	-	0.19	0.25	0.0	0.38	Truck Mo.Car	As considered economical	Ex.Gangs for heavy maintenance.
DT&I	55	50	8,390	85 115	Slag Rock	No	No	Tk.Patr.	5 Times	10.00	Contract	No	No	No	0.60	0.60	-	-	Motor Car	Compressors & Mowers	1 Ex.Gang for Rail Work
DM&IR	55	35	Medium	115	Gravel Rock	No	No	Tk. Insp.	Daily	12.00 20.00	Yes	Yes	No	-	0.60	0.60	-	-	Motor Car	Portable Tampers	
GTW	57	45	4,500	90 100	Gravel	No	No	Sec.Fo. Tk.Patr.	1 Time 5 Times	16.00	Yes	Yes	Yes	No	0.40	0.50	0.00	0.10	Motor Car	Small Mach.Tools Portable Tampers	Special Gangs Rail & Resurfacing
GB&W	-	45	Medium	70 90	Gravel	Yes	No	Sec.Fo. Tk.Patr.	Daily	13.00	Yes	Yes	No	Yes	0.12	0.43	0.00	0.30	Motor Car	90% equipped	Special Gangs Rail & Ballasting
IC(Chicago to Ft.Dodge)	79	50	17,200	115	Chat	Yes	-	Tk.Insp.	Daily	9.00	No	Yes	When surfacing		.64	Aver.	Varies		Motor Car	Rail & surfacing Gangs mechanized.	
MeC	60	45	7,350	85 115	Gravel	Yes	No	Sec.Fo. Tk.Patr.	1 Time 5 Times	8.00	Yes	Yes	No	-	0.35	0.45	-	-	Motor Car	Portable Tampers	Gangs combined for heavy work.
Montour	-	25	6,000	90 115	Slag	Yes	No	Sec.Fo. Rdmstr.	Periodically	5.20	Yes	No	No	No	0.80	1.00	-	-	Hand Car	None	Ex.Gang for rail laying
NH	60	45	Medium	115	Gravel	No Sec. Gangs		Patrol	5 Times	14.00	Div.	Yes	Yes	-	0.30	-	0.30	-	Truck	Completely	wholly maintained by large truck crews
NYCSys.	55 60	40	Medium	80 115	Gravel Rock	Yes	No	Tk.Patr.	3 Times	18.00	No	No	No	-	Varies		Varies		Truck Mo.Car	Heavy work mechanized	

TABLE 4 (CONT'D)

SUMMARY OF REPLIES TO QUESTIONNAIRES
TRACK MAINTENANCE ORGANIZATION

Name of Railroad	Maximum Speed Allowed Pass.	Frt.	Est. Annual Gross Tons Over Track (1000's)	Wt. of Rail	Type of Ballast	Are Section Gangs Supplemented By Small Ex. Gang	Large Ex. Gang	Trk. Inspection By Whom	How Often Per Week	Average Length Section (ST Mi.)	Heavy Maintenance Done By Special Gangs Rail Syst.	Resur. (Div)	Ties	Other Oper'tns	Track Laborers Per Mile of Main Track Section W	S	Ex. Crew W	S	Type of Transport-ation	Extent of Labor Saving Tools and Equipment	Remarks
Penn. Sys. (Cinn. Div.)	65	40	Medium	100 131	Gravel Rock	Yes-Part	No	Patrol Tk. W'ker	1 Time 3 Times	8.00	Yes	No	No	No	0.40	0.90	-	-	Truck Mo. Car	All kinds available on Div.	Large Gangs for special purposes.
WP	79	50	8,000	115	Rock	Yes	No	Sec. Fo. Rdmstr.	1 Time 3 Times	10.00	Yes	Yes	No	Yes	0.30	0.50	0.33	0.50	Truck Mo. Car	Sections 25% equipped	Large Gangs for heavy work

TABLE 5

NORTHERN — Railroads
SINGLE — Track Lines
BRANCH-LIGHT — Traffic

Name of Railroad	Pass.	Frt.	Tons (1000's)	Wt. of Rail	Type of Ballast	Small Ex. Gang	Large Ex. Gang	By Whom	How Often Per Week	Average Length Section (ST Mi.)	Rail Syst.	Resur. (Div)	Ties	Other Oper'tns	Section W	Section S	Ex. Crew W	Ex. Crew S	Type of Transport-ation	Extent of Labor Saving Tools and Equipment	Remarks
AC&Y	-	45	5,000	90 115	Rock	Yes	No	Sect. Gang	Work Days	8.00	No	No	No	No	0.60	0.60	-	-	Motor Car	Portable Tampers	No large Gangs.
B&M	50	30	Light	75 85	Gravel	Yes	No	Track Patr.	5 Times	9.00	No	No	No	No	0.33	0.33	0.07	0.07	Motor Car	None	Gangs combined to Lay Rail
CNR	30 50	25 40	1-3,000	80 100	Gravel	Yes	Yes	Asst. Rdmstr.	6 Times	6.50 to 9.00	Yes (Div)	Yes	No	No	0.40	0.50	-	-	Motor Car	None	Large Gangs partly mechanized
CB&Q	35	25	Light	66 110	Cinders Gravel	No	No	-	-	18.00	Yes	-	Yes	No	0.07	0.30	-	-	Motor Car	None	
CMSP&P	-	-	Light	60 90	Cinders Gravel	Yes	Yes	Sect. Fore.	as re-quired	15.00					0.07	0.07	Varies		Motor Car	None on Sections	
C&NW	45	40	1,100	80 100	Gravel	No	No	Sect. Gang	5 Times	14.50	Yes	Yes	No	No	0.12	0.18	0.00	0.06	Motor Car	Nominal	
DM&IR	55	35	Light	80	Gravel	No	No	Tk. Insp.	Daily	12.00 20.00	Yes	Yes	No	-					Motor Car	None	
ERIE	Under 40		Light			Yes	-	Tk. Supv. Sec. Fo.	Weekly	10.00 16.00	No	No	No	No	0.17	0.17			Motor Car		Heavy mtce. done by enlarged Sect. Gangs.
MeC	25	25	Light	60 to 85	Gravel	Yes	-	Tk. Patrol	5 Times	8.50	No	Yes (Dist)	No	No	0.28	0.38	Varies		Motor Car	None	Gangs combined for special work.
Soo	45	25	Light	80	Gravel	No	No	Sect. Crew	5 Times	15.00	Yes	Yes	No	No	0.15	0.30	0.00	0.50	Motor Car	Assigned as req'd.	
Mo. Pac. (Cairo Sub. Div.)	-	30	Light	80	Cinders	Yes	No	Sect. Gang.	2 Times	25.00	Yes	Yes	No	No	0.16	0.30	-	-	Motor Car	None	Extra Gang for Rail & Surf. as needed
P&LE	35	25	Light	115	Slag	No	Con-struct	Tr. Patr.	5 Times	8.29	No	No	No	No	Var-ies	0.96	0.00	0.00	Truck Mo. Car	Assigned as req'd.	Gangs combined for heavy work.
UP	40	25	Light	90 100	Gravel Cinders	No	No	Track Walker	2 Times	16.00	Yes	Yes	No	-	0.25	0.35	-	-	Motor Car		Large Gangs fully mechanized.
IC (Mattoon Evansville)	35	35	5,800	90	Gravel	Yes	No	Sect. Gang	Daily	9.00	No	No	No	-	0.50	Av.	-	-	Motor Car	Portable Tampers	

TABLE 6

SUMMARY OF REPLIES TO QUESTIONNAIRES
TRACK MAINTENANCE ORGANIZATION

(FROST-FREE)

SOUTHERN Railroad
MULTIPLE Track Lines
HEAVY Traffic

Name of Railroad	Maximum Speed Allowed Pass.	Maximum Speed Allowed Frt.	Est. Annual Gross Tons Over Track (1000's)	Wt. of Rail	Type of Ballast	Are Section Gangs Supplemented By Small Ex. Gang	Are Section Gangs Supplemented By Large Ex. Gang	Trk. Inspection By Whom	Trk. Inspection How Often Per Week	Average Length Section (ST Mi.)	Heavy Maintenance Done by Special Gangs: Rail Syst.	Resur. (Div)	Ties	Other Oper'tns	Track Laborers Per Mile of Main Track: Section W	Section S	Ex. Crew W	Ex. Crew S	Type of Transportation	Extent of Labor Saving Tools and Equipment	Remarks
AT&StFe	100	60	Heavy	132	Slag Stone	Yes	Yes	Track Supvr.	6 Times	12.00	Yes	Yes	Yes	Yes	0.50	0.67	Varies		Motor Car	Pow. Tamps. others as required	Large Gangs for heavy maintenance
ACL	90	60	Heavy	132	Stone	Yes	Partial	Rdmstr.	2 Times	16.00	Yes	Yes	No	No	0.33	0.33	0.11	0.11	Motor Car	Pow. Tamps Mowers	Large Gangs for heavy maintenance.
B&O	80	50	Heavy	140	Stone	No	Yes	Fore.	Weekly	9.50	No	Yes	No	No	0.52	0.54	0.16	0.21	Truck Mo. Car	30% equipped	Large Gangs for heavy work-supplement.
C&O (Chesa. Dist.)	75	55	36,000 to 67,000	132	Limestone	Yes	-	Sec. Fo. Lab.	As necessary	8.00 Min.	Yes				Varies		Varies		Mo. Car Truck	Little on Sec.	Lg. Gangs for heavy maintenance
GM&O	75	50	21,000	112	Gravel Stone	No	No	Supv. Sec. Fo.	2 Times 1 "	10.00	Yes	No	No	No	0.75	0.75	-	-	Motor Car	Few on District	No large gangs.
IC (Fulton to Memphis)	79	50	35,000	132	Rock	Yes	-	Supv. Fore.	Daily	14.00	No	Yes	When Surf.	-	0.85	Aver.			Motor Car	Rail & Surf. Gangs mechanized	
L&N	60	45	18,000	100 132	Gravel Stone	Yes	-	Supv. Sec. Fo.	1-3 Times Weekly	12.00	Yes	Yes	Yes	Yes	0.50	0.50	0.15	0.15	Motor Car	Machines assigned to Dist.	Ex. Gangs combined for heavy work.
Mo. Pac.	79	55	Heavy	112 132	Chat.	Yes	Yes	Rdmstr. Sec. Fo.	3 Times	12.00	Yes	Yes	Yes	Yes	0.30	0.35	0.14	0.28	Truck Mo. Car	Lg. Gangs fully equipped	
N&W	78	78	Heavy	132	Limestone	Yes	Yes	Sec. Fo.	Weekly	8.00	Yes	Yes	No	Yes	0.50	0.50	-	-	Motor Car	All can use econ.	Special Gangs for heavy work.
RF&P	70	50	21,000	131 140	Rock	Yes	No	Track Walker	2 Times	14.00	No	Yes	No	-	0.50	0.50	0.78	0.78	Truck Mo. Car	Limited amounts.	
Southern	70	60	30,000	132	Rock	Yes	-	Motor Car	2 Times	10.00 14.00	Yes (Div)	Yes	-	-	0.21	0.21	0.20	0.20	Truck Mo. Car	Fully as possible	
SP	79	50	15,000	110 132	Slag Rock	Yes	No	Fore. Tk. W'kers	Freq.	10.00	Yes (Div)	Yes	No	No	0.30	0.30			Truck Mo. Car	Fully equipped	Large Gangs for heavy maintenance
T&P	75	60	Heavy	110	Rock	No	Yes	Sec. Fo.	As Req'd.	9.00	Yes	No	No	No	0.60	0.60	-	-	Mo. Car	Few. Tampers	
Vgn.	30	30	Heavy	132	Limestone	No	No	Patr.	Daily	12.00	Yes	-	Yes	-	0.50	0.70	-	-	Truck Mo. Car	Completely equipped	Gangs combined for heavy work

TABLE 7

SUMMARY OF REPLIES TO QUESTIONNAIRES
TRACK MAINTENANCE ORGANIZATION

(FROST-FREE)

SOUTHERN Railroads
MULTIPLE Track Lines
MEDIUM Traffic

Name of Railroad	Maximum Speed Allowed Pass.	Frt.	Est. Annual Gross Tons Over Track (1000's)	Wt. of Rail	Type of Ballast	Are Section Gangs Supplemented By Small Ex.Gang	Large Ex.Gang	Trk. Inspection By Whom	How Often Per Week	Average Length Section (ST.Mi.)	Heavy Maintenance Done By Special Gangs Rail Syst.	Resur. (Div)	Ties	Other Oper'tns	Track Laborers Per Mile of Main Track Section W	S	Ex.Crew W	S	Type of Trans-portation	Extent of Labor Saving Tools and Equipment	Remarks
C. of G.	60	40	Medium	90 112	Slag Gravel	Yes		Supvr.	Weekly	18.00	Yes	-	Yes	-	0.50	0.50	-	-	Mo.Car	Fully equipped	Lg.Gangs for rail & resurfacing
FEC	79	50	Medium	115	Rock	No	No	Sect. Fore.	2 Times	14.00	Yes	No	No	-	0.40	0.40	-	-	Mo.Car	Tampers. Other Tools on Dist.	Lg. Gangs for rail & AFE work
St.L.S.F.	70	55	Medium	115	Chat	Yes	Yes	Sect. Gang	3 Times	24.00	Yes	No	No	No	0.17	0.17	0.25	0.25	Truck Mo.Car	Ex.Gangs equipped	
WM	50	40	Medium	115 132	Rock	Yes	No	Fore. Tk.W'ker	5 Times	10.00	No	No	No	No	0.50	0.50	-	-	Truck Mo.Car	Assigned to Dist.	Combine Gange for heavy work

TABLE 8

(FROST-FREE)

SOUTHERN Railroads
SINGLE Track Lines
HEAVY Traffic

Name of Railroad	Maximum Speed Allowed Pass.	Frt.	Est. Annual Gross Tons Over Track (1000's)	Wt. of Rail	Type of Ballast	Are Section Gangs Supplemented By Small Ex.Gang	Large Ex.Gang	Trk. Inspection By Whom	How Often Per Week	Average Length Section (ST.Mi.)	Heavy Maintenance Done By Special Gangs Rail Syst.	Resur. (Div)	Ties	Other Oper'tns	Track Laborers Per Mile of Main Track Section W	S	Ex.Crew W	S	Type of Trans-portation	Extent of Labor Saving Tools and Equipment	Remarks
Clinchfield	45	45	10,000 to 20,000	100 132	Lime-stone	No	Yes	Supv.	-	9.00	Yes	Yes	No	No	0.67	0.67	0.40	0.40	Motor Car	Ex.Gangs equipped	
C&O	65	50	4,000 to 41,000	115 132	Stone Gravel	Yes	Yes	Sec.Fo. Laborer	As necessary	5.00 20.00	Yes				Varies		Varies		Mo.Car Trucks	Little on Secs.	Lg.Gangs for heavy work
GM&O	60	40	21,000	85 115	Gravel Stone	No	No	Supv. Fore.	2 Times 1 "	11.00	Yes	No	No	No	0.75	0.75	-	-	Motor Car	Some on Dist.	
MKT	75	60	12,000	85 112	Chats Stone	Yes	Yes	Fore.	5 Times	8.00 9.00	Yes	Yes	No	-	0.40	0.40	Varies		Truck Mo.Car	Well equipped	Lg.Gangs only for special work.
NC&StL	70	60	Heavy	112 132	Lime-stone	Yes	No	Supv. Sec.Fo.	3 Times	8.50	Yes	Yes	Yes	-	0.66	0.66	0.00	0.70	Truck Mo.Car	None directly assigned.	
SAL	75	60	21,000	132	Stone	No	Yes	Sec.Fo.	's Req'd.	13.2	Yes	Yes	No	No	0.49	0.49	0.22	0.22	Truck Mo.Car	Portable Tampers	Lg.Gangs used for heavy maintenance.
Southern	70	55	18,000	100 132	Stone	Yes	-	Patr.	2 Times	16.00 30.00	Yes	Yes	-	-	0.20	0.20	0.15	0.15	Truck Mo.Car	Fully as possible	
T&P	75	60	Heavy	112 132	Stone	No	Yes	Sec.Fo.	As needed	8.00 12.00	Yes	Yes	No	No	0.50	0.50	None		Truck Mo.Car	Portable Tampers	Lg.Gangs fully mechanized
Vgn.	55	45	Heavy	132	Lime-Stone	No	No	Track Walker	6 Times	10.00	Yes	-	Yes	-	0.50	0.70	Varies		Truck Mo.Car	Comp. mechanized	Lg.Gangs for special work
IC(Louis-ville to Paducah)	75	50	31,000	115	Slag	Yes	-	Track Insp. Fore.	Daily	8.00 10.00	No	Yes	When Surf.	-	0.85	Aver.	Varies		Mo.Car	Rail & Surface Gangs mechanized.	

(FROST-FREE)

SOUTHERN	Railroads
SINGLE	Track Lines
MEDIUM	Traffic

TABLE 9

SUMMARY OF REPLIES TO QUESTIONNAIRES
TRACK MAINTENANCE ORGANIZATION

Name of Railroad	Maximum Speed Allowed Pass.	Frt.	Est. Annual Gross Tons Over Track (1000's)	Wt. of Rail	Type of Ballast	Are Section Gangs Supplemented By Small Ex.Gang	Large Ex.Gang	Trk.Inspection By Whom	How Often Per Week	Average Length Section (ST.Mi.)	Heavy Maintenance Done By Special Gangs Rail Syst.	Resur. (Div)	Ties	Other Oper'tns	Track Laborers Per Mile of Main Track Section W	Section S	Ex.Crew W	Ex.Crew S	Type of Trans-portation	Extent Of Labor Saving Tools and Equipment	Remarks
ATSF	90	60	Medium	115	Slag Stone	Yes	Yes	Tk.Patr.	6 Times	9.00 10.00	Yes	Yes	Yes	Yes	0.50	0.67	Varies		Motor Car	Portable Tampers	Large Gangs for heavy mtce.
ACL	59	45	Medium	100 115	Stone	Yes	-	Tk.Patr.	2 Times	16.00	Yes	Yes	No	-	0.25	0.25	0.08	0.08	Motor Car	Tampers, Mowers	
B&O	75	60	Medium	115	Gravel Stone	No	Yes	Sec.For.	1 Time	8.20	No	Yes	No	No	0.52	0.54	0.16	0.21	Truck Mo.Car	30% equipped	Lg.Gangs for special work
C.of G.	65	50 60	Medium	90 115	Gravel Slag	Yes	-	-	2 Times	17.00	Yes	Yes	Yes	-	0.33	0.33			Motor Car	Well equipped	
KCS	78	60	Medium	85 127	Chats. Slag	Yes	No	Rdmstr.	6 Times	9.00 18.00	Yes	Yes	partly	No	0.40	0.40	0.18	0.18	Motor Car	Well equipped	
L&N	60	45	Medium	100	Stone	Yes	No	Supv. Sec.Fo.	5 Times	7.50	Yes	Yes	Yes	Yes	0.40	0.50	0.06	0.06	Motor Car	Supplied fr.Div.	Div.Ex.Gangs combined for heavy mtce
MP(Colorado Div.)	70	55	Medium	115	Slag	No	Yes	Rdmstr. Sec.Fo.	3 Times	14.60	Yes	Yes	Yes	No	0.33	0.33	0.00	0.25	Motor Car	Portable Tampers	
NC&St.L	60	50	Medium	90 115	Gravel	Yes	No	Supv. Sec.Fo.	1-2 Times	12.70	Yes	Yes	No	-	0.50	0.50	0.00	0.40	Truck Mo.Car	As required.	
N&W	65	45	Medium	132	Limestone	Yes	Yes	Sec.Fo.	1 Time	7.50	Yes	Yes	No	Yes	0.50	0.50	Varies		Motor Car	All can use economically	
SAL	75	50	9,000	100	Slag Stone	No	Yes	-	As Req'd.	14.30	Yes	Yes	No	No	0.34	0.34	0.18	0.18	Truck Mo.Car	Portable Tampers	Dist.Gangs assist Sections.
SAL	75	60	8,000	100 115	Stone	No	Yes	-	As Req'd.	13.6	Yes	Yes	No	No	0.40	0.40	0.23	0.23	Truck Mo.Car	Portable Tampers	Dist.Gangs assist Sections
SLSF	70	55	Medium	115	Chats	Yes	Yes	Sec. Gang	3 Times	18.00	Yes	No	No	No	0.17	0.17	0.25	0.25	Truck Mo.Car	Extra Gang fully equipped	
SP	50	40	Medium	90 112	Gravel	No	No	Sec. Fore.	1 Time	20.00	Yes (Div)	Yes	No	No	0.20	0.20	-	-	Truck Mo.Car	Bolting Machine	Lg.Gangs for rail & resurfacing.
Vgn.	-	25	Medium	100 132	Limestone	No	No	Track Walker	6 Times	15.00	Yes	-	Yes	-	0.70	0.90	-	-	Truck Mo.Car	Completely mech.	Special Gangs for heavy work
WM	40	30	Medium	90 132	Slag Stone	Yes	Yes	Track Walker	3-5 Times	6.00 10.00	No	No	No	No	0.50	0.50	-	-	Motor Car	Assigned to Dist.	Dist.Gang assists Sections.

TABLE 10

SUMMARY OF REPLIES TO QUESTIONNAIRES
TRACK MAINTENANCE ORGANIZATION

Name of Railroad	Maximum Speed Allowed Pass.	Maximum Speed Allowed Frt.	Est. Annual Gross Tons Over Track (1000's)	Wt. of Rail	Type of Ballast	Are Section Gangs Supplemented By Small Ex.Gang	Are Section Gangs Supplemented By Large Ex.Gang	Trk. Inspection By Whom	Trk. Inspection How Often Per Week	Average Length Section (ST Mi.)	Heavy Maintenance Done by Special Gangs Rail Syst.	Heavy Maintenance Done by Special Gangs Resur. (Div)	Heavy Maintenance Done by Special Gangs Ties	Heavy Maintenance Done by Special Gangs Other Oper'tns	Track Laborers Per Mile of Main Track Section W	Track Laborers Per Mile of Main Track Section S	Track Laborers Per Mile of Main Track Ex.Crew W	Track Laborers Per Mile of Main Track Ex.Crew S	Type of Transportation	Extent of Labor Saving Tools and Equipment	Remarks
																			(FROST-FREE)		
																			SOUTHERN		Railroads
																			SINGLE		Track Lines
																			BRANCH-LIGHT		Traffic
FEC	-	45	Light	70 90	Sand Rock	No	No	Sect. Fore.	2 Times	15.00	Yes	No	No	-	0.27	0.27	-	-	Motor Car	Assigned as needed	Ex.Gang for rail laying
N&W	45	35	Light	131	Cinders	Yes	No	Sec.Fo.	1 Time	5.00 11.00	No	No	No	No	0.50	0.50	-	-	Motor Car	All can use economically.	
NYS&W	50	40	Light	80 112	Gravel Cinder	Yes	-	Sec.Fo.	5 Times	11.00	No	No	No	No	0.20	0.40	-	-			Gangs combined for heavy work.
TC	40	30	Light	80 100	Rock	No	No	Sec. Gang	6 Times	10.5	No	No	No	No	0.40	0.40	-	-	Motor Car	None	
T&P			Light	75 85	Gravel	No	As Req'd	Sec. Fore.	As needed	8.00 12.00	Yes	Yes	No	No	0.50	0.50	-	-	Truck Mo.Car	Portable Tampers	Lg.Gangs for heavy maintenance.
WP	30	25	700	75	Gravel	No	No	Sec. Fore.	1 Time	18.00	Yes	Yes	No	Yes	0.17	0.30	0.00	0.00	Motor Car	25% equipped	Gangs combined for heavy work

TABLE 11

SUMMARY OF REPLIES TO QUESTIONNAIRE

TERMINAL YARD MAINTENANCE — ORGANIZATION - MAINTENANCE OF WAY DEPARTMENT

(Yards too large to be maintained by Regular Main Line Section Gangs)

Name of Railroad	Several Small or Few Large Gangs Used?	Average Mileage Each Gang	Average Size of Gang	Is Definite Territory Assigned to Each Gang	Is Heavy Maintenance done by Special Gangs?	Inspection of Tracks	Chain of Supervision
AC&Y	Small Gangs	17.00	6 to 15 men	Yes	Not Usually	All tracks monthly. Important ones weekly	Foreman - Track Supervisor - Chief Engineer
ATSF	Small Gangs	28.00	18 "	Yes	Yes	As Required	
ACL	Small Gangs	25.00 to 40.00	5,6 "	Yes	Seldom	Roadmaster Weekly	Foreman-Roadmaster-Gen.Roadmaster-Engr.M.of W. - Chief Engineer
B&O	Small Gangs	10.00 to 20.00	7 "	Yes	No	Main Tracks, Switches Weekly	Foreman-Supervisor-Div.Engr.-Dist.Engr.Mtce. - Chief Engineer Mtee.
B&A	Small Gangs	16.00	9 "	Yes	Yes	Foreman Monthly	Foreman-Roadmaster-Gen.Roadmaster-Chief Engineer
B&M	Medium	12.70	12 "	Yes	Yes	TrackWalker Daily	Foreman-Supervisor-Div.Engr.-Engr.M.of W.-Chief Engineer
B&LE	One Large	33.00	22 "		75% Yd.Gang 25% Ex.Gang	Important Tks. - 3 times per week	Foreman-Supervisor-Engineer of Track-Chief Engineer
CNR	Several Gangs	13.00 to 22.00	7 to 18 "	Yes	Yes	None	Foreman-Roadmaster-Div. Engr.-Supt.-Dist.Engr.-Region Engr.M.of W.
CPR	Small Gangs	26.5	8 "	Yes	Yes	Foreman Daily	Foreman-Roadmaster-Div.Engr.-Dist.Engr.-Engr.M.of W.-Chief Engr.
C.of G.	Small Gangs		8 "	Yes	Yes	Limited	Foreman-Supervisor-Div.Engr.-Chief Engineer
CV	Small Gangs	13.0	7 "	Yes	Yes	Daily	Foreman-Supervisor-Gen.Roadmaster-Chief Engineer
C&O	1 Large & sev. Small Gangs	60.00	7 "	Yes	No	Daily	Foreman-Tk.Supervisor-Division Engineer-Asst.Chief Engr.-Chief Engr.
CB&Q	Small Gangs	25.00 to 40.00	6 to 10 "	Yes	Yes	Track Walkers per week 5 days	Foreman-Supervisor-Roadmaster-Dist.Engr.-Engr. Track - Chief Engineer
CMSP&P	Few Large Gangs	48.00	10 "	Yes	Yes	As Required	Fore.-Roadmaster-Div.Engr.-Supt.-Asst.Chief Engr. Sys. - Chief Engr.
CNW	Small Gangs	25.00	8 "	Yes	Yes	Foreman 5 days & Tk.W'kers per week	Foreman-Track Supvr.-Rdmster-Div.Engr.-Engr.Mtee - Chief Engineer
Clinchfield	1 Gang			Yes	Yes	Supvr. & Rdmster.	Foreman-Supervisor-Rdmster-Asst.Chief Engr.-Chief Engineer
DRGW	1 Gang	20.00 to 30.00	10 "		Occasionally	Tk.Walker Daily	
DMIR	1 Gang	5.00 to 75.00	15 to 90 "		No	Tk.Walker 3 per Wk.	Foreman - Roadmaster - Chief Engineer
Erie	Small Gangs	20.00 to 25.00	3 "		No		

SUMMARY OF REPLIES TO QUESTIONNAIRE

TABLE 11 (CONT'D) TERMINAL YARD MAINTENANCE — ORGANIZATION - MAINTENANCE OF WAY DEPARTMENT

(Yards too large to be maintained by Regular Main Line Section Gangs)

Name of Railroad	Several Small or Few Large Gangs Used?	Average Mileage Each Gang	Average Size of Gang	Is Definite Territory Assigned to Each Gang	Is Heavy Maintenance done by Special Gangs?	Inspection of Tracks	Chain of Supervision
FEC	1 Gang	25.00	14 "		No	Fore.Switches twice per week	Foreman-Supervisor-Rdmaster-Supt.-Engr.M.of W.-Chief Engineer
GTW	1 Gang	35.00	13 "		Occasionally	Tk.W'ker 3 times per week	Foreman-Supervisor-Div.Supt. - Chief Engineer
GN	Small Gangs	26.12	7 to 11 "	Yes	Occasionally	Tk.Walker Daily	Fore.-Gen.Fore.-Dist.Rdmster.-Div.Rdmster.-Engr.M.of W.-Chief Engr.
GB&W	1 Gang	20.00	10 "		No	Foreman Daily	Foreman-Rdmster.-Engr.M.of W. - Chief Engineer
CM&O	Small Gangs	24.00	10 "	1 Yes Others No	No	Foreman Twice Monthly	Foreman-Supvr. - Rdmster - Asst.Chief Engr. - Chief Engineer
IC	Small Gangs	15.00 to 20.00	4 to 10 "	Yes	No	Daily	Foreman-Supvr.-Div.Engr.-Asst.Engr.M.of W.-Engr.M.of W.-V.P.& Ch.Engr.
KCS	Small Gangs	20.00	10 "	Yes	Yes	As Required	Foreman-Roadmaster-Division Engineer-Chief Engineer
DL&W	Small Gangs	20.00	10 "	Yes	Yes	Tk.Walkers Daily	Foreman-Supervisor-Roadmaster-Engr.M.of W.-Chief Engineer
L&N	Small Gangs	20.00	6 "	Yes	Occasionally	Daily	Fore.-Supvr. - Asst.Div.Engr.-Div.Engr.-Supt.-Engr.M.of W.-Chief Engr.
MeC	1 Gang	27.00	6 "		Yes	Daily	Foreman-Supervisor-Engr.M.of W.-Chief Engineer
MKT	1 Gang	25.00	5 "	Yes	Occasionally	Switches,Daily, Body Tracks,each 10 days	Foreman-Roadmaster-Div.Engr.-Supt.-Engr.M.of W.-Gen.Mgr.-Chief Engr.
MoPac	Small Gangs	18.75	5 men	Yes	Yes	Asst.Rdmstr.Daily Switches Monthly	Foreman-Asst.Rdmstr.-Rdmstr.-Div.Engr.-Dist.Engr.-Asst.Ch.Engr. Mtce Chief Engr.
NYC	Small Gangs	35.00	12 "	Yes	Yes	Ladders,Daily Body Tks.Weekly	Foreman-Asst.Supvr.-Supvr.-Div.Engr.-District Engr. Engr.M.of W.
NH	Large Gangs	34.00	17 "	No	Yes	Ladders 5/week Other Tks.Weekly	Foreman-Asst.Supvr.-Supvr.-Div.Engr.-Chief Engineer
N&W	Small Gangs	35.00	9 "	Yes	Yes	Rdmstr.3/week Foreman Weekly	Foreman-Rdmstr.-Asst.Supt.-Supt.-Mgr. Roadway Mtce.
NYS&W	1 Gang	19.89	8 "		No	Foreman Daily	Foreman-Supvr.-Rdmstr.-Chief Engineer
NP	Small Gangs	20.00 to 35.00	8 to 20 "	Yes	No	Track Walker	Foreman-Supvr.-Rdmstr.-Div.Rdmstr.-Supt.-Gen.Mgr.
Soo	1 Gang	35.00	30 "		No	None	Foreman-Rdmstr.-Div.Engr.-Supt.-Mtce.Engr.-Gen.Supt.

TABLE 11 (CONT'D)

SUMMARY OF REPLIES TO QUESTIONNAIRE

TERMINAL YARD MAINTENANCE

(Yards too large to be maintained by Regular Main Line Section Gangs)

ORGANIZATION - MAINTENANCE OF WAY DEPARTMENT

Name of Railroad	Several Small or Few Large Gangs Used?	Average Mileage Each Gang	Average Size of Gang	Is Definite Territory Assigned to Each Gang	Is Heavy Maintenance done by Special Gangs?	Inspection of Tracks	Chain of Supervision
Penn.Sys. (Phila Term.)	Small Gangs	17.4	10 "	Yes	Yes	Reports Monthly	Foreman-Supvr.-Div.Engr.-Engr.M.Of W.-Ch.Engr.MW.-Asst.Ch.Engr.Mtce-Chief Engineer
Penn.Sys. (Enola Yd.)	Small Gangs	21.72	8 "	Yes	No	Foreman Weekly	" " " " " " " " " " "
Penn.Sys. (Maryland Division)	Small Gangs	20.00	8 "	Yes	Yes	Tk.Walker Weekly	" " " " " " " " " " "
P&LE	Small Gangs	22.00	10 "	Yes	Yes	Supv.Weekly Foreman Daily	Foreman-Asst.Supvr.-Supvr.-Engr.M.of W.-Chief Engineer
RF&P	Large Gangs	55.00	24 "	Yes	Yes	Tk.Walker Daily	Foreman-Supvr.-Div.Engr.-Chief Engineer
SAL	Small Gangs	16.7	9 "	Yes	Occasionally	Weekly	Foreman-Rdmstr.-Div.Engr.-Chief Engineer
SLSF	Small Gangs	30.00	5 "	Yes	Yes	Tk.Walker Daily	Fore.-Rdmstr.-Div.Engr.-Asst.Chief Engr.-Chief Engineer
Southern	Small Gangs	25.00 to 40.00	4 to 8 "	Yes	Yes	Supv. Monthly	Fore.-Supvr.-Div.Engr.-Chief Engr. M.W.& S.
So.Pac.	Large Gangs	20.00	6 to 20 "	No	No	Track Walker	Fore.-Rdmstr.-Div.Engr.-Div.Supt.-Engr.M.of W.-Chief Engineer
TC	1 Gang	13.00	8 "				Fore.-Rdmstr.-Div.Engr.-Chief Engineer
T&P	Small Gangs		12 to 15 "	Yes	Only for Rail Work, etc.	As needed	Fore.-Dist.Rdmstr.-Gen.Rdmstr.-Div.Supt.Asst.Ch.Engr.-Chief Engineer
UP	1 Gang	20.00 to 25.00	8 "	Yes	Only for Rail Work etc.	Tk.Walker 5 days	Fore.-Gen.Fore.-Rdmstr.-Gen.Rdmstr.-Div.Engr.-Supt.-Gen.Mgr.-Chief Engr.
Vgn	1 Gang	60.00	20 "		No	Tk.Walker Daily	Fore.-Rdmstr.-Engr.M.of W.
WM	Small Gangs	10.00 11.00	5 to 6 "	Yes	No	Tk.Walker Daily	Fore.-Supv.-Asst.Engr.-Div.Engr.-Chief Engineer
WP	1 Gang		5 to 15 "	Yes	Yes	Turnouts weekly for M.L.-Others monthly	Fore.-Rdmstr.-Div.Engr.-Supt.-Engr.M.of W.-Chief Engineer

Report on Assignment 4

Economics of Methods of Controlling Vegetation

P. A. Cosgrove (chairman, subcommittee), A. D. Alderson, J. A. Bunjer, C. G. Davis, W. H. Hamilton, K. H. Hanger, G. L. Harris, J. E. Inman, C. Johnston, W. I. King, E. H. McIlheran, H. C. Minteer, C. W. Reeve, A. G. Reese, D. E. Rudisill, J. S. Snyder, H. J. Weccheider, H. M. Williamson.

This is a progress report, presented as information.

The first phase of this subject, control of vegetation within the ballast and subgrade, was presented by the committee at the convention held in March 1952, and reported in the Proceedings, Vol. 53, 1952, page 363. This year the committee is presenting a study of the control of vegetation on the remainder of the right-of-way.

Vegetation high enough to obstruct the view near highway crossings, to interfere with communication and signal lines, or to prevent enginemen from seeing signs necessary in train movement along the right-of-way, is undesirable. In addition to presenting a fire hazard after drying, it also presents an unsightly appearance.

Chemicals have been used under bridges, from which very successful results have been reported. The first year all flammable vegetation must be scalped before chemical is applied. Thereafter very little scalping is necessary prior to the application. Application in the spring is desirable.

Responses to a questionnaire indicate that the general procedure by most railroads in controlling vegetation is hand mowing, machine mowing, and chemical weed or brush killer. In order to make full use of rubber-tired tractor mowers, many railroads have smoothed their right-of-way with bulldozers, graders, draglines and front-end loaders.

Most of this smoothing was done in connection with ditching, banking and drainage work. Very few railroads have smoothed their right-of-ways for the sole purpose of facilitating the control of vegetation, except in locations where farmers or communities force the control of noxious growths.

Some railroads with wide right-of-ways through rich farm lands, lease the ground to outsiders for cultivation purposes, thus reducing the vegetation control problem over a large portion of the railroad.

A canvass of railroads indicates that the average cost per acre of hand mowing is $58, with very little of this type of work being done. The cost of machine mowing averages $13 per acre, and its use has increased considerably. Very satisfactory results have been reported from the spraying of brush and other vegetation with chemicals, the average cost of which amounts to $23 per acre. This figure does not include the cost of clearing the right-of-way of the dead trees and brush resulting from the use of the chemicals. The application of chemicals to control vegetation under bridges is reported to be increasing rapidly. The cost is less than 1 cent per sq ft.

Conclusions

It has been found that smoothing of right-of-way to permit the use of tractor mowers is justified.

It is economical to spray brush and vegetation with chemicals. This method may be expected to be used to a greater extent in the future as the results to date have been satisfactory.

Chemical applied under bridges reduces the amount of labor required to keep the area clear of vegetation.

Report on Assignment 6

Economic Effect of Slow Orders on Maintenance Operations

T. B. Hutcheson (chairman, subcommittee), M. B. Allen, E. J. Brown, M. W. Clark, A. T. Danver, W. H. Hamilton, C. Johnston, H. W. Kellogg, W. I. King, Roy Lumpkin, J. P. Morrissey, L. F. Racine, R. B. Radkey, J. S. Snyder, E. C. Vandenburgh, J. G. West, Jr., C. R. Wright.

This is a final report, presented as information

While the committee has not previously reported in detail on this subject, it was mentioned briefly in a report contained in the Proceedings, Vol. 38, 1937, page 376, on The Effect of Higher Speed on the Labor Cost of Track Maintenance. That report dealt principally with the effect on track maintenance costs by reason of the operation of the sustained high-speed trains which had come into existence in the five years prior to 1938. The report went on to state that one of the serious obstacles to sustained high-speed operation was the placing of slow orders by track maintenance forces. At that time it was decided by the principal roads having high-speed service that it was necessary to revise their methods of doing work so as to eliminate slow orders or reduce them to the absolute minimum. Those roads made it imperative that section and bridge gangs do their work in such a way as to avoid the necessity for reducing speeds, or that such forces restore the track to condition for normal speed prior to the passage of scheduled trains. Obviously, these requirements materially increased the labor cost of track work.

At the time the 1938 report was prepared, sustained high-speed trains were operated by only a limited number of roads and the roads operating such trains had only a few sustained high-speed schedules. At the present time, practically all roads operating a large volume of passenger traffic run most of this traffic at sustained high speeds and, in addition, the speed of operation for freight trains has greatly increased. As a result, unless slow orders are used in connection with track maintenance substantial increases in the cost of this work are experienced. In addition to the loss of productive time for work on the track, the unit cost of track labor has increased materially since 1938, due to wage increases and the imposition of the shorter work week, so that the economic situation with respect to the use of slow orders has changed considerably since that time.

As an approach to the subject, your committee prepared a questionnaire which was sent to the chief maintenance officers of 72 Class I railroads throughout the United States and Canada in order to secure as wide a cross section of practice with respect to slow orders as was possible. Forty-seven roads replied to the questionnaire and, with four exceptions, all roads reported using slow orders to some extent to increase the amount of productive work for those operations which might otherwise be done without slow orders at greater cost. The four roads stating that slow orders were not used as a means to increased production pointed out slow orders were tolerated only as a matter of safety to employees and equipment, and that where at all possible their track maintenance was done in such a manner as to permit the uninterrupted movement of trains.

Maintenance Operations on Which Slow Orders Are Used

It must be recognized that there are many maintenance operations which cannot be done unless the maintenance forces do have the benefit of a slow order, except in those circumstances where it is possible to detour traffic. No investigation was made into the present practice with respect to detouring traffic in compiling information for this report, as detouring was not considered to be a part of the subject. Since many maintenance operations cannot be done on a single track or where traffic cannot be diverted, unless the maintenance forces do have the benefit of a slow order, it has been extremely difficult to differentiate between those operations where a slow order is used for increased productive work and those operations where a slow order must be used simply as a matter of safety to trains and maintenance employees. This fact was, of course, immediately recognized and mentioned by a number of the reporting roads.

In the questionnaire each road was asked to list the maintenance operations in which slow orders are used to increase production and to give the speed generally allowed in each case. The answers were compiled and there is presented below a table which lists the major maintenance operations for which slow orders are most generally used for increased production, the number of roads using slow orders for that purpose, and the average of the speeds allowed:

Maintenance Operation	*Number of Roads*	*Average of Speeds Allowed*
Rail laying	26	20 mph
Ballasting	20	20 "
Tie renewals	7	20 "
Track raising or general surfacing	21	20 "
Bridge repairs	23	15 "

Some roads report using slow orders for the purpose of increasing production for such maintenance operations as repairing frogs and switches in the track, spot surfacing, lining, regaging, renewing main-line switches, tunnel repairs, track shifting, and other miscellaneous operations. The number of roads stating that slow orders were used for these operations to increase production was small and the savings in productive time reported were usually a small percent of the time used. It should be pointed out that many roads stated that slow orders had always been used on their properties for the maintenance operations listed above, and that, in the opinion of many of these maintenance officers, the operations listed cannot be done efficiently or economically, consistent with safety, and with a proper regard for the quality of the work itself, unless done with the benefit of a slow order. This is true particularly in the case of bridge repairs and rail laying operations, and while it is conceded that the use of the slow order materially increases the production on such projects, the safety of train operation is the principal factor and the increased production is in the nature of a dividend.

Effect of Slow Orders on Train Operations

All roads reporting are fully mindful of the adverse effect of maintenance-of-way slow orders on train operations, particularly as they affect high-speed passenger trains. To minimize the effect of slow orders, the general practice on all of the roads reporting is to schedule maintenance operations which will require the use of slow orders in such a manner so that, where practicable, there will be only one maintenance slow order at a time on an operating district. It is not a general practice to provide in schedules of high-speed trains for time lost by reason of maintenance-of-way slow orders, and such time lost must be recovered within the schedule limitations of the train. The general requirement is that maintenance-of-way slow orders be issued to all trains operating over the district; however, four of the roads reporting exempt certain high-speed passenger trains from the slow order. Maintenance of way forces, informed of this fact, are required to have the track in readiness for the passage of these particular trains. One road reports that time freights are occasionally exempt from maintenance slow orders. Two Western roads follow a practice of allowing somewhat higher speeds for selected trains than are allowed for other trains operating over the slow order.

In addition to the slow order, it is the general practice to use flagmen to protect the point at which maintenance operations are under way, particularly when on-track equipment is in use; however, on some roads flagmen are not used even when on-track equipment is present. It is interesting to note that on five roads train orders are not used for the issuance of slow orders, the situation being protected with speed signs or train bulletins. The general practice is to use train orders and, in addition, to place restrictive speed signs at the point of work.

Economic Factors

It is not possible, from the information received from the replying roads, to give a representative figure for the percentage of productive man-hours saved by the use of slow orders since that figure is dependent upon many varying factors surrounding each operation. These factors include the size of the maintenance of way force, the frequency and spacing of trains operated over the territory during the work period, the type of operation under way, the length of trains operated over the slow order, and other conditions of a local nature.

In the case of rail laying, there are many justifiable reasons for the use of a slow order which, in the opinion of most maintenance and operating officers, are paramount to sustained high-speed operation of trains. These include loss of productive time, which is estimated to be not less than 25 min per train for the entire maintenance of way force, in addition to the time required if a slow order is used; the damage which is likely to occur to the rail if operated over a high speed before the necessary smoothing is done; the safety of train operation and the safety of maintenance forces. For these reasons it is the general practice to lay rail with the benefit of a slow order.

The same factors of safety and economy surrounding rail laying operations are applicable in the case of ballasting, particularly if the ballasting operation involves complete cleaning of the cribs.

Only a few roads at the present time report using slow orders in tie renewal operations. These roads are those which have extensive tie renewal programs under way and are using large tie gangs. Such roads indicate increases of 8 to 10 percent in productive time through the use of a slow order.

In light track raising or general surfacing operations where the raise is on the order of 2½ in or less, and where cribbing is not done in connection with the work, it is possible to increase the production of the gang substantially and improve the quality of the finished work if a slow order is used. When used, it is not necessary to make frequent run-offs for the passing of trains, which will result in a more uniform final surface and, based on replies received, will also result in savings of productive time of not less than 15 min per train, and substantially more under some circumstances.

After carefully considering the replies received with respect to increased production by reason of the use of slow orders for bridge repairs, it is evident that most maintenance officers feel that this work should not be undertaken without the benefit of a slow order, and that work under way on bridges should be protected with flagmen, not only for the safety of train operation, but also for the safety of the maintenance employees involved. It is obvious that if it were necessary to keep the bridge in condition for the normal speed of each train, in many instances unreasonably high costs would be incurred, and that for some types of bridge work it would not be possible to keep the track in condition for normal speed, regardless of cost.

Conclusion

In view of present speeds of both passenger and freight trains, and based on replies received from many chief maintenance officers, it is not considered practicable to perform many heavy maintenance operations unless the maintenance forces have the benefit of a slow order, not only from the standpoint of the present high unit cost of labor, but also from the standpoint of safety to train operations and to maintenance forces. These factors make it highly desirable that such work be carried out with slow order protection.

Report on Assignment 7

Comparative Labor Economy in Maintaining Various Types of Railway–Highway Grade Crossings

Collaborating with Committee 9—Highways

M. H. Dick (chairman, subcommittee), L. C. Gilbert, H. C. Archibald, B. V. Bodie, E. J. Brown, F. G. Campbell, G. E. Chambers, P. A. Cosgrove, G. W. Hunt, W. I. King, Roy Lumpkin, W. H. Miesse, H. C. Minteer, C. R. Montgomery, J. P. Morrissey, G. M. O'Rourke, A. G. Reese, H. M. Williamson.

This is a final report, submitted as information.

In undertaking its study of this subject your committee recognized that the amount of labor required to maintain the various types of grade crossings is, when considered alone, of little significance. It is conceivable that a type of grade crossing having the lowest maintenance cost, in terms of man-hours, would be the most expensive if all elements of the cost are taken into consideration. Hence, to determine the overall cost of each of the various types it is necessary to give weight to other factors, such as the initial cost of construction and the service life.

For this reason, the committee decided to include in its study, in addition to maintenance costs, such other factors as would enable it to arrive at approximate figures showing the overall annual costs of the various types of grade crossings. For the purpose of this investigation the committee divided grade crossings into nine different types as follows: (1) Plank (untreated), (2) plank (treated), (3) prefabricated treated wood, (4) bituminous (without flangeways), (5) bituminous (with flangeways), (6) precast concrete slabs, (7) metal—rolled or cast, (8) metal—grating type, and (9) solid rail type.

A questionnaire was prepared and sent to 58 railroads. This questionnaire listed the types of crossings, with the request that, for each of the types in use, information be furnished giving the present-day initial cost of construction per square yard, the estimated service life in years, and the annual cost of maintenance in man-hours per square yard. The railroads were also asked to indicate, for each type of crossing, whether the highway and railway traffic was light, medium or heavy, and to indicate the maximum speed of both types of traffic. It was stipulated that the figures giving the initial cost of construction should be predicated on only the cost of the work done above the tops of the ties, unless the crossing was of a character that required a special foundation, in which event the cost of the foundation was to be included. The cost of work to improve the drainage was not to be included. Recognizing that very few railroads would have actual figures to fill out the questionnaire, it was stated that estimates would be acceptable.

Answers to the questionnaire were received from 31 railroads, most of which submitted information regarding two or more types of crossings, although no one railroad provided information on more than five types. Only one railroad furnished information on type 7 (metal—rolled or cast); only three included information on type 8 (metal—grating type); and only two gave information on type 9 (solid rail type).

Untreated Plank

Seven railroads furnished information for type 1—plank (untreated). Among these railroads the range in the figures giving the initial cost per square yard was relatively narrow, being from $4.10 to $9. The range in estimated service life was from 4 to 12 years. The road reporting a service life of 4 years said that this was on the basis of medium highway and railroad traffic and maximum speeds of 60 mph for railroad traffic and 40 mph for highway traffic. The road giving an estimated service life of 12 years said that this was based on heavy highway and railroad traffic and maximum railroad and highway speeds of 80 mph and 50 mph, respectively. The figures furnished on the annual cost of maintaining untreated plank crossings ranged from 0.7 man-hours to 4 man-hours per square yard. It is interesting to note that these extremes were reported for almost identical conditions of highway and railway traffic, both as to volume and speed.

The committee recognizes that the use of averages under such circumstances, especially where there is a considerable range between the extremes, is of little value. However, it was felt that averages of the figures obtained, rough as they may be, provided the only available means for making comparisons between the various types of crossings under study.

For the seven railroads furnishing figures on untreated plank crossings, the average initial cost of construction per square yard was $6.72; the average estimated service life was 6.11 years; and the average annual cost of maintenance was $3.12 per sq yd (the labor cost being figured at the rate of $1.50 per hr). When the average cost of construction per square yard is prorated over the service life, and the average annual cost of maintenance is added, it is found that the average annual cost of crossings of this type on the seven railroads reporting is $4.24 per sq yd. If interest on the investment at 5 percent is added, the cost becomes $4.58.

Treated Plank

A total of eight railroads provided figures on type 2—plank (treated). For this type the range in initial cost was from $5.90 to $19 per sq yd, the range in estimated service life was 6 to 20 years, and the range in cost of maintenance was ½ to 4 man-hours per square yard per year. The averages were $11.51 for the initial cost per square yard; 9.37 years for the service life; and $2.43 for the annual cost of maintenance per square yard. These figures give an annual cost of $3.66 per sq yd, or $4.24 including interest. Answers to the questionnaire indicated that most of the crossings included in this group were subjected to medium highway and railway traffic and relatively high speeds on both railroads and highways.

Prefabricated Treated Wood

Thirteen railroads provided figures on type 3 (prefabricated treated wood crossings). In this group the range in initial cost was from $15.58 to $35.00 per sq yd, the range in estimated service life was 3 to 25 years, and the range in the cost of maintenance was ¼ to 2.8 man-hours per square yard per year. It is interesting to note here that the lowest initial cost and the shortest estimated service life were reported by the same railroad, and that, on the other hand, the highest initial cost and the longest service life were also reported by the same railroad, this possibly being an indication of the fact that the standard of construction is a factor in determining the service life. It is also interesting to note that the road reporting the highest initial cost and the longest service life stated that only ½ man-hour per sq yd was required for maintenance per year, whereas the railroad reporting the lowest initial cost and the shortest service life said that the maintenance requirements amounted to 2 man-hours per sq yd per year.

For the 13 railroads giving figures on type 3, the average initial cost of construction was $23.20 per sq yd, the average service life was 13 years, and the average cost of maintenance labor was $1.92 per sq yd per year. These give a total annual cost of $3.71 per sq yd, or $4.87 including interest, for this type of crossing.

Bituminous (Without Flangeways)

Information on type 4—bituminous (without flangeways)—was submitted by 19 roads. For this type of crossing the figures on initial cost ranged from $2.50 to $18 per sq yd, those for service life ranged from 1½ to 10 years, and those for maintenance ranged from ½ to 3 man-hours per square yard per year. The road reporting $2.50 per sq yd for the initial cost said that this figure applied at locations where railway and highway traffic is light and where the maximum speed for both types of traffic is 30 mph. On the road that reported $18 per sq yd as the initial cost the crossings are subjected to medium railroad and highway traffic and maximum speeds of 60 mph and 40 mph for railroad and highway traffic, respectively. In both cases the estimated service life was five years, and the maintenance man-hours per square yard per year amounted to ⅓ for the low-cost crossing and ½ for the high-cost crossing.

The averages for the 19 railroads reporting on type 4 were $6.75 per sq yd for the initial cost; 5.72 years for the service life; and $1.92 per sq yd per year for maintenance. On the basis of these figures the total annual cost is $3.10 per sq yd, or $3.44 including interest.

Bituminous (With Flangeways)

Twenty-two railroads furnished figures on type 5—bituminous (with flangeways). The figures provided by these roads showed a range from $4.36 to $20 per sq yd for the initial construction cost, from 3 to 20 years for the estimated service life, and from "negligible" to 5 man-hours per square yard per year for maintenance. On the railroad that reported the cost of $4.36 per sq yd the estimated service life was 3 years, and on the road reporting an initial cost of $20 per sq yd the estimated service life was 7 years. Medium highway and railroad traffic was reported in both cases.

The average figures for the 22 roads reporting on type 5 were as follows: $9.75 per sq yd for the initial cost; 9 years for the service life; and $2.32 per square yard per year for maintenance labor. On the basis of these figures the total annual cost of crossings of this type is $3.40 per sq yd, or $3.89 including interest.

Precast Concrete Slabs

Figures for type 6 (precast concrete slabs) were reported by five railroads. These figures showed a range in initial cost from $15 to $48.30 per sq yd, from 6 to 25 years for the estimated service life, and from 0.07 to 2 man-hours per square yard per year for maintenance. It is interesting to note that practically identical railway and highway traffic, as regards both volume and speed, was reported for the crossings in this group with the shortest and longest estimated service life. The average initial cost for this group was $19.34 per sq yd; the average service life was 15.20 years; and the average cost of maintenance per square yard per year was $2.10. These figures give a total annual cost for this type of crossing of $3.37 per sq yd, or $4.34 including interest.

Other Types

The information obtained on types 7, 8 and 9 was not considered sufficiently representative to justify presenting the averages. However, it may be interesting to reproduce here the cost figures furnished by one of the three roads giving data on metal grating type crossings (type 8). This road apparently has had considerable experience with crossings of this type. It submitted figures on three different types of installations. One of these was a single-track installation, extending to the ends of the cross ties only and with no special outside foundation. It was estimated to have an initial cost of construction of $109.33 per sq yd. A similar crossing, designed for double-track locations and with an inter-track grating, was estimated to have an initial cost of $98.93 per sq yd. The third type, for double-track and with inter-track grating and grating — approach sections with concrete foundations, had a reported cost of $100.75. All three of these types, which are subjected to relatively high railroad and highway speeds, are estimated to have service lives of 25 years and to require only ¼ man-hour per square yard per year for maintenance. On the basis of these figures the total annual cost of the crossing having an initial cost of $109.33 per sq yd is $4.77 per sq yd, or $10.24 including interest. For the double-track crossing with the estimated initial cost of $98.93 per sq yd the total annual cost is $4.33, or $9.26 including interest.

As stated, only two roads furnished figures pertaining to solid rail type crossings. The figures submitted by these two roads showed considerable variation. One of them reported that the initial cost of crossings of this type was $24.75 per sq yd; that the estimated service life was 15 years; and that the maintenance requirements per year per square yard amounted to 8 man-hours. On the other hand, the other road said that the initial cost was $17 per sq yd, that the estimated service life was 25 years, and that only 1½ man-hours per sq yd per year were required for maintenance.

The figures given in the foregoing are revealing in the wide ranges shown, between different railroads, in the cost of construction, the estimated service life, and the labor requirements for maintenance for crossings of the same type. To a certain extent the reasons for these variations are not difficult to understand. Differences in construction standards for the same types are an obvious reason for variations in the initial cost. Methods vary for determining the service life, which, to a large extent, is a matter of judgment. Since few railroads keep cost figures on the maintenance of grade crossings, this factor is also largely a matter of judgment.

All these factors must be taken into consideration in any use of the figures given in this report. However, as a matter of interest, and by way of summarizing the results, the average figures for maintenance in terms of man-hours per square yard per year for the different types of crossings, starting with the most economical, are as follows: Prefabricated treated wood—1.28; bituminous (without flangeways)—1.28; precast concrete slabs—1.40; bituminous (with flangeways)—1.55; plank (treated)—1.62; and plank (untreated)—2.10. On the same basis the total average cost per square yard per year, including interest, is as follows: Bituminous (without flangeways)—$3.44; bituminous (with flangeways)—$3.89; plank (treated)—$4.24; precast concrete slabs—$4.34; plank (untreated)—$4.58; and prefabricated treated wood—$4.87.

Conclusion

There is a need for more accurate information on the cost of different types of grade crossings. The only way that such information can be made available is for individual roads to make careful cost studies of different types of construction under strictly comparable conditions of railway and highway traffic. All elements of the cost should, of course, be included in such studies.

Report of Committee 8—Masonry

W. R. Wilson, *Chairman,*
M. W. Bruns
J. R. Burkey
W. F. Campbell
L. T. Casson
H. C. Charlton
C. C. Cooke
G. H. Dayett
D. H. Dowe
L. P. Drew
T. K. Dyer
W. J. Eney
J. A. Erskine
J. U. Estes
A. B. Fowler
C. W. Gabrio
W. J. Galloway
R. W. Gilmore
J. F. Halpin
J. S. Hancock
R. Hayes
D. E. Hoeffel
A. C. Johnson
J. E. Kalinka
A. P. Kouba
A. N. Laird
J. F. Leppman
W. C. Love
R. F. M. Marshall
R. L. Mays
W. L. McDaniel
E. A. McLeod
L. M. Morris
M. Nearing
L. H. Needham
Roscoe Owen
D. B. Packard, Jr.
G. H. Paris
Donald Patterson
R. E. Paulson
M. S. Norris,
Vice Chairman,
R. B. Peck
C. B. Porter
H. Posner
W. T. Richards
J. L. Rippey
J. H. Sawyer, Jr.
C. P. Schantz
C. M. Segraves
J. H. Shieber
D. H. Shoemaker
Ralph Smillie
F. R. Smith
L. Spalding*
Neil Van Eenam
K. J. Wagoner
C. A. Whipple
W. Wilbur
E. P. Wright
Committee

* Died August 8, 1952.

To the American Railway Engineering Association:

Your committee reports on the following subjects:

7. Methods for improving the quality of concrete and mortars, collaborating with Committee 6.

   Final report on reapproval, with revisions, of Specifications for Concrete and Reinforced Concrete Railroad Bridges and other Structures, submitted for adoption and publication in the Manual .... page 819

   Recommendation for deletion of Standard Specifications for Portland Cement, submitted for adoption .... page 821

8. Specifications for the construction and maintenance of masonry structures.

   Recommendations with respect to Specifications for Stone Masonry, submitted for adoption .... page 821

9. Means of conserving labor and materials, including the adaptation of substitute non-critical materials, and specifications for the reclamation of released materials, tools and equipment, collaborating with Committee 3–A, General Reclamation, Purchases and Stores Division, AAR.

   No report.

THE COMMITTEE ON MASONRY,
W. R. WILSON, *Chairman*.

AREA Bulletin 505, December 1952.

MEMOIR

Lawrence Spalding

Lawrence Spalding, principal assistant engineer, Bessemer & Lake Erie Railroad, Greenville, Pa., died on August 8, 1952. He was born in Yonkers, N. Y., on July 25, 1890, the son of Lawrence and Elizabeth Hill Spalding. On April 20, 1920, he married Lillian Cartwright who survives him.

Mr. Spalding was graduated from Cornell University in 1913 with the degree in Civil Engineering. Upon graduation he began his engineering career as a draftsman with the Pittsburgh, Shawmut & Northern Railroad, at Angelica, N. Y. In April 1914 he entered the service of the Bessemer & Lake Erie as chainman and draftsman. Through honest and diligent work he was promoted periodically until he attained the position he held at the time of his death. On March 1, 1916, he was appointed supervisor of structures. He was promoted to assistant valuation engineer, November 1, 1919, valuation engineer, April 16, 1924, and principal assistant engineer, August 1, 1947. In addition to his duties as principal assistant engineer, he was a director of the railroad company.

Mr. Spalding joined the American Railway Engineering Association in 1920. He became a member of Committee 8—Masonry, in 1948, and always gave freely of his time and effort to further the work of the committee.

He was a member of St. Clement's Episcopal Church, where he served as vestryman and senior warden. His club affiliations were with the Greenville Country Club and Greenville Lodge No. 145, BPOE. He contributed much toward the betterment of the municipal authority of the Borough of Greenville, and at one time was its president.

Mr. Spalding typified the highest ideals of the engineering profession and will be missed by his friends. Therefore, Committee 8—Masonry, of the American Railway Engineering Association, presents this memorial to Lawrence Spalding as an expression of its profound sorrow in his passing.

Report on Assignment 1

Revision of Manual

A. C. Johnson (chairman, subcommittee), M. S. Norris, R. W. Gilmore, R. L. Mays, M. Nearing, R. E. Paulson, R. B. Peck, D. H. Shoemaker.

Since the revision of the Manual constituted a large part of the work of your committee, this work was assigned to the proper subcommittees which prepared the necessary revisions with the assistance of Subcommittee 1.

The recommendations of the committee with respect to the Manual are, therefore, presented in the following reports on Assignments 2, 3, 4, 5, 6, 7 and 8.

Report on Assignment 2

Principles of Design of Masonry Structures, Including Design of Masonry Culverts

Collaborating with Committees 1, 5, 6, 7, 13, 15, 28, 29 and 30

R. L. Mays (chairman, subcommittee), H. C. Charlton, W. J. Eney, J. U. Estes, J. E. Kalinka, A. P. Kouba, A. N. Laird, J. F. Leppman, W. L. McDaniels, Donald Patterson, J. H. Shieber.

Your committee submits the following report recommending the adoption of revisions and additions to certain material now in the Manual, and the withdrawal of certain other material from the Manual.

Pages 8–1 to 8–26, incl.

SPECIFICATIONS FOR CONCRETE AND REINFORCED CONCRETE RAILROAD BRIDGES AND OTHER STRUCTURES

Page 8–5. Art. 121. Quality

Delete the first sentence and replace with the following:

All steel reinforcing bars carrying calculated stresses shall be of structural or intermediate grade billet steel, except that bars made of rail or axle steel may be used only if directed by the chief engineer. Bars made of rail or axle steel may be used in structures where all of the bars used carry only temperature stresses.

To provide for the use of deformed bars as now manufactured, add the following to the paragraph on Bars:

Specification for Minimum Requirements for Deformation of Deformed Steel Bars for Concrete Reinforcement ....A 305.

Page 8–5. Art. 122. Deformed Bars.

Delete present material and substitute the following:

Deformed bars shall be manufactured in accordance with ASTM Specifications.

Page 8–6. Art. 123. Size of Bars

In order to conform to practices now generally used, delete the material under the table "Sizes and Areas of Reinforcing Bars," and substitute the following:

SIZES AND AREAS OF REINFORCING BARS

Dimensions are for Round Sections

*Bar Number	Nominal Diameter Inches	Cross-Sectional Area Square Inches	Perimeter Inches	Weight Pounds per Foot
2	0.250	0.05	0.786	0.167
3	0.375	0.11	1.178	0.376
4	0.500	0.20	1.571	0.668
5	0.625	0.31	1.963	1.043
6	0.750	0.44	2.356	1.502
7	0.875	0.60	2.749	2.044
8	1.000	0.79	3.142	2.670
9	1.128	1.00	3.544	3.400
10	1.270	1.27	3.990	4.303
11	1.410	1.56	4.430	5.313

* Bar numbers denote nominal diameters of round bars in eighths of an inch.

Pages 8–35 to 8–67, incl.

SPECIFICATIONS FOR DESIGN OF PLAIN AND REINFORCED CONCRETE MEMBERS

Reapprove with the following revisions.

Page 8–36. Sec. C, Art. 2. Dead Load

Add to the fifth line the following words "—200 lb per lin ft of track" and delete the sixth line.

Page 8–36. Sec. C, Art. 3. Live Load

Delete the special loading of two 90,000-lb axle loads spaced 7 ft apart from Cooper E 72 Axle Load Diagram.

Pages 8–39 and 8–40. Sec. D. Art. 2. Concrete

As a result of your committee's recommendation that ASTM Specification A 305 be adopted for the manufacture of deformed bars, it also recommends that the unit stresses be revised upward, as follows, for flexure in concrete, shear and bond, in order to take full advantage of the deformations of bars furnished under this specification:

First line under Flexure f_c, increase the value f'_c, extreme fiber stress in compression from 0.40 f'_c to 0.45 f'_c.

Delete the second and third lines reading—Extreme fiber stress in compression in continuous beams adjoining supports ....0.45 f'_c.

Delete all the material in statements on Shear v and Bond u and substitute the following:

Description	*For Any Strength of Concrete*	*Maximum Value, Psi*
SHEAR: v (as a measure of diagonal tension)		
Beams with no web reinforcement	$0.03f'_c$	
Beams with properly designed web reinforcement	$0.10f'_c$	
Isolated footings where shear is calculated by formula (2), Sec. F, Art. 2, on critical section (See Sec. I, Art. 3), shall not exceed $0.03f'_c$, nor in any case shall it exceed 75 psi.		
BOND: u		
DEFORMED BARS (Except top bars)		
Straight or hooked		
In beams, slabs, one-way footings, and as stirrups	$0.08f'_c$	280
In two-way footings	$0.065f'_c$	227

PLAIN BARS (Except top bars)		
In beams, slabs, one-way footings, and as stirrups (Must have hooked ends)	$0.045f'_c$	158
In two-way footings (Must have hooked ends)	$0.036f'_c$	126
TOP BARS		
Bars near the top of beams and girders having more than 12 in of concrete under the bars		
Deformed bars	$0.055f'_c$	192
Plain bars (Must have hooked ends)	$0.03f'_c$	105

Page 8–43. Sec. F, Art. 1. Notation. Place a period after the word "concrete" in the fourteenth line and delete the remainder of the sentence.

Page 8–43. Sec. F, Art. 2. Shearing Unit Stress. Delete the last paragraph.

Page 8–43. Sec. F, Art. 4. Stirrups. Correct formula (3), changing sub $_s$ to s, making formula read: $A_v = \frac{V's}{f_w jd}$.

Page 8–44. Sec. F, Art. 5. Bent Bars. Correct formula (5), changing sub $_s$ to s, making formula read: $A_v = \frac{V's}{f_w jd\,(\sin\alpha + \cos\alpha)}$

Page 8–45. Sec. G, Art. 4. Special Anchorage Requirements. Delete this article and renumber following articles of this section.

Page 8–46. Sec. G, Art. 5. Anchorage of Web Reinforcement. In fifth, twenty-eighth, thirty-fourth, and forty-third lines on page 8–46, change $0.04f'_c$ to $0.045f'_c$ and $0.05f'_c$ to $0.08f'_c$.

Page 8–47. Sec. G, Art. 6. Anchorage of Bars in Footing Slabs. Change first word "All" in first line to "Plain". In the second line, after the word "hooks", insert the following words "and the ends of deformed bars".

Page 8–48, Sec. H, Art. 2. Spirally Reinforced Columns. Under Longitudinal Reinforcement, fourth line, delete the word "round" and add a period after "bars". Delete the remaining part of the fourth line.

Under Splices in Longitudinal Reinforcement, second line, place a comma after the word "steel" and delete the following words in the third line "and 24 diameters for bars of." In the sixth line change "25 percent" to "75 percent." In the ninth and tenth lines delete the words "in cases where the bar size equals or exceeds 1⅛ in." and substitute therefor: "for No. 10 and No. 11 bars."

Page 8–49. Sec. H, Art. 2. In the eighth line from top of page change "¼ in." to "No. 2." In the ninth line from top of page change "⅜ in." to "No. 3."

Page 8–49. Sec. H, Art. 3. Tied Columns. Under Longitudinal Reinforcement in second line change the word "diameter" to "size." In same line change "⅝ in." to "No. 5."

Under Laterial Ties in first line delete the words "¼ in. in diameter" and substitute therefor "No. 2 bars."

Page 8–52.2. Sec. H, Art. 11. Reinforced Concrete Bearing Walls. In the eighteenth line from top of page delete the words "½-in. round" and substitute therefor, "No. 4."

Pages 8–53 to 8–56, incl.

309. DESIGN OF GIRDERLESS FLAT SLAB STRUCTURES FOR RAILROAD LOCOMOTIVE LOADINGS

All of the material under this heading is obsolete and it is recommended that it be withdrawn from the Manual, along with the diagrams on page 8–81.

Pages 8–59 to 8–67, incl.

312. DESIGN OF REINFORCED CONCRETE ARCHES FOR RAILROAD LOADING

Portions of this material are now out of date and since modern textbooks offer better solutions for design, the following is recommended:

Withdraw all material under Art. 9. Notations and Symbols.

Delete the words "and Formulas" in heading of Art. 10.

Withdraw material under center heading "Formulas for Thrust, Shear and Moment" near bottom of page 8-61 down to Art. 11.

Pages 8–73.1 to 8–74, incl.

SPECIFICATIONS FOR RIGID FRAME CONCRETE BRIDGES

Page 8–73.6. Art. 7. Unit Stresses. Reapprove with the following change:

In second line place a period after the letters "AREA" and delete the remaining part of paragraph.

Pages 8–76 to 8–80, incl.

APPENDIX A. PLAIN AND REINFORCED CONCRETE

Reapprove with the following revisions.

Correct inverted diagram shown as Fig. 820, Nomenclature for Reinforced Concrete T-Beam.

Fig. 821. Delete the words ";Principal Longitudinal Bars Without Special Anchorage" and substitute therefor: "Without Web Reinforcement." Also change the value for allowable shear from $0.02f'_c$ to $0.03f'_c$.

Delete Fig. 822.

Fig. 823. Delete the following words and semicolon in first line, "Without Special Anchorage;" and add the word "With" following the word "Beam."

Fig. 825. Change caption to read, "Typical Reinforced Concrete Beam With Vertical Stirrups."

Fig. 827. Change diagram to show straight bar in bottom of beam by removing hook. Change the value of v following the word "exceed" from $0.02f'_c$ to $0.03f'_c$.

Fig. 828. Delete the words "With Special Anchorages" and add a period after the word "Beams."

Pages 8–90.7 and 8–90.8

SPECIFICATIONS FOR REINFORCED CONCRETE CULVERT PIPE

It is recommended that the material under this specification be withdrawn in view of the fact that it is inadequate, and also in view of the new specifications which are now being prepared and which will be recommended for approval next year.

Pages 8–123 to 8–127, incl.

SPECIFICATIONS FOR THE PLACEMENT OF CONCRETE CULVERT PIPE

Reapprove without change pending the preparation of a revised specification.

SPECIFICATIONS FOR REINFORCED CONCRETE CULVERT PIPE

Your committee also submits the following progress report on the preparation of Specification for Reinforced Concrete Culvert Pipe.

In connection with the preparation of this specification, 24 pieces of full-size concrete pipe were tested ranging in size from 24 in to 84 in. in diameter. The test specimens were manufactured by the Massey Concrete Products Company and the funds for the manufacture of the pipe were provided by the AAR. The testing machine and facilities were provided, without cost, by the Chesapeake & Ohio Railway at its Huntington, W. Va., laboratory, where the tests were made in the early part of 1952, under the direction of the AAR research staff. The pipe was standard reinforced concrete pipe and extra-strength reinforced concrete pipe, manufactured in accordance with the proposed specifications. The pipe specimens were tested to destruction. Strain gages, located at appropriate places to determine the actual stress in the concrete and steel reinforcing while the pipe was under load, were used.

It is the intention of your committee to have tests made on 12 additional pieces of pipe, in diameters ranging from 36 in to 84 in, during the latter part of 1952 or early part of 1953. This pipe will be manufactured with 4500-lb concrete, maximum. When all tests have been completed, the information made available will be used in preparing the final draft of the proposed specifications, which should be completed in 1953.

Subcommittee 3

Foundations for Masonry Structures

Collaborating with Committees 1, 6, 7, 15 and 30

M. Nearing (chairman, subcommittee), J. R. Burkey, G. H. Dayett, Roscoe Owen, L. Spalding, K. J. Wagoner, E. P. Wright.

Pages 8–91 to 8–93, incl.

GENERAL SPECIFICATIONS FOR SUBSTRUCTURES OF RAILWAY STRUCTURES

Your committee recommends that these specifications be withdrawn.

Report on Assignment 4

Earth Pressure as Related to Masonry Structures

R. B. Peck (chairman, subcommittee), L. P. Drew, J. A. Erskine, E. A. McLeod, H. Posner, W. Wilbur.

In 1951 your committee presented as information a tentative draft of Specifications for Design of Retaining Walls and Abutments. (Proceedings, Vol. 52, 1951, pages 384 to 393, incl.), requesting comments and criticisms thereon. These specifications, with additions and revisions, are now submitted in the following with the recommendation that they be adopted and published in the Manual, and that the material which they will replace, Secs. 310—Design of Retaining Walls, and 311—Design of Reinforced Concrete Retaining Walls, pages 8–56 to 8–59, incl., and Appendix B—Retaining Walls, pages 8–82 to 8–86 incl., be withdrawn.

SPECIFICATIONS FOR DESIGN OF RETAINING WALLS AND ABUTMENTS

A. DEFINITIONS

1. Types of Retaining Walls and Abutments

A retaining wall is a structure used to provide lateral support for a mass of soil which, in turn, may provide vertical support for loads acting on or within the soil mass.

The principal types of retaining walls are as follows:

a. The gravity wall, which is so proportioned that no reinforcement other than temperature steel is required.

b. The semi-gravity wall, which is so proportioned that some steel reinforcement is required along the back and along the lower side of the toe.

c. The cantilever wall, which has a cross section resembling an L or an inverted T, and which requires extensive steel reinforcement.

d. The counterfort wall, which consists of a reinforced vertical face slab supported laterally at intervals by vertical reinforced counterforts extending into the backfill, and supported by a reinforced base slab which usually projects in front of the face slab to form a toe.

e. The buttress wall, which is similar to the counterfort wall except that the vertical members, called buttresses, are exposed on the face of the wall rather than buried in the backfill.

f. The crib wall, which consists of an earth-filled assembly of individual structural units, and which relies for its stability on the weight and strength of the earth fill. The design of such walls is treated in the AREA Specifications for Crib Walls, Part 8, this Chapter.

An abutment commonly consists of a retaining wall that incorporates a bridge seat in its face. It may also be of the spill-through type, however, in which the bridge seat rests on horizontal beams supported by piles or columns between which the fill is permitted to extend.

B. INFORMATION REQUIRED

1. Field Survey

Sufficient information shall be furnished, in the form of a profile and cross sections or a topographic map, to determine the structural requirements. Present grades and alinements of tracks and roads shall be indicated, together with the records of high water, low water, and depth of scour, the location of underground utilities, and information concerning any structures that may affect or be affected by the construction.

2. Controlling Dimensions

Information shall be assembled concerning clearances, proposed grades of tracks and roads, and all other factors that may influence the limiting dimensions of the proposed structure.

3. Loads

Loads to be superimposed either on the wall or abutment, or on the backfill, shall be indicated.

4. Character of Backfill

Backfill is defined as all material behind the wall, whether undisturbed ground or fill, that contributes to the pressure against the wall.

The backfill shall be investigated and classified with reference to the following soil types:

TYPES OF BACKFILL FOR RETAINING WALLS

Type

1. Coarse-grained soil without admixture of fine soil particles, very free-draining (clean sand, gravel or broken stone).
2. Coarse-grained soil of low permeability due to admixture of particles of silt size.
3. Fine silty sand; granular materials with conspicuous clay content; or residual soil with stones.
4. Soft or very soft clay; organic silt; or soft silty clay.
5. Medium or stiff clay that may be placed in such a way that a negligible amount of water will enter the spaces between the chunks during floods or heavy rains,

5. Character of Foundation

The character of the foundation shall be determined by means of test pits, auger borings or core borings, of a type and to an extent consistent with the magnitude of the project.

If the subsoil is essentially sandy or gravelly in character, the groundwater level shall be ascertained. In addition, the relative density of the material shall be investigated, preferably by means of penetration tests or static load tests. The penetration test shall consist of driving a sampling spoon (2-in O.D.; 1⅜-in I.D.) into the material by means of a weight of 140 lb falling through a distance of 30 in. The relative density is measured by the number of blows N required to obtain a penetration of 1 ft.

If the subsoil consists of clay, it is advisable to obtain intact specimens suitable for determination of the unconfined compressive strength. In the absence of such samples, the consistency of the clay shall be described in the following terms:

CONSISTENCY OF CLAY

Consistency	*Field Identification*	*Ultimate Unconfined Compressive Strength Tons Per Sq Ft*
Very Soft	Easily penetrated several inches by fist	less than 0.25
Soft	Easily penetrated by thumb	0.25 to 0.50
Medium	Can be penetrated by thumb with moderate effort	0.50 to 1.0
Stiff	Readily indented by thumb but penetrated only with great effort	1.0 to 2.0
Very Stiff	Readily indented by thumbnail	2.0 to 4.0
Hard	Indented with difficulty by thumbnail.	over 4.0

Where seasonal changes in the consistency of clay subsoils are likely to occur, their influence shall be taken into consideration.

Other procedures for investigating the relative density of sands or the consistency of clays may be used in place of those recommended in the preceding paragraphs, provided such procedures lead to numerical results.

C. COMPUTATION OF APPLIED FORCES

1. Loads Exclusive of Earth Pressure

In the analysis of retaining walls and abutments, due account shall be taken of all superimposed loads carried directly on them, such as building walls, columns, or bridge structures; and of all loads from surcharges caused by railroad tracks, highways or building foundations supported on the fill back of the walls.

In calculating the surcharge due to track loading, the entire load shall be taken as distributed uniformly over a width of 14 ft for a single track or tracks spaced more than 14 ft centers, and as distributed over 14 ft, plus the distance center to center of tracks, where tracks are spaced 14 ft or less.

Impact shall not be considered unless the bridge bearings are supported by a structural beam, as in a spill-through abutment.

2. Computation of Backfill Pressure

Values for the unit weight, cohesion, and angle of internal friction of the backfill material shall be determined directly by means of soil tests or, if the expense of such tests is not justifiable, by means of the following table referring to the soil types defined in Sec. B, Art. 4. Unless the minimum cohesive strength of backfill material can be evaluated reliably the cohesion shall be neglected and only the internal friction considered.

Soil Type	*Unit Weight Lb Per Cu Ft*	*Cohesion c Lb Per Sq Ft*	*Angle of Internal Friction Degree*
1	105	0	33°42′ (38° for broken stone)
2	110	0	30°
3	125	0	28°
4	100	0	0
5	120	240	0

The magnitude, direction and point of application of the backfill pressure shall be computed on the basis of appropriate values of the unit weight, cohesion and internal friction, by means of one of the following procedures.

When the backfill is assumed to be cohesionless; when the surface of the backfill is or can be assumed to be plane; when there is no surcharge load on the surface of the backfill; or when the surcharge can be converted into an equivalent uniform earth surcharge, Rankine's or Coulomb's formulas may be used under the conditions to which each applies. Formulas and charts given in Appendix A and the trial wedge methods given in Appendix B are both applicable.

When the backfill cannot be considered cohesionless, when the surcharge of the backfill is irregular, or when the surcharge cannot be converted to an equivalent uniform earth surcharge, the trial wedge methods illustrated in Appendix B may be used.

If the wall or abutment is not more than 20 ft high and if the backfill has been classified according to Sec. B, Art. 4, the charts given in Appendix C may be used.

If the wall or abutment is prevented from deflecting freely at its crest, as in a rigid-frame bridge or some types of U-abutments, the computed backfill pressure shall be increased 25 percent.

In spill-through abutments, the increase of pressure against the columns due to the shearing strength of the backfill shall not be overlooked. If the space between columns is not greater than twice the width across the back of the columns, no reduction in backfill pressure shall be made on account of the openings. No more than the active earth pressure shall be considered as the resistance offered by the fill in front of the abutment.

In computing the active earth pressure of this fill, the negative or descending slope of the surface shall be taken into consideration.

If local conditions do not permit the construction of drains and, consequently, water may accumulate behind the wall, the resulting additional pressure shall be taken into account.

D. STABILITY COMPUTATION

1. Point of Intersection of Resultant Force and Base

The resultant force on the base of a wall or abutment shall fall within the middle third if the structure is founded on soil, and within the middle half if founded on rock, masonry or piles. The resultant force on any horizontal section above the base of a solid gravity wall should intersect this section within its middle half. If these requirements are satisfied, safety against overturning need not be investigated.

2. Resistance Against Sliding

The factor of safety against sliding at the base of the structure is defined as the sum of the forces at or above base level available to resist horizontal movement of the structure divided by the sum of the forces at or above the same level tending to produce horizontal movement. The numerical value of this factor of safety shall be at least 1.5. If the factor of safety is inadequate, it shall be increased by increasing the width of the base, by the use of a key, by sloping the base upward from heel to toe, or by the use of batter piles.

In computing the resistance against sliding, the passive earth pressure of the soil in contact with the face of the wall shall be neglected. The frictional resistance between the wall and a non-cohesive subsoil may be taken as the normal pressure on the base times the coefficient of friction f of masonry on soil. For coarse-grained soil without silt, f may be taken as 0.55; for coarse-grained soil with silt, 0.45; for silt 0.35.

If the wall rests upon clay, the resistance against sliding shall be based upon the cohesion of the clay, which may be taken as one-half the unconfined compressive strength. If the clay is very stiff or hard the surface of the ground shall be roughened before the concrete is placed.

If the wall rests upon rock, consideration shall be given to such features of the rock structure as may constitute surfaces of weakness. For concrete on sound rock the coefficient of friction f may be taken as 0.60.

The factor of safety against sliding on other horizontal surfaces below the base shall be investigated and shall not be less than 1.5.

3. Soil Pressure

The factor of safety against a bearing capacity failure at the toe of the structure is defined as the ultimate bearing capacity of the material beneath the toe divided by the maximum pressure beneath the toe. The value of this factor of safety shall be not less than 2 if the structure rests on sand and gravel, or 3 if it rests on clay.

The pressure on the foundation shall be calculated by the following formulas (see Fig. 1):

Case 1—Resultant within the middle third.

$p_1 = (4B - 6a)\ F/B^2$

$p_2 = (6a - 2B)\ F/B^2$

When $a = B/2$, $p_1 = p_2 = F/B$

Case 2—Resultant at edge of middle third.

$$p_1 = (4B - 6a)\ F/B^2 = 2F/B$$
$$p_2 = (6a - 2B)\ F/B^2 = 0$$

Case 3—Resultant outside the middle third.

$$p_1 = 2F/3a$$
$$p_2 = 0$$

The ultimate bearing capacity of sand and gravel shall be estimated on the basis of the relative density or angle of internal friction Ø of the material. If the relative density has been investigated by means of the penetration test described in Sec. B, Art. 5, the ultimate bearing capacity corresponding to the appropriate N value can be determined by means of the chart, Fig. 2. The same chart can be used if the value of Ø is known. The value of N or Ø shall be the average within the significant depth below the base of the footing. This depth may be taken as equal to the width of the base, unless the upper part of the subsoil is appreciably looser than the lower. In this event, the average value for the looser part shall be used. If groundwater level is closer to the base of the footing than a depth equal to one-half the width of the base, the ultimate bearing capacity shall be taken as one-half the value determined from the chart. For positions of the water table intermediate between the base and a depth equal to one-half the width of the base, the appropriate values may be determined by interpolation.

The ultimate bearing capacity of a clay subsoil may be considered equal to three times the average unconfined compressive strength of the clay within the significant depth below the base of the footing. This depth may be taken as equal to the width of the base unless the upper part of the subsoil is appreciably softer than the lower. In this event, the average value for the softer part shall be used. The position of the groundwater table is immaterial.

4. Settlement and Tilting

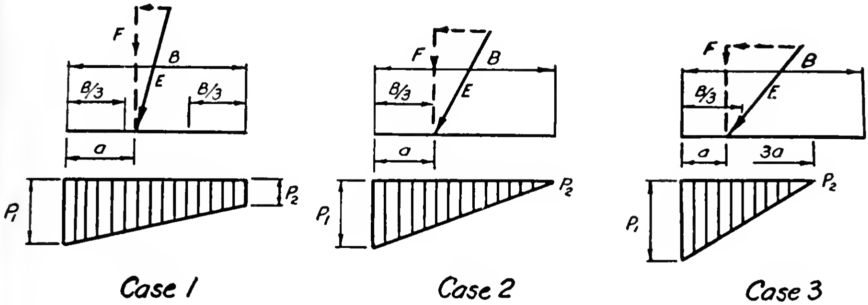
The soil pressures determined in accordance with Sec. D, Art. 3, provide for adequate safety against failure of the soil beneath the structure. If the subsoil consists of soft clay or silt it is necessary to determine the compressibility of the soil and to estimate the amount of settlement.

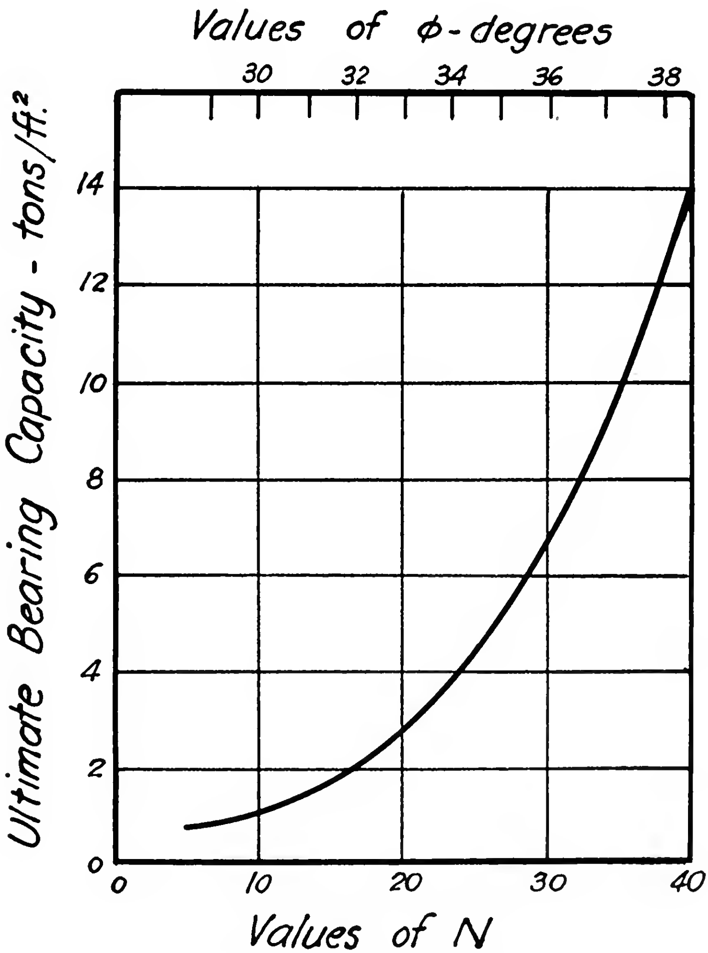
If the compressibility of the subsoil would lead to excessive settlement or tilting, the movement can be reduced by designing the wall so that the resultant of the forces acting at the base of the wall intersects the base near its midpoint.

If the pressure on a subsoil containing fairly thick layers of soft clay or peat is increased by the weight of the backfill, the wall may tilt backward because of the compression of the clay or peat. The tilt may be estimated on the basis of a knowledge of the compressibility of the subsoil. If the tilt is likely to be excessive, it is advisable to use backfill of lightweight material, to replace the backfill by a structure, or otherwise to change the type of construction so as to avoid overloading the subsoil.

5. Progressive Creep or Movement

If the weight of the backfill is greater than one-half the ultimate bearing capacity of a clay subsoil, progressive movement of the wall or abutment is likely to occur, irrespective of the use of a key, a tilted base, or batter piles. In such cases, it is advisable to use backfill of lightweight material, to replace the backfill by a structure, or otherwise to change the type of construction so as to avoid overloading the subsoil.





Figs. 1 (above) and 2 (below)

E. DESIGN OF BACKFILL

1. Drainage

The material immediately adjacent to the wall should be noncohesive and free draining. Cinders shall not be used. If a special back drain is installed, the grain size of the drain shall be coarse enough to permit free flow of water, but not so coarse that the fill material may ultimately move into it and clog it. Where economical, it is preferable that free-draining material be used within a wedge behind the wall bounded by a plane rising at 60 deg to the horizontal. Water from the free-draining material shall be removed, preferably by horizontal drain pipes or by weep holes. Horizontal drain pipes, if used, shall be not less than 8-in diameter and shall be installed in such a position that they will function properly. Such drains shall be accessible for cleaning. Weepholes are considered less satisfactory than horizontal drains. If used, they shall have diameters not less than 6 in and shall be spaced not over 10 ft.

2. Compaction

The backfill shall preferably be placed in layers not to exceed 12 in. in thickness. Each layer shall be compacted before placing the next, but overcompaction shall be avoided.

No dumping of backfill material shall be permitted in such a way that the successive layers slope downward toward the wall. The layers shall be horizontal or shall slope downward away from the wall.

F. DETAILS OF DESIGN AND CONSTRUCTION

1. General

The principles of design and permissible unit stresses for walls and abutments shall conform to the Specifications for Design of Plain and Reinforced Concrete Members, Part 2, this Chapter, with the modifications or additions in the following paragraphs.

Retaining walls and abutments shall preferably be of the gravity or semi-gravity type. The width of the stem of a semi-gravity wall, at the level of the top of the footing, shall be at least one-fourth of its height.

The base of a retaining wall or abutment supported on soil shall be located below frost line, and in no case at a depth less than 3 ft below the surface of the ground in front of the toe. The base shall be located below the anticipated maximum depth of scour. Where this is not practicable the base shall be supported by piles or piers.

To prevent temperature and shrinkage cracks in exposed surfaces, not less than 0.25 sq in of horizontal metal reinforcement per foot of height shall be provided, irrespective of the type of wall. Consideration shall be given to providing additional reinforcement above horizontal joints.

The backs of retaining walls and abutments shall be damp-proofed by an approved material.

At horizontal joints between the bases and stems of retaining walls, raised keys are considered preferable to depressed keys. The unit shearing stress at the base of such a key shall not exceed $0.25f'_c$.

Vertical grooved lock joints shall be placed not over 60 ft apart to care for temperature changes. They shall be protected by membrane waterproofing or noncorrosive metal water stops.

The walls above the footings shall be cast as units between expansion joints, unless construction joints are formed in accordance with the provisions of these specifications.

The heels of cantilever, counterfort and buttress retaining walls shall be proportioned for maximum resultant vertical loads, but when the foundation reaction is neglected the permissible unit stresses shall not be more than 50 percent greater than the normal permissible stresses.

2. Cantilever Walls

The unsupported toe and heel of the base slabs shall each be considered as a cantilever beam fixed at the edge of the support.

The vertical section shall be considered as a cantilever beam fixed at the top of the base.

3. Counterfort and Buttress Walls

The face walls of counterfort and buttress walls and parts of base slabs supported by the counterforts or buttresses shall be designed in accordance with the requirements for a continuous slab, Specifications for Design of Plain and Reinforced Concrete Members, Part 2, this Chapter. Due allowance shall be made for the effect of the toe moment on shears and bending moments in the heel slabs of counterfort walls.

Counterforts shall be designed in accordance with the requirements for T-beams. Stirrups shall be provided to anchor the face slabs and the heel slabs to the counterforts. These shall be proportioned to carry the end shears of the slabs. Stirrups shall be U-shaped with their legs in the counterforts, and shall extend as close to the exposed face of face walls and the bottom of base slabs as the requirements for protective covering permit. It is desirable to run reinforcing bars through the loops of the U.

Buttresses shall be designed in accordance with the requirements for rectangular beams.

Appendix A

EARTH PRESSURE FORMULAS FROM RANKINE–COULOMB THEORIES

The following formulas are applicable only to materials that may be considered cohesionless.

Cases 1 to 3 are for vertical walls without heels. The pressure P is the same as the pressure on a vertical plane in the backfill. Vertical walls with heels come under Cases 4 to 6.

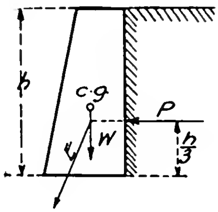
Cases 4 to 6 are for walls with heels. The wall may be vertical or may lean forward, or may lean backward as long as the upper edge of the back of the wall is in front of the vertical plane through the edge of the heel.

Cases 7 to 9 are for walls without heels. Walls with heels come under Cases 4 to 6 as long as the upper edge of the back of the wall is in front of the vertical through the edge of the heel; if the upper edge of the back of the wall extends back of the vertical plane through the edge of the heel, the problem can be solved by combining the solutions of Cases 4 to 6 and 7 to 9.

For walls leaning forward or walls with the base extending into the backfill the pressure of the backfill on a vertical plane through the back of the heel of the wall is to be combined with the weight of backfill contained between this vertical plane and the back of the wall.

For walls leaning toward the backfill the resultant pressure P will be horizontal for a wall without surcharge, or for a wall with uniform surcharge, if the surface of the backfill is horizontal, and will make an angle λ with the horizontal for a wall with a sloping surcharge. The values of λ will vary from δ, where the wall is vertical, to zero, where Rankine's theory shows that the resultant pressure is horizontal. Values of λ and values of K, where $P = \frac{1}{2} wh^2K$, are given for Case 10.

1 Vertical Wall, Horizontal Surcharge

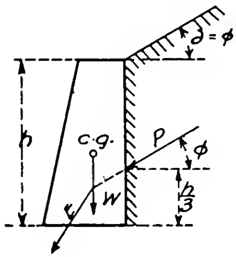


$$P = \frac{1}{2} wh^2 \frac{1 - \sin\phi}{1 + \sin\phi}$$
$$= \frac{1}{2} wh^2 \tan^2\left(45° - \frac{\phi}{2}\right)$$

For $\phi = 1\frac{1}{2}$ to 1 $(\phi = 33°42')$

$P = 0{\cdot}143\, wh^2$

2· Vertical Wall, Sloping Surcharge

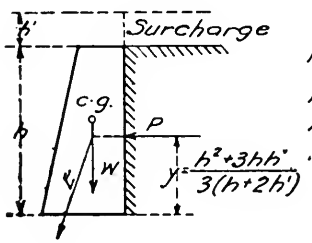


$$P = \frac{1}{2} wh^2 \cos\phi$$

For $\phi = 1\frac{1}{2}$ to 1 $(\phi = 33°42')$

$P = 0{\cdot}416\, wh^2$

3· Vertical Wall, Loaded Surcharge

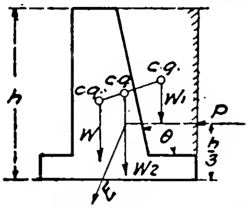


$$P = \frac{1}{2} wh(h + 2h') \frac{1 - \sin\phi}{1 + \sin\phi}$$

For $\phi = 1\frac{1}{2}$ to 1 $(\phi = 33°42')$

$P = 0{\cdot}143\, wh(h + 2h')$.

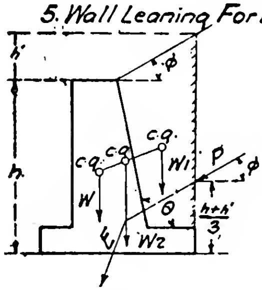
4. Wall Leaning Forward, Horizontal Surcharge



$$p = \frac{1}{2} wh^2 \frac{1-\sin\phi}{1+\sin\phi}$$
$$= \frac{1}{2} wh^2 \tan^2(45° - \frac{\phi}{2})$$
as in Case 1.

W = total weight of wall one ft. long.
W_1 = " " earth wedge " " "
$W_2 = W + W_1$.

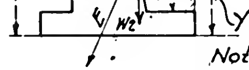
5. Wall Leaning Forward, Inclined Surcharge



$$p = \frac{1}{2} w(h+h')^2 \cos\phi$$

W = total weight of wall one ft. long.
W_1 = " " earth wedge " " "
$W_2 = W + W_1$

6. Wall Leaning Forward, Loaded Surcharge.



h' = surcharge per sq. ft. ÷ w.

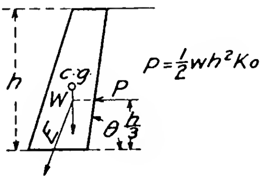
$$p = \frac{1}{2} wh(h+2h') \frac{1-\sin\phi}{1+\sin\phi}$$
as in case 3

W = total weight of wall one ft. long.
W_1 = " " earth wedge " " "
$W_2 = W + W_1$

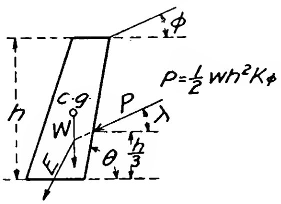
$$y = \frac{h^2 + 3h'h}{3(h+2h')}$$

Note: Wall should be investigated when W_1 includes surcharge, and when surcharge over wedge is omitted.

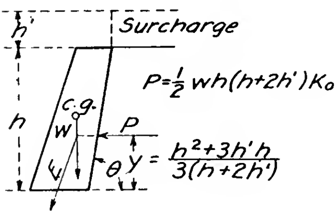
7·Wall Leaning Toward the Filling, Horizontal Surcharge

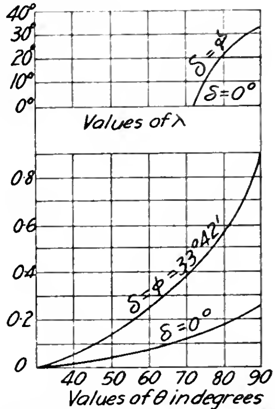


8·Wall Leaning Toward the Filling, Inclined Surcharge



9·Wall Leaning Toward the Filling·Loaded Surcharge





10·Values of Ko and Kφ for φ-33°42'

Appendix B

TRIAL WEDGE METHOD OF EARTH PRESSURE COMPUTATION

The trial wedge method is applicable for backfills of soils possessing cohesion, internal friction, or both; for backfills having any configuration of ground surface; and for surcharges located at any position on the backfill. The procedure, illustrated in Fig. 3, is outlined as follows:

A. COMPUTATION OF TOTAL PRESSURE

1. Make scale drawing of wall with backfill and any surcharge loads.
2. Locate surface AB against which earth pressure is to be computed. For walls with heels use vertical section as shown in Chart 1, Fig. 3. For walls without heels use back of wall as shown in Chart 2.
3. Establish direction of earth pressure with respect to line AB, by the procedure described under B following.

4. Compute depth h_o of tension cracks if soil has cohesion.
5. Draw boundaries of trial wedges BC1, BD2, etc., wherein BC, BD etc., are assumed plane surfaces of sliding.
6. Compute weights of successive wedges BC1, ABD2, etc., including any surcharge acting on the ground surface within the limits of each wedge.
7. Lay off weight vectors for successive wedges.
8. Compute total cohesion on each surface of sliding BC, BD, etc.
9. Lay off cohesion vectors from lower ends of weight vectors, each parallel to the surface of sliding on which it acts.
10. From end of each cohesion vector draw line parallel to earth pressure P.
11. From point B in force diagram lay off radial lines BC, BD, etc., each making an angle Ø with the normal to its respective surface of sliding (as force R on surface BF).
12. Locate intersections of vectors R with corresponding lines drawn in step 10 and connect intersections with smooth curve. This is the earth pressure locus.
13. Determine maximum distance between line TT' and the earth pressure locus, measured parallel to line of action of P. This distance represents the active earth pressure P.

B. DIRECTION OF PRESSURE P

For walls with heels, the following procedure is applicable:

1. Determine height h of wall, measured from point a.
2. Locate point b on the surface of the backfill at a distance 2h measured horizontally from a.
3. Draw line ab.
4. Take direction of resultant earth pressure P as parallel to line ab.

For walls without heels, where AB is the back of the wall, take angle Ø′ equal to 2/3 Ø.

C. POINT OF APPLICATION OF PRESSURE

The point of application of the resultant pressure P can be obtained by determining the approximate pressure-distribution diagram, Fig. 3. The procedure is as follows:

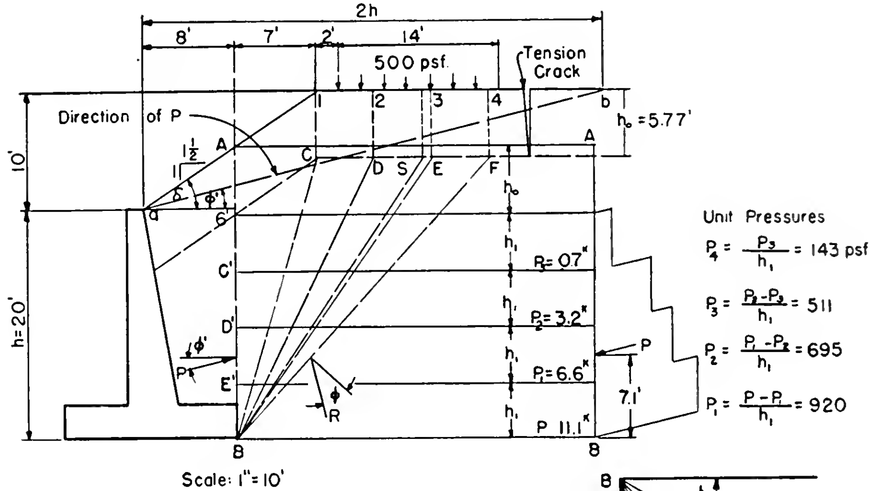
1. Subdivide the line BB′ into about 4 equal parts h_1 below the depth h_o of tension cracking.
2. Compute the active earth pressures P_1, P_2, P_3, etc., as if each of the points C′, D′, E′, etc., were at the base of the wall. The trial wedge method is used for each computation.
3. Determine the average pressures p_1, p_2, etc., over each distance B′C′, C′D′, etc., as indicated in Fig. 3.
4. Determine the elevation of the centroid of this approximate pressure diagram. This is the approximate elevation of the point of application of the resultant earth pressure P.

If the backfill may be considered cohesionless, the point of application of pressure may be obtained as follows:

a. Determine the center of gravity of the earth and ballast in the wedge between the plane of rupture and the vertical plane passing through the heel of the wall (Chart 1) or the back of the wall (Chart 2), Fig. 3.

b. Assume the center of gravity of the surcharge loads to be located at the surface of the backfill.

c. Determine the center of gravity of the combined loads and draw a line from this point parallel to the plane of rupture to a point of intersection with the vertical plane through the heel of the wall (Chart 1) or the back of the wall (Chart 2), Fig. 3.



w = Unit weight of soil = 120 pcf
c = Cohesion per unit of area = 200 psf (Should usually be neglected)
ϕ = Angle of internal friction of soil = 30°
δ = Slope of backfill
ϕ' = Direction of P

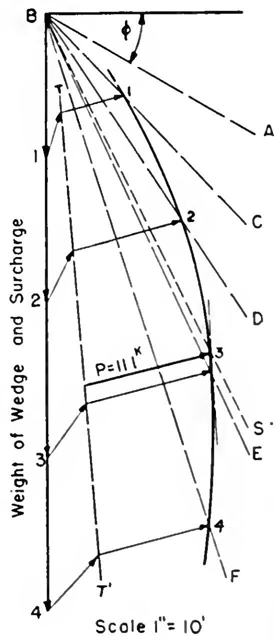
$$h_o = \frac{2c}{w} \tan\left(45^\circ + \frac{\phi}{2}\right) = 5.77'$$

WEDGE VECTORS

Wedge	Area	Σ Area	Σ Wt.	Σ Sur-chg.	Total Wt (Kips)
1	$19.56 \times \frac{7}{2} + 5.77 \times 7 = 108.9$	108.9	13.1	0	13.1
2	$24.23 \times \frac{5}{2} + 5.77 \times 5 = 89.4$	198.3	23.8	1.5	25.3
3	89.4	287.7	34.5	4.0	38.5
4	89.4	377.1	45.3	6 5	51.8

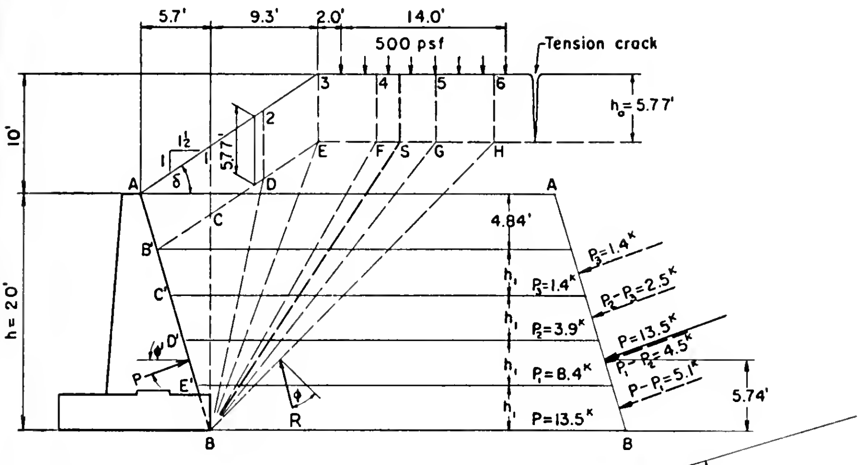
COHESION VECTORS

Wedge	Length	Cohesion (Kips)
1	25.2	5.0
2	27.0	5.4
3	29.6	5.9
4	32.7	6.5



TRIAL WEDGE METHOD
EARTH PRESSURE COMPUTATIONS

Fig 3.- CHART I (Walls with large heels.)



Scale: 1"=10'

w = Unit weight of soil = 120 pcf

c = Cohesion per unit of area = 200 psf (Should usually be neglected)

ϕ = Angle of internal friction of soil = 30°

δ = Slope of backfill

ϕ' = Direction of P = $\frac{2}{3}\phi$ = 20°

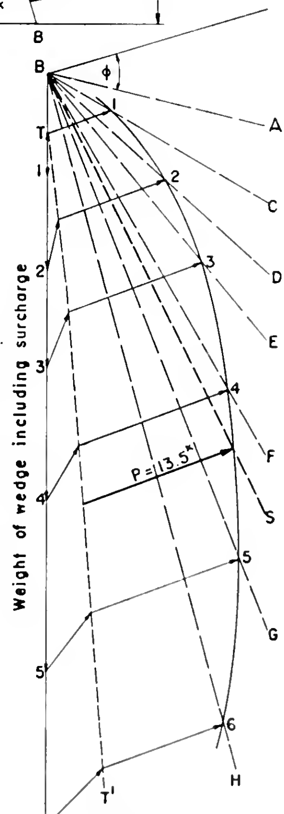
$h_o = \frac{2c}{w}\tan\left(45° + \frac{\phi}{2}\right) = 5.77'$

WEDGE VECTORS

Wedge	Area		Σ Area	Σ Wt.	Σ Sur-chg.	Total Wt. (Kips)
1	$18.03 \times \frac{4.32}{2} + \frac{6.88+5.26}{2} \times 4.8$	= 68.1	68.1	8.2	0	8.2
2	$18.03 \times \frac{4.65}{2} + 5.77 \times 4.65$	= 68.7	136.8	16.4	0	16.4
3	41.9 + 26.8	= 68.7	205.5	24.7	0	24.7
4	$24.23 \times \frac{5}{2} + 5.77 \times 5$	= 89.4	294.9	35.4	1.5	36.9
5	" "	= 89.4	384.3	46.2	4.0	50.2
6	" "	= 89.4	473.7	56.9	6.5	63.4

COHESION VECTORS

Wedge	Length	Cohesion (Kips)
1	18.0	3.6
2	21.7	4.3
3	26.0	5.2
4	28.2	5.6
5	31.0	6.2
6	34.4	6.9



Scale: 1"=10^K

TRIAL WEDGE METHOD
EARTH PRESSURE COMPUTATIONS
FIG. 3 - CHART 2 (Walls with small heels)

Appendix C

EARTH PRESSURE CHARTS FOR WALLS LESS THAN 20 FT HIGH

Figs. 4 and 5 may be used for estimating the backfill pressure if the backfill material has been classified in accordance with Sec. B, Art. 4.

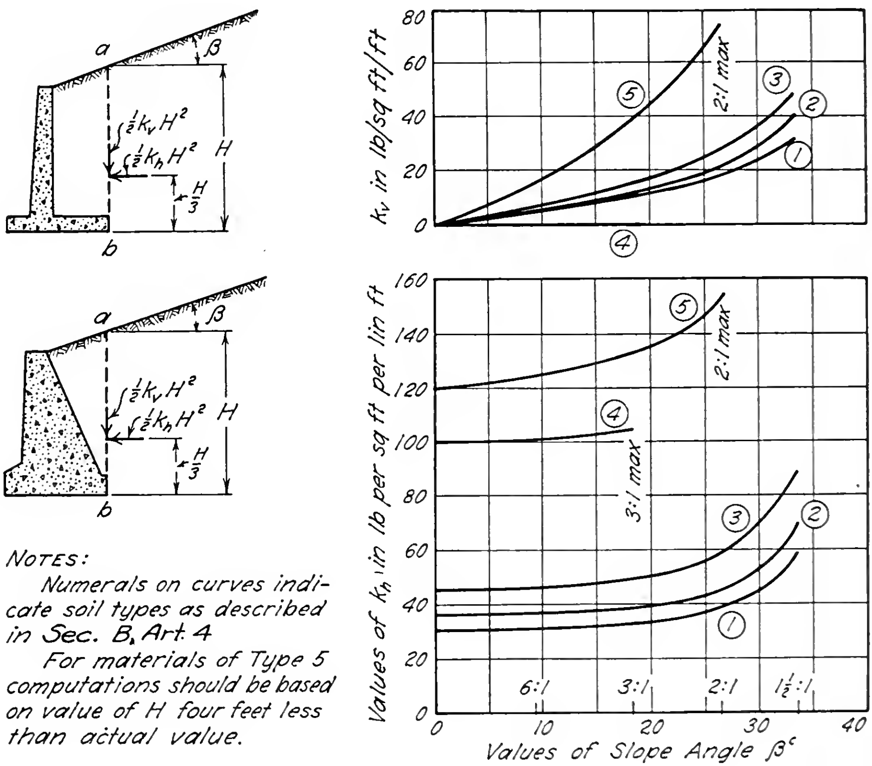
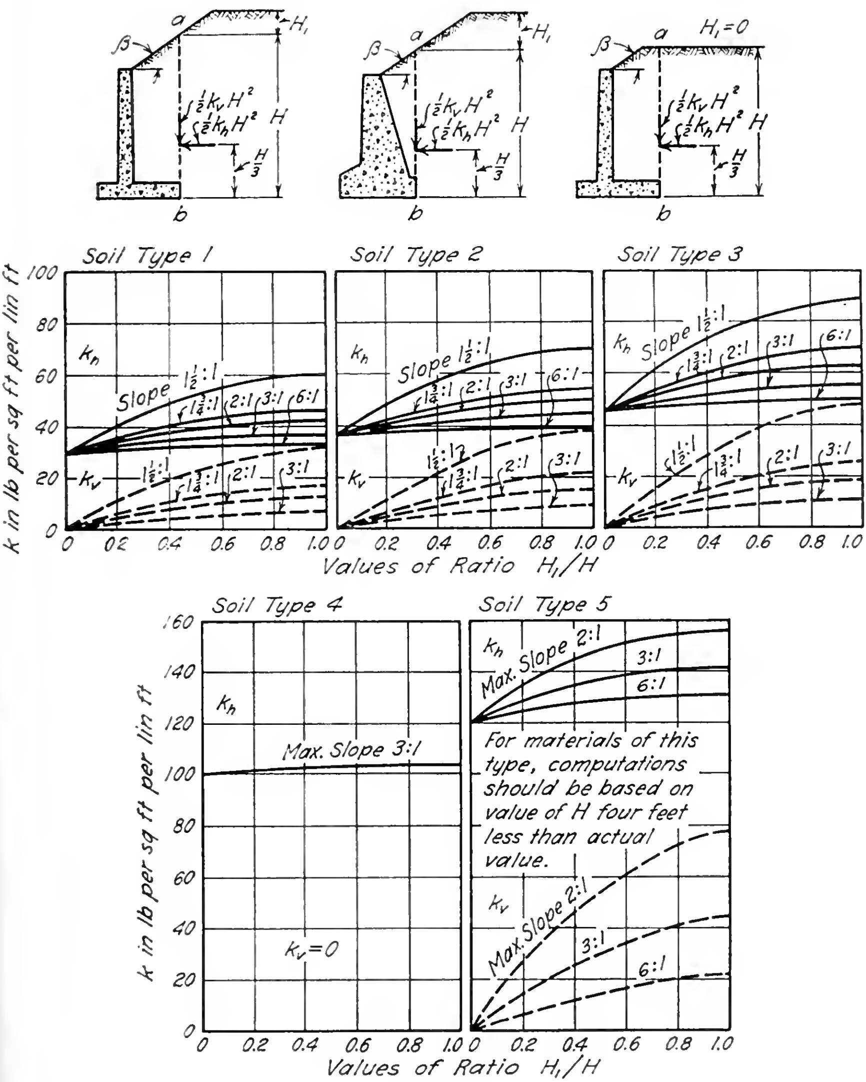


Fig. 4.



a
β
H_1
$\frac{1}{2}k_vH^2$
$\frac{1}{2}k_hH^2$
H
$\frac{H}{3}$
b
$H_1=0$
Soil Type 1
Soil Type 2
Soil Type 3
Soil Type 4
Soil Type 5
k in lb per sq ft per lin ft
k_h
k_v
Slope $1\frac{1}{2}$:1
$1\frac{3}{4}$:1
2:1
3:1
6:1
Max. Slope 3:1
$k_v=0$
Max. Slope 2:1
For materials of this type, computations should be based on value of H four feet less than actual value.
Values of Ratio H_1/H

Fig. 5.

Report on Assignment 5

Tunnel Linings: Design, Construction and Maintenance

Collaborating with Committees 1, 5, 28 and 29

D. H. Shoemaker (chairman, subcommittee), C. W. Gabrio, C. B. Porter, W. T. Richards, R. Smillie, N. Van Eenam.

Your committee recommends the following Manual changes:

Reapprove without change Specifications for Lining Railway Tunnels with Brick, pages 8–135 to 8–140, incl.

Delete Specifications for Lining Railway Tunnels with Metal Liner Plates and Shotcrete, pages 8–129 to 8–133, incl., for the following reasons:

1. This type of construction cannot, in general, be considered a structural lining, as it would only be used in tunnels where there is very little, if any, pressure of any kind, either on the sides or on the roof.

2. This type of lining does not prevent corrosion of the outside, unprotected part, of the steel.

3. With ordinary methods of application there would be very little difference in the cost of such a lining compared with the cost of lining placed in accordance with Specifications for Lining Railway Tunnels with Concrete.

4. Such lining would normally be used where some special conditions exist, perhaps limited clearances. The tunnel specifications in the Manual are prepared on the assumption that the lining is through ordinary rock formation which involves no special features.

The following Specifications for Lining Railway Tunnels with Concrete are submitted with the recommendation that they be adopted and published in the Manual, replacing the current Specifications, pages 8–103 to 8–108, incl.

SPECIFICATIONS FOR LINING RAILWAY TUNNELS WITH CONCRETE

A. SCOPE

These specifications cover the lining of new tunnels and the relining of old tunnels through ordinary rock formations which involve no extraordinary side pressure or special features.

B. DESIGN

1. Interior Dimensions

The interior dimensions of the clear space provided for single and double-track tunnels shall not at any point be less than tunnel clearances recommended by the AREA. Where legal requirements provide greater clearances than AREA, such legal requirements shall govern.

On curved track, the clearance shall be increased to allow for a car 85 ft long, 60 ft between center of trucks, and 14 ft high. The superelevation of the outer rail shall be in accordance with the recommended practice of the AREA.

To provide for drainage, minimum side clearance of 9 ft shall be used in tunnels likely to be wet, and in addition where ventilation is required, the height of single-track tunnel shall be increased 1 ft or more.

2. Preliminary Data

Information shall be obtained for design of new tunnel, consisting of field survey showing geological formations, ground-water conditions, location of faults, core borings, hardness of rock to be encountered, together with any special features and data on existing tunnels through similar formations. Where new tunnel is driven adjacent to an existing tunnel, old office records shall be searched for data as to ground-water conditions, fault zones and other special features. Consideration should be given to providing core borings from existing adjacent tunnels if office records are incomplete.

3. Floor and Ballast Walls

Floors shall be paved but may be either ballast wall sections or solid track sections with ties embedded in concrete, conforming to details shown on Fig. 1. Rails shall be supported on creosoted tie blocks 8 in by 10 in by 2 ft 6 in, spaced 19½ in on centers, embedded in the concrete floor, with double-shouldered tie plates fastened to ties with suitable drive spikes or lag screws. Superelevation shall be provided on curves by increasing the thickness of the tie blocks under the high rail.

4. Sidewalls and Arch

The depth of the sidewalls in hard, durable rock shall be at least 6 in below the bottom of the gutter for ballast track section and at least 6 in below the intersection of the floor surface with the sidewalls for solid track sections. In unsound rock, the sidewalls shall be carried down to stable foundation. At portals and vicinity, sidewalls shall extend at least 6 in below the frost line.

The minimum thickness of the sidewalls shall be:

a. Where temporary supports for excavation are not required:
   Single track—1 ft 3 in
   Double track—1 ft 9 in
b. Where temporary supports are required for face of excavation, the inner face of the concrete shall be:

Timber sets—spaced at least 12 in apart:

Single track—1 ft–2 in from inner face of supports
2 ft–2 in from inner face of lagging
Double track—1 ft–6 in from inner face of supports
2 ft–6 in from inner face of lagging

Timber sets are not recommended unless conditions are such that steel or bent rail sets are unobtainable.

Where timber sets are spaced less than 12 in apart, the thickness of walls and arch shall be increased and side and arch loads computed to determine advisability of using reinforced sections.

Steel sets—spaced at least 4 in apart, and in general not greater than 4 ft apart. Where supports are used primarily to protect workmen from falling rock and do not carry much load, wider spacing may be used.

Single track—9 in from inner face of supports
1 ft–3 in from inner face of lagging
Double track—1 ft–0 in from inner face of supports
1 ft–8 in from inner face of lagging

Lagging may be wood, steel lags, steel liner plates or steel water-diverting lagging. Where the nature of the rock and water conditions permit, lagging shall be spaced to allow clearance of 4 in or more between lags to permit free access of concrete to the face of the tunnel excavation. Prior to concreting, remove as many lags as is possible. Where it is necessary to solid lag for protection during excavation and where it is impractical to open up the lagging just prior to concreting, the space between the lagging and face of excavation shall be packed with lean concrete, durable stone rammed into place, coarse gravel placed by hand, or pea gravel placed pneumatically.

Thickness of the arch shall be as shown on Fig. 1.

5. Construction Joints

Each section of the lining shall be adequately keyed to adjacent sections. Non-corrosive water seals shall be used where necessary (Fig. 1). Monoliths shall not be longer than 40 ft through the tunnel and not longer than 30 ft within 120 ft of the portals.

6. Drains

Wherever ground water is encountered, vertical and diagonal openings, trench drains, tile or iron pipe drains shall be installed between the concrete lining and rock. Provide adequate outlets through sidewalls with the outer end of the outlets not less than 12 in above the bottom of the gutter. Provide subdrains under the concrete floor wherever ground water is found. Provide 4 in diameter holes through curb at 10 ft centers, to drain ballast section. Fig. 1.

Wherever drains are installed, they shall be sealed to the rock so as to prevent being clogged when concrete is poured.

7. Refuge Niches

Provide refuge niches as shown on Fig. 1 at approximate intervals of 200 ft and staggered with opposite sides so that spacing of niches shall be approximately 100 ft. Bottom of niches shall be at elevation of bottom of track ties for ballast track section and at elevation of intersection of invert and walls for solid track section. Where tunnels are more than 1 mile in length, larger refuge niches shall be provided to accommodate motor cars.

8. Conduit and Inserts

Where required, provision shall be made in the lining for conduit or hangers for cables and wires.

C. FORMS

1. General

Forms shall conform to requirements as outlined in the AREA Specifications for Concrete and Reinforced Concrete Railroad Bridges and Other Structures, Part 1, this Chapter, together with additional provisions given herewith.

The length of forms between construction joints shall be limited as outlined previously in these specifications for contraction and by the ability of the placement method to insure complete and homogenous filling of the space between the forms.

2. Filling of Forms

The space between the face of the form and face of excavation or tight lagging shall be entirely filled with concrete, except for drainage openings, and except that large cavities back of the normal face of excavation may be packed as outlined previously in these specifications.

3. Removal of Forms

In no case shall forms be removed until concrete has reached a strength of 1500 psi. and in not less than 52 hr where surrounding temperature is 60 deg F or over. When temperature is below 60 deg F, or where walls and arch are subject to squeezing or external pressures from the excavation, the time shall be increased as directed by the engineer.

4. Inspection Doors

Forms shall be provided with inspection doors in arch and walls so that the concrete can be thoroughly vibrated and inspected during the pouring.

D. CONCRETE

1. Specification

Concrete for lining shall be made and placed in accordance with the AREA Specification for Concrete and Reinforced Concrete Railroad Bridges and Other Structures, Part 1, this Chapter, together with the additional provisions given herewith.

2. Proportioning

Concrete shall contain not to exceed 5.75 gal of water (including moisture in the aggregate) per sack of cement, and shall have a minimum compressive strength of 3750 psi in 28 days, and the slump at the mixer shall not exceed 3 in. Concrete shall be air entrained with air content of not less than 3 percent or more than 6 percent of air by volume. Approved admixtures may be used if necessary to maintain workability with the required water-cement ratio.

3. Hand Placing

Concrete placed by hand shall be of such consistency that it can be thoroughly compacted to entirely fill the forms. This consistency shall be obtained without increasing the allowable maximum water-cement ratio.

4. Pneumatic Placing

Pneumatic placing of concrete shall be done with a concrete placing machine which blows the concrete through a pipe line with compressed air. The air pressure and the consistency of the concrete shall be so regulated, without increasing the allowable maximum water-cement ratio, that the coarse aggregate is not blown away from the mortar matrix when the concrete issues from the end of the delivery pipe. Flexible pipe branches shall be provided when necessary to deliver the concrete to approximately its final position in the lining. The end of the delivery pipe shall be kept buried in the concrete whenever possible, otherwise the concrete shall be shot into a metal baffle box or against the face of previously poured concrete. Concrete shall be so placed, regardless of the method used, so there is no separation of the mixture.

5. Pumping

Placement of concrete by pumping shall be done with a plunger pump which forces the concrete through a pipe line by direct pumping action, with or without using compressed air in the line. The concrete shall be pumped as closely as possible to its final position, using flexible pipe branches where necessary.

6. Shotcrete

Placement of shotcrete shall be in accordance with AREA specifications for Shotcrete, Part 15, this Chapter.

7. Order of Placing

A section of the wall and footing may be poured separate from the rest of the wall but construction joint shall not be more than 2 ft above the top of ballast curb elevation. The remainder of the wall and arch shall be poured monolithically. The floor and ballast walls shall preferably be poured in one operation.

8. Compaction

All concrete shall be compacted during and immediately after depositing by means of internal vibration applied in the mass of concrete and not by vibrating the forms.

9. Laitance and Bonding

Concrete surfaces receiving new concrete shall be roughened and cleaned of all laitance, dirt and water before fresh concrete is placed. Just prior to placing fresh concrete, the old surface shall be flushed with a ½ in thick layer of grout. Grout shall have the same proportions as the cement and sand in the regular mix. The consistency of the concrete and method of placement shall be such that laitance seams are not formed. If such seams are formed, they shall be completely removed before additional concrete is placed.

All loose or unsound rock shall be removed below walls and floors before concrete is placed. Where the type of rock makes this impractical, the floor and foundations for the walls shall be reinforced.

10. Drainage During Placing

Concrete shall not be placed in moving water. Separate and distinct provisions shall be provided to drain any area receiving fresh concrete. Effective weeps and drains shall be provided to prevent any hydrostatic pressure against the lining.

11. Curing and Cold Weather Protection

After the forms are removed the concrete lining shall be kept moist for a period of 5 days. In freezing weather the ends of the tunnel or sections of the tunnel shall be closed up and suitable means provided for maintaining the temperature of concrete at not lower than 50 deg F for a period of not less than 72 hr after placing.

E. CONSTRUCTION AND EXPANSION JOINTS

1. Construction Joints

Construction joints or fill planes shall not be formed at such locations where they might reduce the effectiveness of the lining to resist pressure from surrounding earth or rock. Where necessary, non-corrosive water stops shall be installed at construction joints.

2. Expansion Joints

No expansion joints need be provided other than construction joints.

9

e,
3.

is
s
n
l

d
e
l.

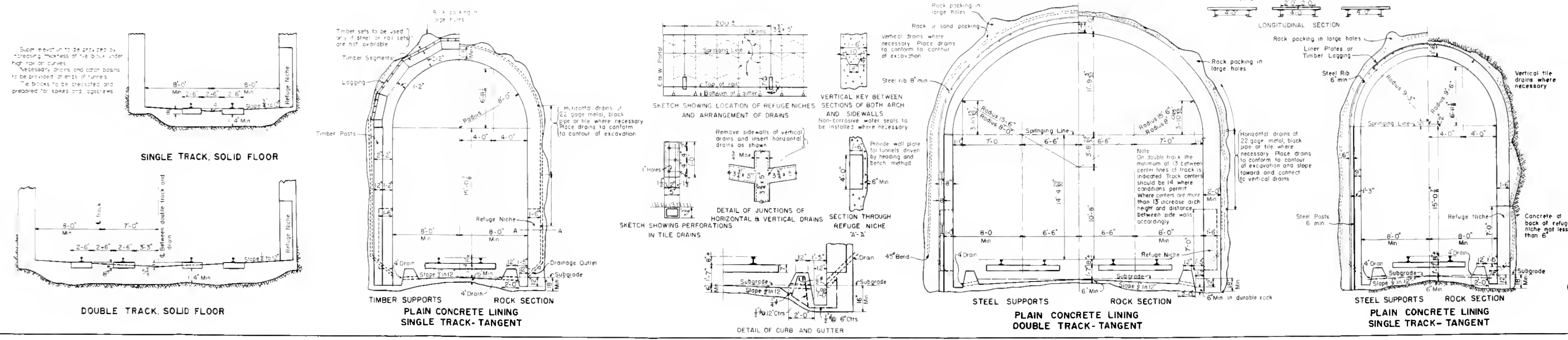
n,

E

nd
is,

42
27
28
70

ft
n-
2.
in



GENERAL NOTES

On curved track the clearances shall be increased to allow for car 85' long, 60' between centers of trucks and 14' high. The super-elevation of the outer rail shall be in accordance with the recommend practice of the A.R.E.A.

Refuge Niche 4'-0" wide, 7'-0" high and 1'-6" deep spaced about 200' apart and staggered with other side. No timbers to be exposed in Refuge Niche.

For detail for timber supports see specifications for lining Railway Tunnels with timber.

Temperature steel to be provided for curb and gutter sections. Consideration shall also be given for use of similar steel in side walls and arch.

In dry tunnels without side pressure paving of invert may be omitted.

Steel ribs to be blocked against rock especially at springing line.

CONCRETE TUNNEL LINING
Fig. 1

Report on Assignment 6

Methods of Repairing Masonry, Including Internal Pressure Grouting

R. W. Gilmore (chairman, subcommittee), L. T. Casson, C. C. Cooke, D. H. Dowe, J. S. Hancock, R. Hayes, W. C. Love, R. F. M. Marshall, L. H. Needham, D. B. Packard, Jr., J. L. Rippey, C. P. Schantz, F. R. Smith.

Last year your committee presented as information a tentative draft of Specifications for Shotcrete (Proceedings, Vol. 53, 1952, pages 617 to 622, incl.), requesting comments and criticisms thereon. These specifications are now submitted with the recommendation that they be adopted without change and published in the Manual, and that the material which they will replace, pages 8–95 to 8–97, incl., be withdrawn.

It is recommended that the material under Specifications for Repairing Deteriorated Concrete, pages 8–99 to 8–101, incl., be withdrawn, since it has been superseded by the material under Repairing and Solidifying Masonry Structures, page 8–141 to 8–142.6, incl.

Report on Assignment 7

Methods for Improving the Quality of Concrete and Mortars

Collaborating with Committee 6

M. S. Norris (chairman, subcommittee), M. W. Bruns, W. J. Galloway, J. F. Halpin, W. L. McDaniel, L. M. Morris, G. H. Paris, C. M. Segraves.

Pages 8–1 to 8–25, incl.

SPECIFICATIONS FOR CONCRETE AND REINFORCED CONCRETE RAILROAD BRIDGES AND OTHER STRUCTURES

The committee recommends the reapproval of the Specifications for Concrete and Reinforced Concrete Railroad Bridges and Other Structures with the following revisions, plus the revisions which are presented in the report on Assignment 2.

To present Art. 103. Sampling and Testing, add the following references:

(g) Clay Lumps in Aggregates	Designation	C 142
(h) Specific Gravity and Absorption of Coarse Aggregate	"	C 127
(i) Specific Gravity and Absorption of Fine Aggregate	"	C 128
(j) Surface Moisture	"	C 70

At the March 1952 annual meeting, the committee presented, as information, draft of revisions of the following present sections in the Specifications for Concrete and Reinforced Concrete Railroad Bridges and Other Structures (see Proceedings, Vol. 53, 1952, pages 623 to 625, incl.), which revisions are now offered for adoption and inclusion in the Manual:

Sec. 110. Mortar Strength.

Sec. 119. Mortar Strength.

Sec. 124. Quality and Methods of Sampling and Testing.

Sec. 204. Assumed Strength of Concrete Mixtures.

Sec. 266. General.
Sec. 267. Heat Curing.
Sec. 268. Wet Curing.
Sec. 269. Field Tests.

At the same time, the committee presented, as information, a new Sec. 203.1. Air Content for Air-Entrained Concrete, which is now recommended be adopted for publication in the Specifications for Concrete and Reinforced Concrete Railroad Bridges and Other Structures.

Pages 8–25 and 8–26.

APPENDIX A ASTM SPECIFICATIONS AND DESIGNATIONS

Delete all of these references and substitute the following references, which have been revised to include additional aggregate, steel reinforcement, and air-entrainment references; to delete references to cement tests, which are included by reference in ASTM Designation C 150; and to insert the latest dates of revision by ASTM of all of the documents involved.

Designation	*Specification For or Standard Method of Test For*
A 7–50T	Steel for Bridges and Buildings (Tentative)
A 15–50T	Billet–Steel Bars for Concrete Reinforcement (Tentative)
A 16–50T	Rail–Steel Bars for Concrete Reinforcement (Tentative)
A 44–41	Cast Iron Pit–Cast Pipe for Water or Other Liquids
A 82–34	Cold Drawn Steel Wire for Concrete Reinforcement
A 160–50T	Axle–Steel Bars for Concrete Reinforcement (Tentative)
A 184–37	Fabricated Steel Bar or Rod Mats for Concrete Reinforcement
A 185–37	Welded Steel Wire Fabric for Concrete Reinforcement
A 305–50T	Minimum Requirements for the Deformations of Deformed Steel Bars for Concrete Reinforcement (Tentative)
C 29–42	Unit Weight of Aggregate
C 31–49	Method of Making and Curing Concrete Compression and Flexure Test Specimens in the Field
C 33–49	Concrete Aggregates
C 39–49	Compressive Strength of Molded Concrete Cylinders
C 40–48	Organic Impurities in Sands for Concrete
C 70–47	Surface Moisture in Fine Aggregate
C 87–47	Measuring Mortar-Making Properties of Fine Aggregate
C 88–46T	Soundness of Aggregates by Use of Sodium Sulphate or Magnesium Sulphate (Tentative)
C 117–49	Amount of Material Finer than No. 200 Sieve in Aggregates
C 123–44	Coal and Lignite in Sand
C 127–42	Specific Gravity and Absorption of Coarse Aggregate
C 128–42	Specific Gravity and Absorption of Fine Aggregate
C 131–51	Abrasion of Coarse Aggregate by Use of the Los Angeles Machine
C 136–46	Sieve Analysis of Fine and Coarse Aggregates
C 138–44	Weight Per Cubic Foot Yield and Air Content (Gravimetric) of Concrete
C 142–39	Clay Lumps in Aggregates
C 143–39	Slump Test for Consistency of Portland-Cement Concrete
C 150–49	Portland Cement

Designation	*Specification For or Standard Method of Test For*
C 173–42T	Air Content (Volumetric) of Freshly Mixed Concrete (Tentative)
C 175–51T	Air-Entraining Portland Cement (Tentative)
C 185–50T	Air Content of Hydraulic Cement Mortar (Tentative)
C 231–49T	Air Content of Freshly Mixed Concrete by the Pressure Method (Tentative)
C 233–50T	Air-Entraining Admixtures for Concrete (Tentative)
C 260–50T	Air-Entraining Admixtures for Concrete (Tentative)
D 75–48	Standard Methods of Sampling Stone, Slag, Gravel, Sand and Stone Block for Use as Highway Materials

Pages 8–27 to 8–30, incl.

SPECIFICATIONS FOR PORTLAND CEMENT

Delete this entire specification, since it is now proposed that it be referred to in the Manual only by serial designation in Appendix A at the end of the Specifications for Concrete and Reinforced Concrete Railroad Bridges and Other Structures.

Report on Assignment 8

Specifications for the Construction and Maintenance of Masonry Structures

R. E. Paulson (chairman, subcommittee), W. F. Campbell, T. K. Dyer, A. B. Fowler, D. E. Hoeffel, J. H. Sawyer, Jr., C. A. Whipple.

Pages 8–109 to 8–114, incl.

SPECIFICATIONS FOR STONE MASONRY

Reapprove with the following revisions.

Page 8–111, 305. Backing. Change last sentence of Par. (a) to read: "Voids shall be thoroughly filled with concrete."

Change Par. (b) to read: "Backing shall be of concrete."

Delete Par. (c) and (d).

Page 8–112, IV Bridge and Retaining Wall Masonry—Block Ruble. Change second paragraph, lines 2 and 3, to read: "..........having all voids in the heart of the wall thoroughly filled with concrete."

Pages 8–112 and 8–113, 505. Backing. Delete Par. (a) and (b) and substitute therefor: "Backing shall consist of concrete and shall form the extrados. When required, an approved waterproofing shall be applied."

Page 8–113 and 8–114, VII. Culvert Masonry. Delete in full.

Page 8–114, VIII. Dry Masonry. Renumber as VII.

Report of Committee 29—Waterproofing

T. M. von Sprecken, *Chairman,*	W. G. Harding	L. J. Deno, *Vice Chairman,*
A. L. Becker	W. H. Hoar	W. E. Robey
S. P. Berg	E. A. Johnson	G. E. Robinson
Lyle Bristow	M. L. Johnson	F. S. Schubert
R. J. Brueske	J. F. Marsh	Henry Seitz
R. A. M. Deal	R. L. Mays	A. L. Sparks
L. P. Drew	B. J. Ornburn	V. G. Tellis
O. E. Fort	H. A. Pasman	J. P. Walton
E. T. Franzen	F. J. Pitcher	C. A. Whipple
Nelson Handsaker	R. D. Powrie	K. B. Woods
		Committee

To the American Railway Engineering Association:

Your committee reports on the following subjects:

1. Revision of the Manual.

   Progress report, including recommended revisions .... page 823

2. Waterproofing of railway structures, collaborating with Committees 6, 8 and 15.

   No report. The work of this committee will be covered in the report made by Committee 15.

3. Waterproofing protection to prevent concrete deterioration, collaborating with Committees 6 and 8.

   Final report on tests on waterproofing coatings for concrete surfaces, presented as information .... page 828

   Specifications for waterproofing coatings for exposed concrete surfaces, presented for adoption as recommended practice for inclusion in Manual .... page 829

4. Means of conserving labor and materials, including the adaptation of substitute noncritical material and specifications for the reclamation of released materials, tools and equipment, collaborating with Committee 3-A, General Reclamation, Purchases & Stores Division, AAR.

   No report.

The Committee on Waterproofing,
T. M. von Sprecken, *Chairman.*

AREA Bulletin 505, November 1952.

Report on Assignment 1

Revision of the Manual

L. J. Deno (chairman, subcommittee), R. J. Brueske, E. T. Franzen, R. L. Mays, H. A. Pasman, F. S. Schubert, Henry Seitz, J. P. Walton.

During the past year your committee reviewed and revised the material appearing in its chapter in the Manual. Some of the specifications had become ineffective as they were based on asphalts derived from Mexican crudes which are no longer commercially available in the markets of this country. From this and other considerations it was found necessary to make a number of changes in the specifications. Changes were made to have them cover the best materials practically obtainable in commercial markets and to bring them up to date.

Changes in the definitions of certain terms in the Glossary were deemed advisable.

Your committee recommends the revision, inclusion or deletion of the following documents in the Manual, and the reapproval of all of this Manual material as revised.

Pages 29–1 through 29–12

SPECIFICATIONS FOR MEMBRANE WATERPROOFING

Reapprove with the following revisions:

Page 29–1

102—After second sentence, first paragraph, add, "Flexibility shall also be provided in the waterproofing membrane over all expansion joints."

In the second paragraph after brick, add, "asphalt plank."

Page 29–2

202 (a) Change to read—Softening point (ring and ball method) 145 deg to 170 deg F (62.8 deg to 76.7 deg C).

202 (f) Change 20 cm to 15 cm.

202 (g) Delete.

202 (h) Renumber as (g).

203 (a) Delete.

Renumber remaining sub-items, in order, from (a) to (i).

Page 29–3

207–1.—Change as follows:

1. Fabric shall consist of high-grade cotton cloth saturated thoroughly and uniformly with asphalt specified in Sec. 202 when used with asphalt mopping, or either type of coal-tar pitch specified in Sec. 204 when used with coal-tar pitch mopping.

Page 29–7

213—Change second sentence, first paragraph, to read as follows:

Poured-in-place mastic shall be composed of (a) asphalt mixed with mineral aggregates and mineral filler, or (b) mastic cake mixed with asphalt and mineral aggregates.

213–2.—Change as follows:

2. Coarse mineral aggregate shall be well graded crushed stone or washed gravel that will pass a ⅜-in sieve and be retained on a No. 10 (2000 micron) sieve. It shall be free from soft particles and organic matter.

213–3. Third, fourth and fifth lines—change as follows:

Passing a No. 100 (149 micron) sieve ....not more than 6 percent
Passing a No. 40 (420 micron) sieve ....40–80 percent
Passing a No. 10 (2000 micron) sieve ....not less than 90 percent

213–4.—Change as follows:

4. Mineral filler shall be portland cement or finely ground limestone or silica meeting the following requirements:

Passing a No. 200 (74 micron) sieve ....not less than 75 percent
Passing a No. 30 (590 micron) sieve ....not less than 100 percent

Delete subhead 5 only and incorporate this sentence under subhead 4; renumber item 6 as 5, and add new item 6 as follows:

6. Asphalt mastic shall be mixed to the proportions shown in Section 302 (3 or 4).

Page 29–8

214–4.—Change as follows:

4. Mineral filler shall be finely ground limestone or silica meeting the following requirements:

Passing a No. 200 (74 micron) sieve ....not less than 75 percent
Passing a No. 30 (590 micron) sieve ....not less than 100 percent

214–5.—Insert new section as follows:

5. Coal-tar pitch mastic to be mixed to the proportions shown in Sec. 302 (5).

216–1.—Replace item 1 with items 1, 2, 3 and 4, as follows:

1. Asphalt plank shall be a mixture of asphalt, mineral aggregate and fiber. It shall be not less than 1¼ in thick, and shall weigh not less than 85 lb per cu ft. The asphalt shall have such characteristics that when combined with other ingredients, a plank of desired quality will result.

2. The mineral aggregate shall consist of finely crushed slate, limestone, silica or other aggregate suitable for use with asphalt.

3. The fiber shall consist of finely divided whole threads or fiber free from lumps. Fiber shall be free from all foreign materials such as metal, leather, straw, sawdust or other deleterious material.

4. The average of three tests shall show the following proportions by weight:

Asphalt (by Soxhlet extraction apparatus): Min 40 percent; max 48 percent; avg 42.5 percent.

Mineral aggregate (measured as ash): between 35 percent and 45 percent.

Fiber, etc. (sum of asphalt and ash subtracted from 100): 8 percent to 22 percent.

The percent of ash shall not exceed the percentage of asphalt.

216–2.—Change to 5.

216–3.—Change to 6.

Page 29–9

301–5. Extend the first sentence to read: at expansion and deflection joints to provide flexibility in the membrane waterproofing as referred to in Sec. 102.

Page 29–10

301–7. First line, change 250 deg F to 300 deg F.

301–8. Insert new sentence at beginning—"Lapping of membrane waterproofing shall be in accordance with arrangement shown on Fig. 1."

301–13. Insert new section as follows:

13. At deflection and expansion joints provision shall be made in the membrane waterproofing for adequate movement of the structure. Primer shall be omitted for a width of 18 in on each side of the joint and a strip of impervious paper or other suitable material 36 in wide laid thereon before waterproofing is applied. Typical joints of the above type are shown in the AREA Specifications for Iron and Steel Structures.

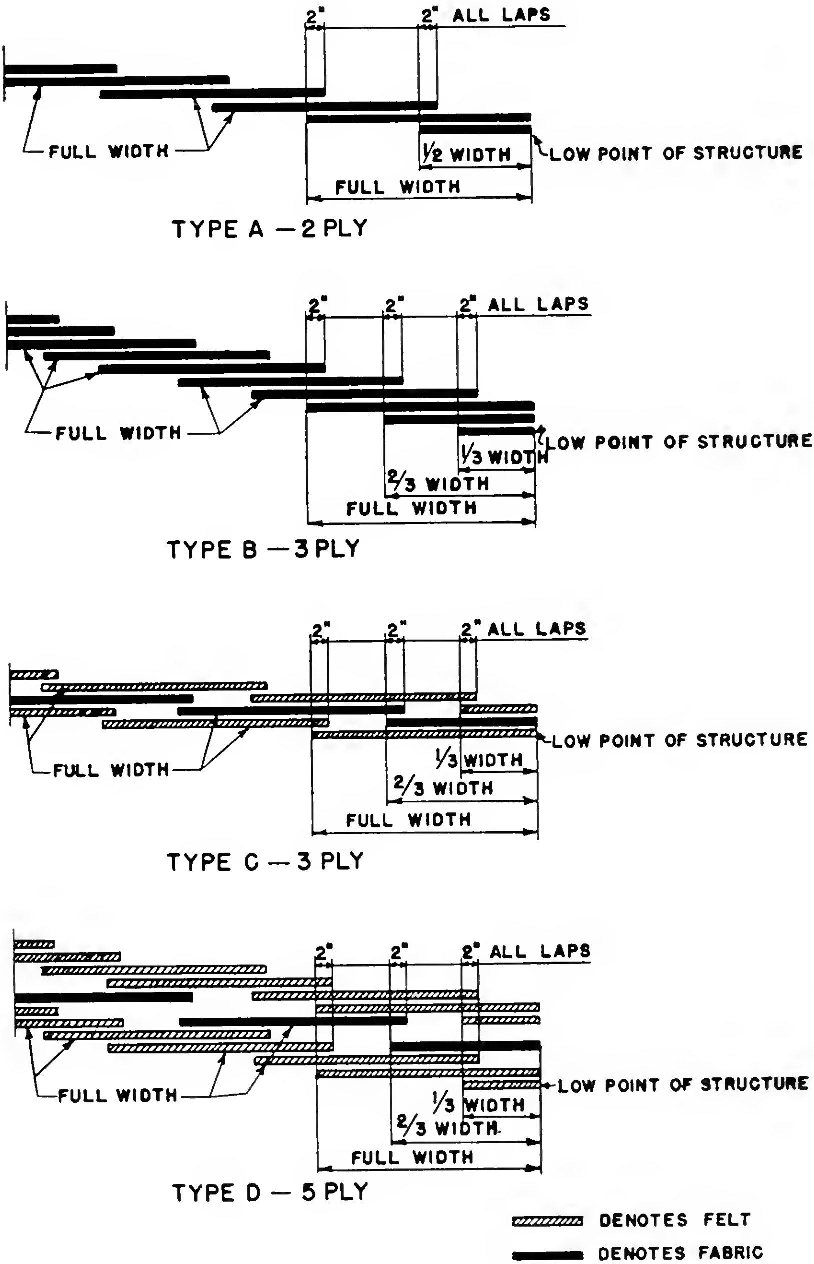
Change present Par. 13 to 14.

Page 29–11

302–2. Change the fifth word of first sentence from shall to may, and the twelfth word from "insulating" to "impervious."

302–3. Change last item to read "Mineral filler meeting requirements of Sec. 213 (4) ....15 percent to 19 percent."

302–4.—First item, change Sec. 213 (6) to 213 (5).



LAPPING OF MEMBRANE WATERPROOFING
FIG. 1

Change last item to read as follows:

Fine mineral aggregate, and mineral filler meeting requirements of Sec. 213 (3 or 4) ....19 percent

302–5.—Last item, change to read:

Mineral filler, meeting requirements of Sec. 214 (4)........15 percent to 20 percent

302–6.—In third sentence, fifth line, insert after stirring rods "or suitable mechanical heaters and mixers,"

Pages 29–13 to 29–16, incl.

PRINCIPLES GOVERNING THE WATERPROOFING OR DAMPPROOFING OF RAILWAY STRUCTURES

Reapprove with the following revisions:

Item 3—Insert after Waterproofing ", or waterproofing coatings."

In Secs. 3, 4, 5, and 7 A, change "should" to "shall."

Page 29–14

Item 8—In the second line after the word "waterproofing" place a period and delete the remainder of the sentence.

Item 9—Second line, change "against external pressure" to "from external sources."

SPECIFIC CASES

Item 1—Change "Abutments, Piers and Retaining Walls" to read "Abutments and Retaining Walls."

Item 2—Change "should" to "shall."

Item 3—Change to read "Pedestrian subways shall be waterproofed on surfaces in contact with the fill."

Page 29–15

Item 4—Change "should" to "shall" in second line.

Item 5—Delete entire Art. and substitute the following:

(a) The top surface of reinforced slabs and the backs of parapets shall be dampproofed or waterproofed. When construction is over streets or walkways, slabs shall be waterproofed.

(b) Joints shall be calked with oakum up to within 2 in or 3 in of tops of slabs, the calking extending downward as far as necessary to close the joints against the flow of the waterproofing material used to fill the joints. The space above this oakum packing shall then be filled to the top surface of the slab with plastic joint-filling material.

Items 6, 7, 8, 9, and 10—Change "should" to "shall" in eight places.

Page 29–16

Change "should" to "shall" in three places.

Pages 29–17 to 29–19, incl.

SPECIFICATIONS FOR BITUMINOUS EMULSIONS FOR DAMPPROOFING

Reapprove without change.

Glossary

Your committee recommends the revision of the following definitions now appearing in the Glossary in the Manual:

Page 9—Change definition of Dampproofing to:

DAMPPROOFING.—The treatment of any surface or structure to retard the entrance or passage of water in liquid form.

Page 32—Change definition of Waterproofing to:

WATERPROOFING.—The treatment of any material, surface or structure to prevent the entrance and passage of water in liquid form.

INTEGRAL.—The incorporation of any material other than the usual ingredients to prevent the entrance or passage of water in liquid form.

MEMBRANE.—The application of alternate layers of bitumen and fabric or felt to form a covering on a surface to prevent the entrance or passage of water in liquid form.

METALLIC.—The application to a surface of a mixture of a metal and a reagent, the chemical reactions of which tend to fill the pores, to prevent the entrance or passage of water in liquid form.

Report on Assignment 3

Waterproofing Protection to Prevent Concrete Deterioration

Collaboration with Committees 6 and 8

E. A. Johnson (chairman, subcommittee), Lyle Bristow, L. J. Deno, L. P. Drew, O. E. Fort, W. G. Harding, W. H. Hoar, W. E. Robey, K. B. Woods.

Your committee has sponsored tests on waterproofing coatings for concrete surfaces and their effect on the durability of concrete. These tests have been under way for the past several years at Purdue University under the general direction of Professor K. B. Woods, and have been conducted by J. B. Blackburn, research engineer, Engineering Experiment Station, assisted by members of the staff of the university.

Investigations were undertaken to determine relative merits of various waterproofing coatings when used on concrete exposed to outdoor weathering. Tests were made on 85 commercial and some experimental products. The final report on these tests will be found in Bulletin 503, September–October 1952.

The conclusions reached as a result of these tests are:

1. The impermeable type of coating can be applied satisfactorily to concrete surfaces that are exposed to severe outdoor weathering so long as all the surfaces that are subject to moisture absorption can be coated.

2. The impermeable type of coating is superior to the permeable type of coating in preventing the passage of moisture in either the vapor or the liquid form, in total immersion tests, or in outdoor absorption tests.

3. The impermeable type of coating is superior to the permeable type of coating from the standpoint of the durability of the coating, as well as the durability of the concrete when the coated concrete is subjected to freezing and thawing.

4. The impermeable type of coating is more durable than the permeable type of coating when applied to structures, as is evidenced by the results of tests in which coatings were applied to the south-facing wing walls of an overpass structure.

5. Only 2 of the 85 commercial waterproofing coatings that were tested were sufficiently waterproof to be classed as impermeable. These were both pigmented linseed oil coatings.

6. Nine pigmented-oil house paints used experimentally showed good durability and waterproofing ability when subjected to the first series of weathering tests. These results

were substantiated by data on one of these from the second series of weathering tests. Two undercoats and one finish coat were used.

7. Linseed oil used experimentally showed good results in both the first and second series of weathering tests when 3 coats were applied at 140–160 deg F.

8. A specification for waterproofing coatings can be written on the basis of the results of this investigation, which would involve some sort of weathering procedure, coupled with before-weathering and after-weathering immersion tests that would insure the use of a coating which was initially effective, which would be durable during the weathering test, and which would retain its effectiveness as a waterproofing coating.

Your committee presents the foregoing as a final report for publication in the Proceedings of the Association as information.

SPECIFICATIONS FOR WATERPROOFING COATINGS

Your committee has drawn up specifications of the acceptance type for waterproofing coatings based on the tests made at Purdue University, which are submitted in the following, with the recommendation that they be adopted and published in the Manual.

SPECIFICATIONS FOR WATERPROOFING COATINGS FOR EXPOSED CONCRETE SURFACES

A. GENERAL

1. Scope

These specifications apply to:

(a) Waterproofing coatings intended as surface waterproofers on concrete exposed to outdoor weathering to prevent concrete surface deterioration by eliminating the entrance of water through the exposed surface and

(b) the procedure for the acceptance testing of such surface waterproofing coatings.[1]

2. Limitation

Waterproofing coatings should not be used on surfaces that are reached by water passing through the concrete, such as abutments or retaining walls, the backs of which were not waterproofed or on which the waterproofing has failed, permitting water to pass through to the face. The use of a waterproofing coating on such a surface, which effectively prevents the escape of water, will result in earlier concrete disintegration than if the exposed face had not been coated.

These specifications do not apply to surface coatings for interior walls or other surfaces that are not exposed to outdoor weather conditions.

3. Uses

These specifications cover waterproofing coatings that are applicable for use on exposed surfaces such as handrails, parapets, stairwells, piers, concrete piles, caps, columns, etc.; and the face of abutments, wing walls and retaining walls, the backs of which have ben effectively sealed to prevent the entrance of water.

4. Preparation of Surface

Before applying the coating, the surface shall be cleaned of all dirt, loose and foreign material by sand blasting, the use of wire brushes, or washing with water.

---

[1] Tests on a large number of waterproofing coatings have shown that none of these are strictly speaking waterproof. Coatings were found to be water resistant in widely varying degrees. The more impermeable coatings were fairly waterproof. The term "waterproof" has been retained in these specifications to cover products commercially designated as waterproofing coatings.

Spalled, cracked or honeycombed areas shall be repaired in accordance with AREA Specifications for Repairing Deteriorating Concrete.

It is recommended that new concrete be permitted to cure for at least one year before applying a waterproofing coating.

B. ACCEPTANCE TEST

1. General

A material to be used as a waterproofing coating must satisfactorily withstand the acceptance test as set forth in these specifications.

2. Criteria for Acceptance

The criteria for acceptance shall be the ability of a coating applied to concrete test specimens to pass the requirements of:

(a) The 72-hr immersion test (Sec. E)
(b) The freeze and thaw test (Sec. F)
(c) The final 72-hr immersion test (Sec. G)

C. CONCRETE TEST SPECIMENS

1. General

At least three specimens 1 in by 3 in by 8 in shall be prepared for each waterproofing coating being tested.

2. Materials

The concrete test specimens shall be fabricated from materials conforming to applicable AREA Specifications for Concrete.

Cement—Type 1 or Type 2

Coarse Aggregate—Crushed stone or gravel to be of one size which passes a ⅜-in sieve, and all of which is retained on a No. 4 sieve (4760 microns)

3. Mix Design

The concrete mix from which the specimens are fabricated shall contain 6 (plus or minus 0.5) sacks of cement per cubic yard and have a water-cement ratio of 0.60 (plus or minus 0.02) by weight. The fine aggregate and the coarse aggregate shall be proportioned in a ratio of 1 to 1 by volume.

4. Fabricating

The fresh concrete shall be thoroughly mixed either mechanically or by hand, carefully placed and rodded in molds forming test specimens measuring 1 in by 3 in by 8 in. The specimens shall be cast with the 3-in dimension as the vertical dimension. The molds shall be covered with damp cloths for 24 hr, after which time the specimens shall be removed from the mold and weighed (W_1). At this weighing the specimen is assumed to be holding all the moisture that it can hold under these test conditions. The specimens shall then be cured in fresh water at room temperature for 7 days.

5. Curing

At the end of 7 days curing in water, the specimens shall be removed and placed in an oven to dry for 7 days. The temperature of the oven to be held at 90 (plus or minus 5) deg F, and the relative humidity inside the oven shall be less than 30 percent during the drying period.

D. COATING THE TEST SPECIMENS

1. Preparing Specimens for Coating

The specimens shall be removed from the oven at the end of 7 days and etched with a 15 percent solution of muriatic acid and immediately rinsed in fresh water for complete removal of the acid. The specimens shall then be placed back in the 90 deg F oven for 48 hr of drying. They shall then be removed and weighed (W_2).

2. Application of Coatings

The waterproofing coating shall be applied to three concrete test specimens, all in a like manner, in accordance with manufacturer's instructions as to number of coats and methods of applications. The test specimens are to be coated in the same manner and method as proposed for use on the structure to be waterproofed.

Carefully coat each specimen so that all surfaces shall be covered. Each successive coat shall be permitted to dry thoroughly before applying the next coat.

3. Determination of Number of Applications Required

If the number of coats required for effective waterproofing has not been predetermined, apply a varying number of coats to each group of three test specimens, i.e., one coat, two coats, three coats .... Three like-coated test specimens are required for each series of tests.

4. Curing the Coatings

After the last coat has dried, so that the specimens can be handled, the specimens shall be placed in the 90-deg F oven for a period of 7 days in order to cure the coatings.[2]

5. Weight of Coating

At the end of 7 days the specimens shall be removed from the oven and weighed (W_3). The difference between this weight (W_3), and the weight (W_2) determined prior to the application of coating, shall be the weight of the coating (W_c). That is $W_c = W_3 - W_2$.

The weight of the coating thus determined shall be subsequently deducted from the weight of the specimens after being immersed in water for 72 hr.

E. THE IMMERSION TEST

1. Procedure

After the coated specimens have been cured and weighed, they shall be immersed in water at room temperature for a period of 72 hr. The specimens shall then be removed, all surface moisture blotted or wiped off, and weighed (W_4).

2. Requirement for Acceptance

The acceptance of a waterproofing coating shall be determined by the ability of the coating to prevent the absorption of water by the test specimens.

The difference in the weight W_1 of a specimen when removed from the mold (Sec. C, Art. 4) and the weight W_2 when prepared for coating (Sec. D, Art. 1) shall be a measure of the volume available within the specimen for the further absorption of water. This difference in weight to be expressed as D; that is $D = W_1 - W_2$.

[2] Exceptions to the 7 days of oven drying are the cement-base coatings, which should be cured in a moist atmosphere of not less than 98 percent relative humidity for 4 days, followed by 3 days in the oven.

The weight of moisture absorbed by the test specimen during the immersion test is the difference in weight W_1 of the specimen when removed from the mold (Sec. C, Art. 4), and the weight W_t of the specimen after the immersion test (Sec. E), less the weight W_c of the coating (Sec. D, Art. 5). This difference in weight to be expressed by d; that is $d = W_1 - (W_t - W_c)$.

3. Efficiency Determination

The efficiency E of the coating is the average of the three test specimens, and is a measure of the impermeability of the coating. E in percent $= 100 \frac{d}{D}$

To be acceptable under this test, the efficiency of any coating must be 85 percent or higher, as determined by the average of three test specimens. If the efficiency of any one of the specimens falls below 85 percent, it must not vary more than 5 percent from the average of the group.

If the waterproofing coating passes the requirements of this section, the test specimens shall then be subjected to the freeze and thaw weathering test in accordance with Sec. F, Art. 1.

F. FREEZE AND THAW WEATHERING TEST

1. Procedure

The coated specimens which have met the requirements of Sec. E, Art. 2 shall be subjected to 50 cycles of freezing and thawing, as outlined below. During this test there shall be no signs of deterioration of the coatings upon visual inspection.

The specimens shall be frozen in air at a temperature of 0 (plus or minus 5) deg F, and thawed in water at 130 (plus or minus 5) deg F at the rate of 3 cycles per day. The specimens shall be in the freezer from 9 am to 12 noon, 1 to 4 pm and 5 pm to 8 am. The freezer shall be of such capacity that when filled with test specimens it will lower the temperature at the center of a test specimen to 10 (plus or minus 2) deg F in less than 1 hr, but in not less than 30 min. When the freezer is only partially filled with test specimens, dummy specimens shall be used to keep the freezing load constant.

2. Requirements for Acceptance

If a coating should blister, crack, or peel, or otherwise fail during the freeze and thaw test, this shall be a cause for rejection.

If a coating meets the requirements of this section, the coated specimens shall be subjected to the final 72-hr immersion test as outlined in Sec. G.

G. THE FINAL 72-HR IMMERSION TEST

1. Procedure

Coated specimens which have met the requirements of Secs. E, Art. 2 and F, Art. 2 shall be subjected to a final 72-hr immersion test in accordance with the test procedure outlined in Sec. E.

To be accepted under this test the efficiency must be 85 percent or higher, as determined by the average of 3 test specimens. If the efficiency of any one of the specimens falls below 85 percent, it must not vary more than 5 percent from the average of the group.

The efficiency E shall be determined as set forth in Sec. E, Art. 3.

2. Requirement for Final Acceptance

To be finally accepted the waterproofing coatings shall have met the requirements of Secs. E, F and G of these specifications.

Report of Committee 28—Clearances

A. R. Harris, *Chairman*,
C. O. Bird
E. S. Birkenwald
B. Bristow
W. S. Campbell
A. B. Chapman
S. M. Dahl
W. T. Davis
D. H. Dowe
R. A. Emerson
J. E. Fanning
J. L. Fergus
N. O. Geuder
J. E. Good
J. G. Greenlee
W. F. Hart
W. L. Hartzog
J. D. Hudson
C. F. Intlekofer
M. L. Johnson
M. V. Kane
F. Martin
T. W. Meushaw
A. G. Neighbour
R. C. Nissen
C. E. Peterson
A. M. Weston, *Vice Chairman*,
W. F. Pohl
A. D. Quackenbush
W. E. Quinn
A. J. Rankin
W. S. Ray
J. C. Scholtz
J. H. Shieber
J. E. South
O. W. Stephens
J. W. Wallenius
E. R. Word
Committee

To the American Railway Engineering Association:

Your committee reports on the following subjects:

The Committee on Clearances,
A. R. Harris, *Chairman*

AREA Bulletin 505, December 1952.

Report on Assignment 1

Revision of Manual

J. E. Fanning (chairman, subcommittee), R. A. Emerson, A. R. Harris, W. F. Pohl, W. E. Quinn, A. M. Weston, E. R. Word.

The committee recommends that the following notes and clearance and equipment diagrams appearing in Chapter 28 of the Manual be reapproved without change:

Page 28–1

SPECIAL NOTES

Page 28–2

CLEARANCE DIAGRAM FOR RAILWAY AT BRIDGES

Page 28–3

CLEARANCE DIAGRAM FOR TURNTABLES

Page 28–4

CLEARANCE DIAGRAM FOR SINGLE TRACK TUNNEL

Page 28–5

CLEARANCE DIAGRAM FOR DOUBLE TRACK TUNNEL

Page 28–6

CLEARANCE DIAGRAM FOR BUILDINGS AND SHEDS ADJACENT TO SIDE TRACKS

Page 28–7

CLEARANCE DIAGRAM FOR WAREHOUSE AND ENGINEHOUSE DOORS

Page 28–8

CLEARANCE DIAGRAMS FOR PLATFORMS

Page 28–9

EQUIPMENT DIAGRAM UNRESTRICTED

Page 28–10

EQUIPMENT DIAGRAM UNRESTRICTED FOR MAIN LINES

Report on Assignment 5

Clearance Allowances to Provide for Vertical and Horizontal Movements of Equipment Due to Lateral Play, Wear, and Spring Deflection,

Collaborating with the Mechanical Division, AAR

S. M. Dahl (chairman, subcommittee), C. O. Bird, B. Bristow, J. L. Fergus, J. G. Greenlee, A. R. Harris, W. F. Hart, J. D. Hudson, M. L. Johnson, A. G. Neighbour, C. E. Peterson, W. F. Pohl, A. D. Quackenbush, A. J. Rankin, J. C. Scholtz, J. W. Wallenius, A. M. Weston.

The clearances of equipment on tangent track present no difficult problem and have been solved with a reasonable degree of accuracy. The movement of equipment on curved track presents problems of a different nature and of more importance. In the last 20 years new factors have been introduced, such as higher speeds, the soft steel spring, changes in design to promote better riding qualities, etc. Some of these factors have increased the lateral displacement of equipment.

Heretofore it has been commonly assumed that the center line of equipment is always perpendicular to the plane of the rails and midway between the rails, as shown in Fig. 2. Allowances have always been made in the past for offset due to curvature and tilting due to superelevation, but other factors, such as tilting on the springs, lateral play and wear, have not generally been taken into account, except, possibly, to add 3, 6, or 9 in as a safety factor. Whether these figures are too great or too small has never been determined adequately.

Lateral displacement of equipment can be due to any or all of the following:

1. Offset due to curvature.
2. Tilting due to superelevation.
3. Lateral movement due to play in various parts of the truck, including lateral movement of bolster and lateral movement wheel to rail.
4. Tilting due to unequal compression of the springs and play in the side bearing.

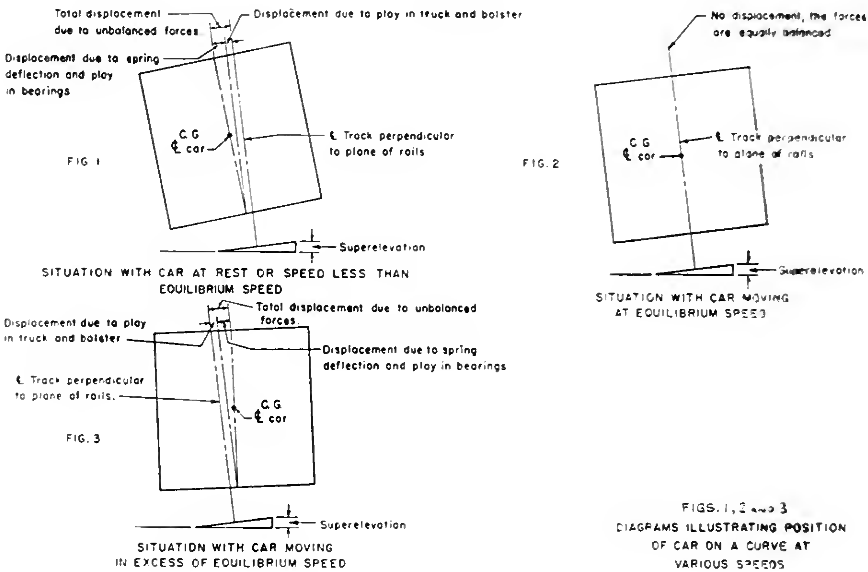
Items 1 and 2 are not included in the discussion that follows. These items have long been recognized and should be handled separately. For a given curvature and superelevation the offset due to curvature, and tilting due to superelevation, may be easily calculated. However, it should be brought out that track maintenance will cause material changes in these items.

The last two items (3 and 4) may be called the "minor lateral displacements," as they are composed of a number of small displacements, but the sum may be of considerable magnitude. The collective sum of these items will be referred to as "total displacement," by which term is meant the distance between the center line of the car and the perpendicular to the plane of the rails at the center of the track, at any height above the top of rails, usually taken at or near the eaves. Figs. 1 and 3 illustrate the total displacement diagrammatically.

The factor that causes the above mentioned lateral displacements is the centrifugal force that is not balanced by the superelevation in the track. This force is due to the "unbalanced elevation" as contrasted to "equilibrium elevation". Under the latter condition, the centrifugal force is exactly balanced by the superelevation; therefore these forces are in equilibrium. The speed that brings about this condition is the "equilibrium speed." If the speed is increased above the equilibrium speed, the centrifugal force is increased, while the superelevation remains the same. This results in an excess of centrifugal force which tends to tilt the car on its springs and take up the play in the trucks. The superelevation is now "unbalanced" and the amount of additional elevation required to bring the forces back to equilibrium is the "unbalanced elevation". Fig. 4 illustrates unbalanced elevation diagrammatically.

The same condition obtains when the speed is reduced below the equilibrium speed, but in this case the lateral gravity component due to superelevation exceeds the centrifugal force and the unbalanced elevation becomes negative, requiring a lesser elevation to produce equilibrium. At rest, there is no centrifugal force and the unbalanced elevation is equal to the actual superelevation in the track.

Fig. 1 illustrates the position of a car at rest, or moving at a speed less than the equilibrium speed. The car tilts toward the low rail due to unequal spring deflection and has moved laterally due to play in the truck parts. Fig. 2 illustrates the position of a car at equilibrium speed when the lateral forces are equally balanced. Fig. 3 illustrates the position of a car moving in excess of the equilibrium speed. The car tilts toward the high rail and has also moved laterally due to play in the truck parts. It will



FIGS. 1, 2 AND 3
DIAGRAMS ILLUSTRATING POSITION OF CAR ON A CURVE AT VARIOUS SPEEDS

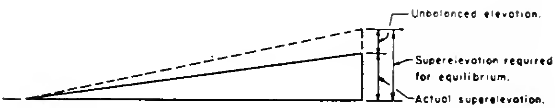


Fig. 4 Diagram illustrating unbalanced elevation.

also be noted that the center of gravity (C.G.) has moved from the left side (Fig. 1) to the right side (Fig. 3) of the center line perpendicular to the plane of rails.

Theoretically, it can be proved that the displacement of a moving car on a curve is a function of the displacement at rest, varying as the square of the speed. Since it would be highly impractical to make running tests to determine the displacement of all cars on which this information is desired, your committee requested field tests to confirm the theoretical determination of the displacement, which, if confirmed, will provide a practical solution to the problem.

The ride tests made by the AAR in behalf of Committee 5—Track, have provided some of the field information required by our committee. In these tests, cars were equipped with special instruments which recorded, among other things, the angular tilt of the cars while traversing the curves. The speed, degree of curve and superelevation were recorded for each curve and the unbalanced elevation calculated. These data were secured on several hundred curves on each railroad over which these tests were made.

For the special benefit of the Clearance committee, additional field tests were made to determine the displacement at rest of the same cars at selected superelevations, usually 2, 4 and 6 in. In these tests the amount of displacement was secured by placing the car on a superelevated track and measuring the horizontal and vertical coordinates to selected points on the car.

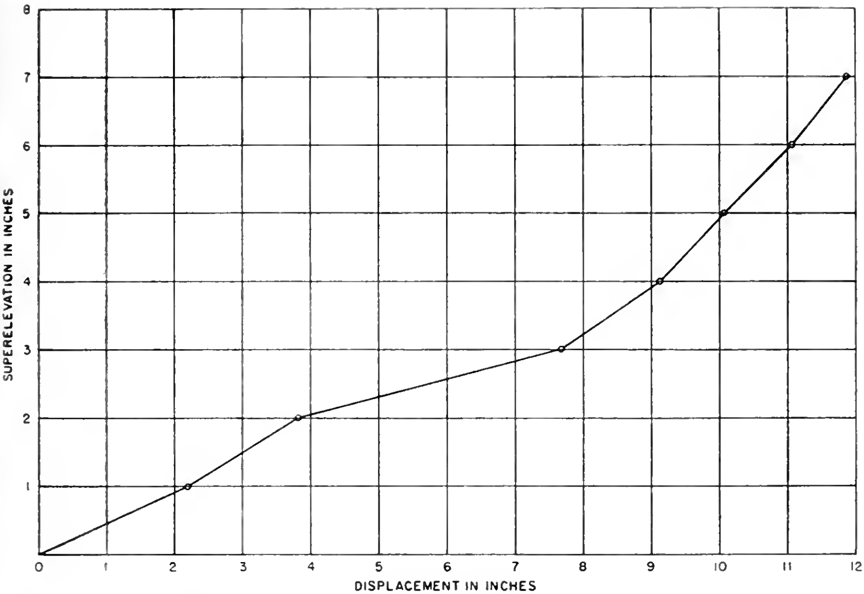


Fig 5 Diagram showing displacement of a car at rest at various superelevations

Running and static tests were made on cars of the following railroads:

Kansas City Southern
Delaware, Lackawanna & Western
New York, New Haven & Hartford
Chicago, Burlington & Quincy
Chicago, Milwaukee, St. Paul & Pacific
Pennsylvania

Cars with trucks of different types were selected for the field tests, such as trucks with outboard swing hangers, inboard swing hangers, no swing hangers, with and without roll stabilizers, soft steel springs, etc.; also one dome car. To date tests have been made only on passenger equipment, but field tests will eventually be made on freight cars and locomotives.

Fig. 5 shows the amount of displacement for a typical passenger car at rest at superelevations varying from 1 to 7 in. The displacement is that due to spring deflection and play in truck and bearing and does not include any offset due to curvature. The irregularity below 4 in of superelevation is due to play in the truck which was not taken up uniformly as the superelevation was increased. At 4 in the play was all out and the increase in displacement thereafter was due to unequal spring deflection.

Fig. 6 shows the relation between displacement and unbalanced elevation for a particular car in both running and static tests. Each running point represents the average displacement on a particular curve at the unbalanced elevation corresponding to the recorded speed while traversing the curve. There are also three points platted showing the displacement of the same car at rest on superelevations of approximately 2, 4, and

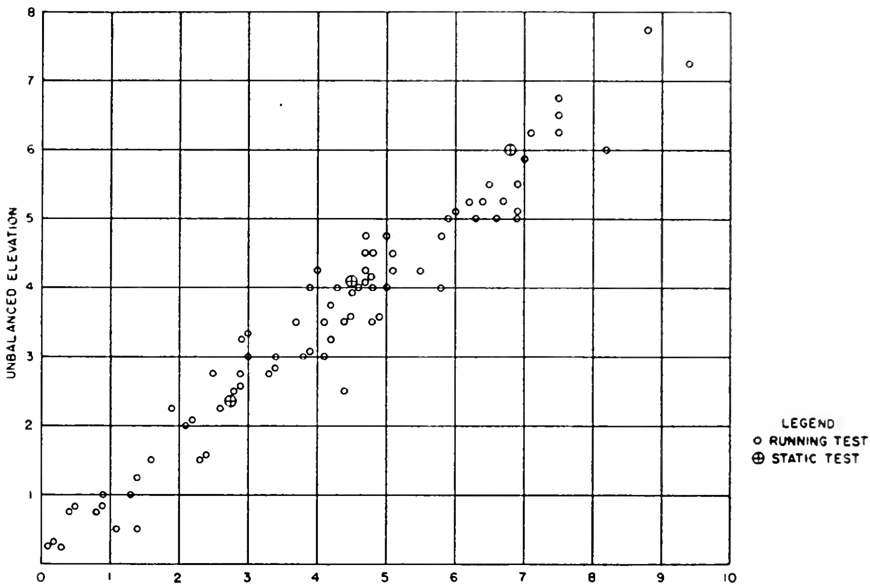


Fig 6 Diagram showing relation between displacement and unbalanced elevation

6 in, in which cases the unbalanced elevation is equal to the superelevation. It will be noted that the static displacement and the running displacement follow closely for equal amounts of unbalance.

Field tests of the type described have been completed and it is expected that the analysis of the data will be completed in time to present a full report on the results next year.

This report is presented as information only.

Report on Assignment 6

Methods for Measuring Railway Clearances

A. M. Weston (chairman, subcommittee), B. Bristow, W. S. Campbell, J. E. Good, A. R. Harris, M. V. Kane, F. Martin, T. W. Meushaw, W. S. Ray, O. W. Stephens.

At the annual meeting in 1951 your committee presented as information a report pertaining to present practices of the railroads in measuring clearances (see Proceedings, Vol. 52, 1951, pages 405–408). Included in the report was a detailed description of cars used by the New York Central System and the Baltimore and Ohio Railroad.

Since that time the Pennsylvania Railroad has constructed a new car for measuring clearances and the Erie Railroad has submitted a description of a modern device which it uses for measuring clearances.

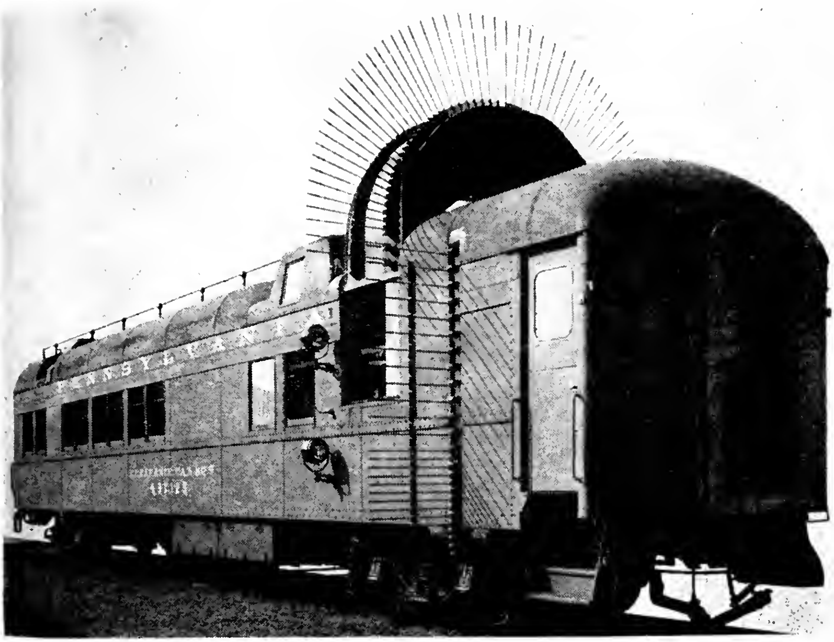


Fig. 1—Pennsylvania Railroad car with "horse shoe template" in raised position, feelers extended.

Clearance Car on the Pennsylvania

The new car of the Pennsylvania, shown in Fig. 1, is described as follows.

The car, which was designed by the mechanical and engineering departments of the railroad, was built at its Altoona, Pa., shops, and is divided into five compartments: 1. Template room; 2. kitchen, wash room and toilet; 3. dining and sleeping; 4. lounge room; and 5. recording room (see Fig. 4).

All measuring instruments, 126 in all, are located in the "template room" (Figs. 2 and 3), and are divided into four groups.

a. Oval template, called "Horse Shoe", which is adjustable in height from 17 ft to 21 ft above top of rail. This has a straight portion on each side beginning at 8 ft above top of rail and extending upward, perpendicular to plane of rail, to a point 9 ft above the rail when the template is in normal or down position, at which point it curves over the car on a 5-ft radius.

b. "Main Template" remains in a fixed position on both sides of the car between heights of 2 ft and 11 ft 6 in above top of rail.

c. "Right Foot" and d. "Left Foot" Templates, each of which extends downward from a height of 2 ft 6 in above top of rail, are adjustable, and when not in use can be raised by means of a hydraulic lift to prevent striking objects along the track when in transit.

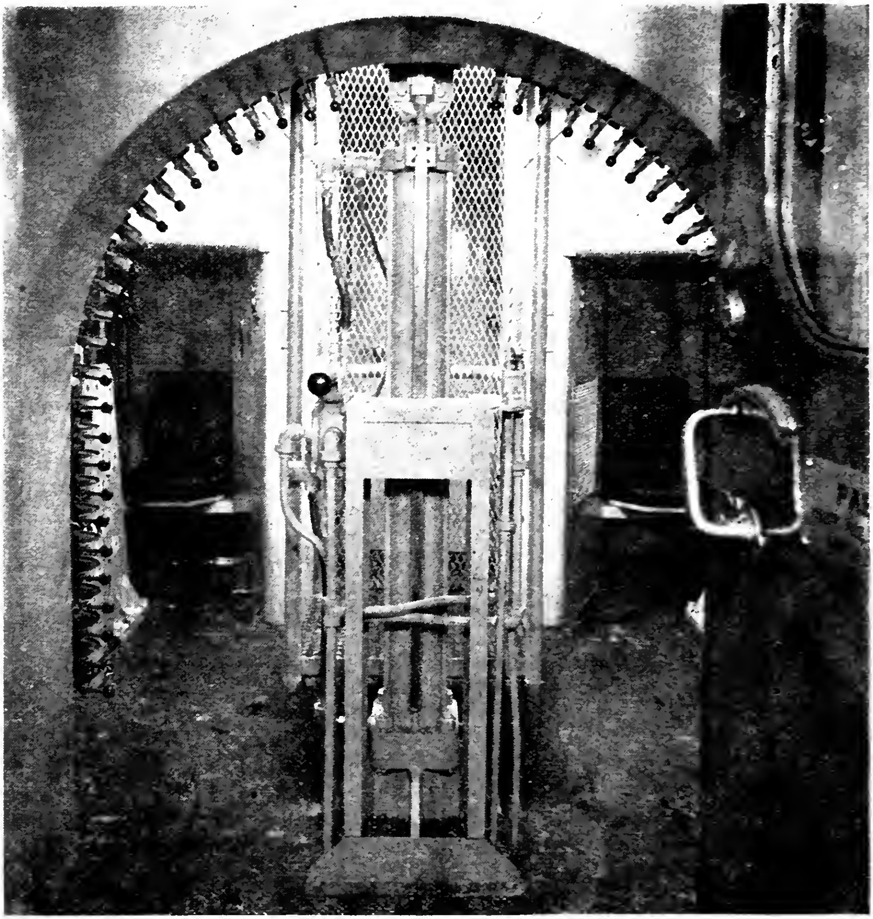


Fig. 2—Template room in Pennsylvania car where measuring equipment is operated.

The measuring and recording instruments consist of three main parts:

1. "Feelers", which are 36 in long, attached to outside of car and made of ½-in aluminum tubing with tool steel hardened tip.
2. "Teleflex Cable", which passes from the outside gear box to gear box on indicator quadrant.
3. "Indicator Quadrant", which is attached to inside gear box, has on outer circumference of quadrant a scale graduated to the ⅛ in from 0 to 36 to indicate exactly the clearance measurement for the position taken by feeler.

Located directly over the center line of the rear truck is a rear template which is used to measure overhead structures more than 21 ft above top of rail, and which cannot

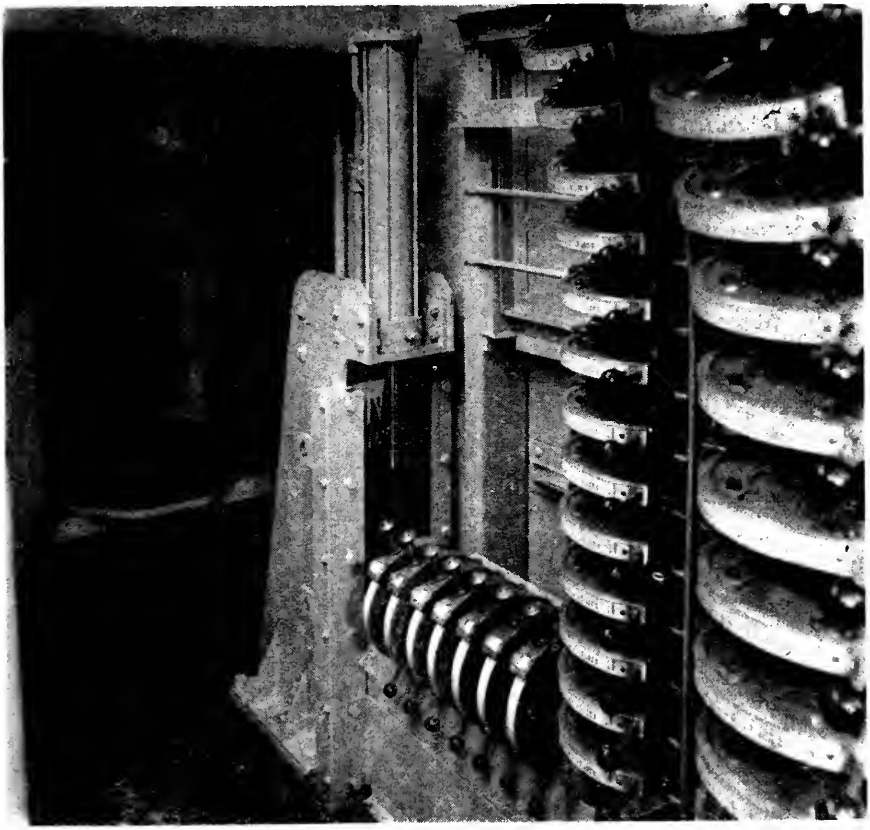


Fig. 3—Closeup view of template room in Pennsylvania car, showing recording instruments.

be reached by the "Horse Shoe" template. These structures are measured by means of telescoping gages which are extended to the under side of the structure, and as the car moves are pushed down to minimum clearance. Gages are graduated for readings in feet and inches above top of rail.

When the car is in measuring position, the feelers are extended outward, and as the car moves slowly by the structure the feelers are brushed back to the contour of the structure, which is recorded on a diagram to a scale of ½ in to the foot. Upon completion of the recording of measurements the clearance diagram is complete and the clearance of a structure can be determined immediately.

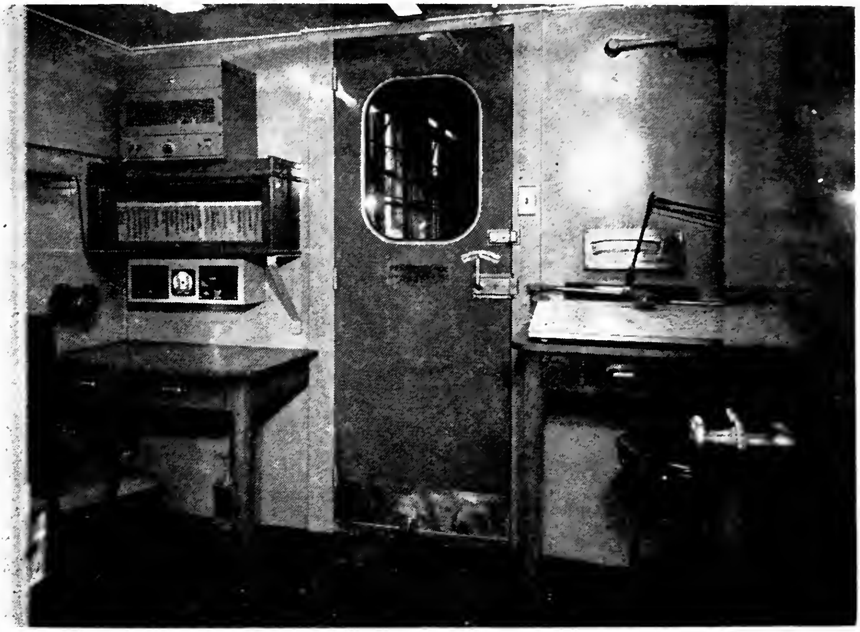


Fig. 4—Recording room in Pennsylvania car.

Clearance Measuring Machine on the Erie

The clearance measuring machine of the Erie, shown in Fig. 5, is assembled for operation and is described as follows:

This machine is entirely constructed of aluminum tubing and sections, weighing approximately 50 lb, exclusive of carrying cases. It comprises a three-wheeled carriage or substructure, which is built to travel along a standard gage track so that structures to be investigated along or over the track can be located with respect to the center line of the track. On the carriage on one side is mounted a vertical column which supports a swingable boom. On the free end of the boom is mounted a vertical telescopic rod, which is perpendicular to the plane across top of rails and at a fixed distance from vertical or reference axis at half of the track gage. This rod can be used for direct measurements and is telescopic, vertically extensible and contractible. Measurements from the vertical axis to obstructions, other than those made with the extensible upright rod, are made laterally by extending arms on the upright rod and by a supplemental element mounted in a vertical position on the upper arm. The lateral arms are longitudinally extensible and contractible, and the supplemental vertical element is bodily shiftable along the upper arm. The connections of the lateral arms to the upright rod and of the upright rod to the boom include suitable indexing means for orienting the arms in the plane of the boom and the main reference axis. An illuminated visual

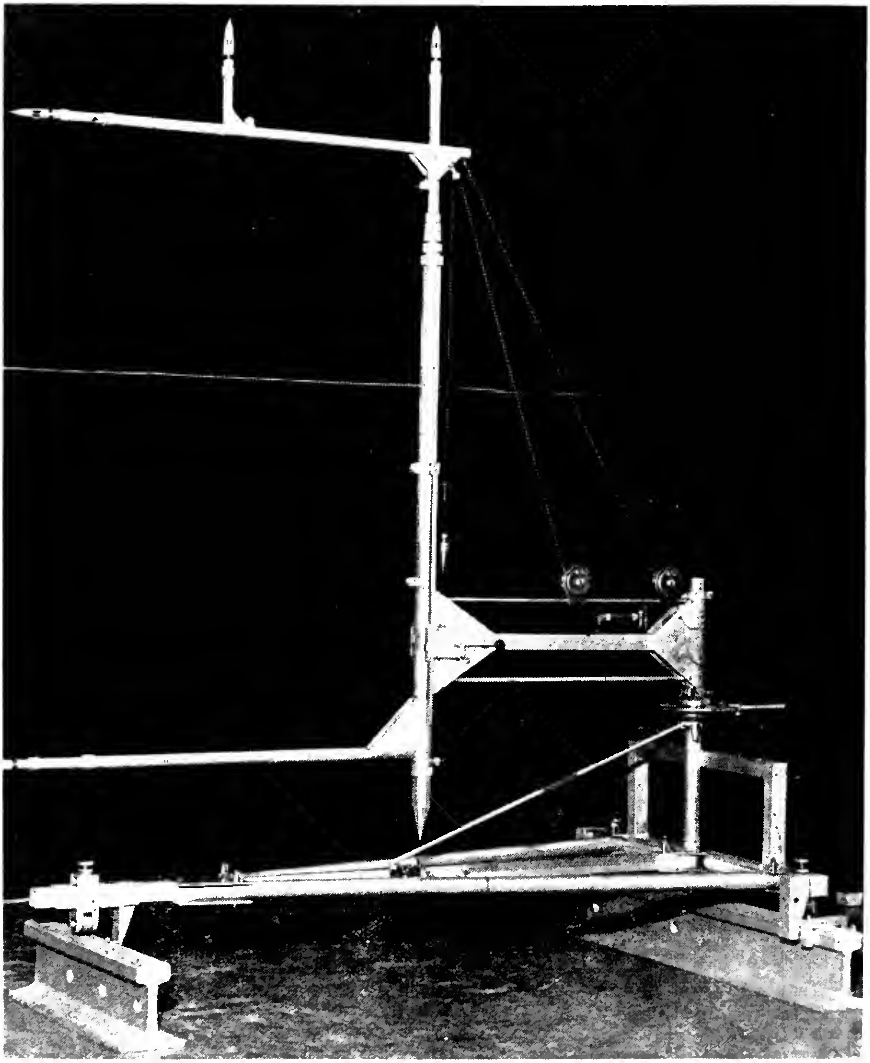


Fig. 5—Erie Railroad measuring machine assembled for operation.

indicator is provided for use on the measuring upright rod and lateral extending arms to indicate contact or limit of movement.

The machine can be disassembled and readily placed in the carrying cases, as shown in Fig. 6. (See page 844).

This is a final report, presented as information.

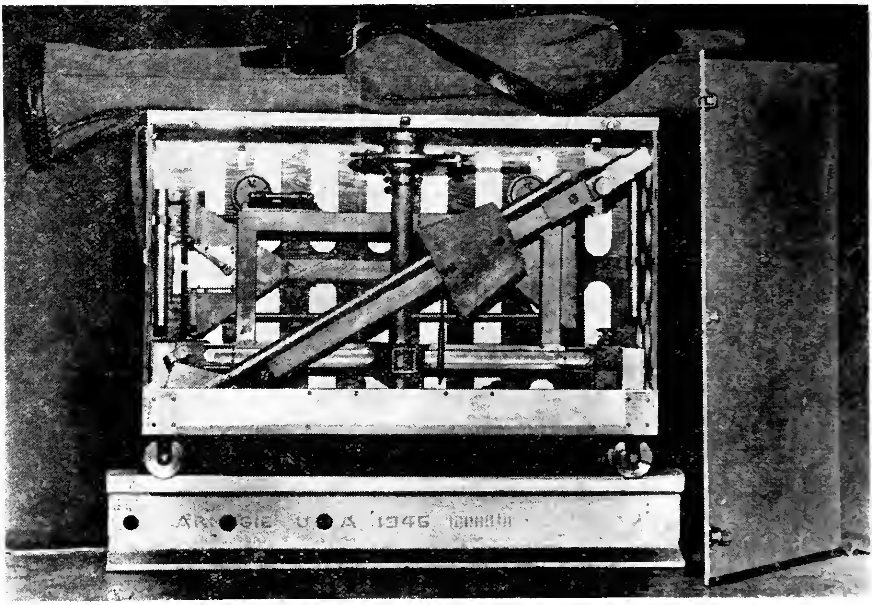


Fig. 6—Erie machine disassembled and in carrying case.

Report of Committee 11—Records and Accounts

Louis Wolf, *Chairman,*
R. B. Aldridge
F. B. Baldwin
H. D. Barnes
S. H. Barnhart
W. C. Bolin
H. T. Bradley
M. A. Bryant
P. D. Coons
V. R. Copp
Spencer Danby
V. H. Doyle
Benjamin Elkind
D. E. Field
Morton Friedman
W. S. Gates, Jr.
M. M. Gerber
W. A. Godfrey
B. H. Moore, *Secretary,*
W. M. Hager
C. C. Haire
A. T. Hopkins
L. W. Howard
C. Jacoby
E. M. Killough
W. A. Krauska
W. M. Ludolph
M. F. Mannion
C. B. Martin
A. H. Meyers
O. M. Miles
J. B. Mitchell
F. H. Neely
J. H. O'Brien
M. G. Pettis
A. T. Powell
H. N. Halper,
Vice Chairman,
H. L. Restall
J. H. Roach
E. J. Rockefeller
S. M. Rodgers
H. B. Sampson
R. L. Samuell
W. F. Sanders
J. E. Scharper
J. H. Schoonover
R. W. Scott
H. A. Shinkle
J. N. Smeaton
J. R. Traylor
H. C. Wertenberger
J. L. Willcox
Committee

To the American Railway Engineering Association:

Your committee reports on the following subjects:

Special Subject:

The Committee on Records and Accounts,
Louis Wolf, *Chairman.*

AREA Bulletin 506, January 1953.

Report on Assignment 1

Revision of Manual

J. B. Mitchell (chairman, subcommittee), F. B. Baldwin, W. C. Bolin, M. A. Bryant, P. D. Coons, D. E. Field, C. C. Haire, E. M. Killough, W. M. Ludolph, M. F. Mannion, S. M. Rodgers, R. L. Samuell, J. H. Schoonover, J. N. Smeaton.

Your committee offers the following recommendations with respect to the Manual:

Eliminate all form numbers in Chapter 11 of the Manual as to be reprinted in 1953 and substitute full titles of forms.

Page 11–45

(1) Adoption of revised Form 1125 "Side Track Record" and addition of instructions for its use. The proposed form and text are as shown in Statement "A".

Pages 11–1 to 11–70, incl.

(2) Reapprovals, revisions, or deletions of the subject-matter appearing on these pages. The recommendations are as presented in Statement "B".

Statement A

Proposed Text to Be Added in the Manual Covering the Use of Form 1125—Side Track Record

Instructions for use of Form for Side Track Record

This form is designed (1) to provide data for compiling reports to State Railroad Commissions and the Interstate Commerce Commission; (2) to provide data for annual reports; (3) keep a record of ownership of side tracks; (4) keep records for taxation purposes and (5) provide a convenient method by means of which the officers of a railroad in direct charge of maintenance or the changing of side tracks may become familiar with the conditions under which the tracks are constructed and maintained. This information is especially valuable in connection with side tracks which are owned wholly or in part by private parties or corporations, the maintenance of which is performed by the railroad company and the cost charged against the owner. (See Proceedings, Vol. 12, Part 3, 1911).

NORTH & SOUTH RAILROAD

SIDE TRACK RECORD

STATE..............................

VALUATION SECTION..................

ORIGINAL / CONTINUATION } SHEET Nº...........

NOTE RED USED TO INDICATE REMOVALS

				LOCATION							TURNOUT FROG Nº		LENGTH-TRK FT						
													RAILROAD-OWNED						
	TRACK INDEX Nº	NAME OF TRACK	DATE OF ENTRY	MILE POST	NAME OF NEAREST STATION	COUNTY	SURVEY STATION AT P.S.	AFE Nº	DATE COMPL	CONTRACT Nº	OFF MAIN TRK	OFF SIDE TRK	WHOLLY	CUM TOTAL	JOINTLY	CUM. TOTAL	PRIVATE	REMARKS	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
1																			1
2																			2
3																			3
4																			4
5																			5
6																			6
7																			7
8																			8
9																			9
10																			10
11																			11
12																			12
13																			13
14																			14
15																			15
16																			16
17																			17
18																			18
19																			19
20																			20
21																			21
22																			22
23																			23
24																			24
25																			25
26																			26
27																			27
28																			28
29																			29
30																			30
31																			31
32																			32
33																			33
34																			34
35																			35
36																			36
37																			37
38																			38
39																			39
40																			40
41																			41
42																			42
43																			43
44																			44
45																			45
46																			46
47																			47
48																			48
49																			49
50																			50
51																			51

Fundamentally, this record is not an inventory, but rather a continuous condensed history of each side track, containing the minimum basic data required for the various purposes. With this form provision must be made for collecting further data and for submitting the information in summary form as required. The additional data will vary according to the details desired by individual railroads and can be entered on fly or continuation sheets. Suggested data that may be shown is indicated as follows:

1—Length by ICC Classification
- Running Tracks (passing tracks, etc.)
- Way Switching Tracks
- Yard Switching Tracks

2—Tax District Data
- Township
- Road District
- Sanitary District
- School District, etc.

3—Other Data
- Track Section Number
- Car Capacity
- Use of Track

The purpose and use of many of the columns on the form are evident from the headings, but for others which are more obscure, an explanation follows:

Col. 7, "SURVEY STATION AT P S", is intended to help identify and locate side tracks with reference to yard maps by showing the survey station and plus to the point of switch of the turnout. Where there is a turnout at both ends of a track, the station pluses for both turnouts may be recorded, one above the other, on the same horizontal line, or on separate lines as preferred.

Col. 8, "AFE NO.", the notation "ER" or "ICC" should be used to designate initial entries based upon ICC Engineering Report, and for which no AFE reference is available.

Col. 10, "CONTRACT NO.", is used to record any references to contracts pertaining to ownership, use, maintenance, etc., of either joint or private trackage.

Cols. 11 and 12 show the frog numbers of turnouts, the data being used to compute distances to clearance points. Separate columns are used for turnouts "OFF MAIN TRACK" and "OFF SIDE TRACK" in order to determine equated mileage. This information is used both for ICC annual reports and maintenance matters.

Cols. 13 and 15 are used to show the initial lengths of each track and also, on succeeding lines, the lengths of subsequent changes.

Cols. 14 and 16 are provided to show the revised lengths after each change. If it is necessary to show lengths on and off the right-of-way, these lengths can be shown in Col. 18.

Col. 18, "REMARKS", may be used for making any special notations, including especially, ownership of right-of-way, data regarding maintenance of joint and private tracks, tax districts, etc., and these notations may be referred to the proper column entry by use of various symbols. It may, in some cases, be convenient to prepare a separate list of various notations that occur frequently, or that are of considerable length, and assign a different symbol to each one. Then, by entering one of the symbols on the form, along with the item to which it applies, any amount of information may be conveyed in a small space. This system is particularly useful in connection with more or less standard forms of agreements relating to track maintenance, such as "Railroad to Maintain at Industry's Expense", etc.

The side tracks may be listed in any order desired, but it will probably be most convenient to group them by towns within any one state, taking the towns in the sequence in which they occur along each line. Where a town is located on several different lines, the side tracks for that town may all be listed under the line most convenient, making suitable cross references where the name of the town occurs under the other lines.

The record is intended to be made continuous by spacing initial entries for tracks not closer than 5 lines apart (more, if an unusual number of changes is anticipated) on the original sheet, and then using continuation sheets as needed. The word "ORIGINAL" or "CONTINUATION", printed in the heading (whichever is not applicable) may be struck out.

Statement B

Recommended Approvals, Revisions, or Deletions: Pages 1 to 70, incl., of Chapter 11 of the AREA Manual

Pages 11–1 to 11–4, incl.

SPECIFICATIONS FOR THE DESIGN, ARRANGEMENT AND PRINTING OF FORMS

Reapprove without change, except Par. 19 on page 3, which is to be rewritten as follows:

19. Quality and Weight of Paper

Paper is made from two basic substances, namely, rags or wood pulp. Wood pulp paper is suitable only for interoffice or temporary forms. Forms for permanent record should be printed on paper with a rag content. Paper made from a rag stock has been standardized at 25 percent, 50 percent, 75 percent, 100 percent and 100 percent plus, rag content, with the chemical pulp being mixed with other than all rag content. The paper selected for the task in hand should be durable and tough and flexible enough to crease without cracking. It should be of a grade which will not fade or turn yellow with age, and should stand several erasures without allowing the ink to show through on the reverse side. The weight of the paper should receive consideration as economies may be effected through preparation at one writing of sufficient copies to complete the records in all offices requiring the report.

Page 11–5—Form 1101—Track Foreman's Daily Material Report.

Reapprove as blank form only. Eliminate written-in data.

Page 11–6

Form 1102—Monthly Bridge Material Report.
Form 1103—Bridge Section Tool Report
Reapprove forms as shown, but eliminate column width dimensions.

Pages 11–7 to 11–9, incl.

Form 1102—Foreman's Monthly Material Report—Bridges.
Form 1103—Foreman's Bridge Section Daily Report.
Form 1104—Authority for Expenditure.

Form 1105—Detailed Estimate.

Form 1106—Register of AFE's.

Eliminate specifications for all of these forms. Reapprove instructions for use of these forms.

Page 11–8—Form 1104—Authority for Expenditure

Reapprove without change.

Page 11–10—Form 1105—Detailed Estimate.

Reapprove without change.

Page 11–11—Form 1106—Register of Authorities for Expenditure.

Reapprove without change.

Pages 11–12 to 11–14, incl.—Form 1107—Time Rolls.

Reapprove with the following change:

Eliminate specifications for Form 1107 on page 12.

Page 11–15

Eliminate specifications for Form 1108—Roadway Completion Report, Form 1109—Equipment Completion Report, and Form 1110—Contract and Lease Record.

Reapprove instructions for the use of Forms 1108, 1109 and 1110.

Page 11–16—Form 1108—Roadway Completion Report.

Reapprove without change.

Page 11–17—Form 1109—Equipment Completion Report.

Reapprove as shown, except omit provision for certification and substitute statement as to accuracy and responsibility, as shown on Form 1108—Roadway Completion Report.

Page 11–18—Form 1110—Contract and Lease Record.

Reapprove without change.

Page 11–18.1

Register of Title Deeds.

Reapprove without change.

Specifications for Form 1111.

Eliminate.

Instructions for use of Form 1111.

Reapprove without change.

Page 11–19—Form 1111—Record of Ballast Changes.

Reapprove with change.

Page 11–21

Eliminate specifications for Forms 1112 and 1113, Foreman's and Conductor's Daily Report for Work Train Performance.

Reapprove instructions for use of Forms 1112 and 1113 without change.

Pages 11–22 and 11–23

Form 1112—Foreman's Daily Report of Work Train Performance.

Form 1113—Conductor's Daily Report of Work Train Performance.

Reapprove without change.

Pages 11–24 to 11–28, incl.—Joint Facility Records.

Forms 1114 and 1115, and Fig. 1101, Sheets 1 and 2.
Reapprove without change.

Pages 11–29 to 11–31, incl.

Reapprove without change Forms 1116 and 1117—Annual Report of Highway Grade Crossings and Individual Highway Grade Crossing Data, and also instructions for use of these forms.

Pages 11–34 to 11–36, incl.—Construction Report and Property Records.
Reapprove without change.

Page 11–37

Reapprove text, with the elimination of specifications for Forms 1118, 1119, 1120 and 1121.

Pages 11–38 to 11–44, incl.

Form 1118—Daily Tracklaying Report Record.
Reapprove without change.
Form 1119—Daily Ballasting Report and Record.
Reapprove with addition of the following note: "Location can be shown by Survey Station instead of Mile Post if desired."
Form 1120—Resident Engineer's Monthly Estimate of Grading.
Form 1121—Resident Engineer's Monthly Estimate of Bridges and Other Roadway items.
Form 1122—Resident Engineer's Monthly Estimate of Buildings.
Reapprove without change.
Form 1123—Assistant Engineer's Consolidated Monthly Estimate.
Reapprove with the following change:
Substitute "Steel" for "Wrought Iron" in Structures.
Form 1124—Monthly Track Material Report.
Reapprove without change.

Page 11–47

Add new heading "Bridge Construction Reports" immediately ahead of Instructions for Use of Forms 1126, 1127, 1128 and 1129.
Eliminate specifications for Forms 1122 to 1129, incl.
Eliminate specifications and instructions for Form 1130.
Reapprove remaining data on this page.

Pages 11–48 to 11–51, incl.

Form 1126—Construction Report of Timber Trestles.
Form 1127—Construction Report for Wood Boxes and Pipe Culverts.
Form 1128—Construction Report for Concrete Trestles and Arches and Boxes.
Form 1129—Construction Report for Steel Bridges.
Reapprove without change.

Page 11–52—Form 1130—Report of Rail Change.
Eliminate.

Pages 11–53 and 11–54

Eliminate specifications for Forms 1131, 1132 and 1133.
Reapprove instructions for forms without change.

Pages 11–55 to 11–57, incl.

Form 1131—Report of Quantities in Completed Work.
Form 1132—Cost of Property Retired.
Form 1133—Roadway Machine Record.
Reapprove without change.

Page 11–58—Rail Chart.

Reapprove without change.

Pages 11–63 to 11–66, incl.—Bridge and Building Records.

Reapprove without change.

Page 11–67—Form 1134—Register of Buildings.

Reapprove without change.

Pages 11–68 to 11–70, incl.

Form 1135—Bridge Inspection Report, Masonry, Steel Bridges and Trestles.
Form 1136—Bridge Inspection Report, Wood Boxes and Pipe Culverts.
Form 1137—Bridge Inspection Report—Summary.
Eliminate the forms and text shown on these pages.

For further recommendations with respect to the Manual material of Committee 11, see report on Assignment 3.

Report on Assignment 2

Bibliography on Subjects Pertaining to Records and Accounts

A. H. Meyers (chairman, subcommittee), V. H. Doyle, M. M. Gerber, C. B. Martin, O. M. Miles, B. H. Moore, F. H. Neely, E. J. Rockefeller, J. E. Scharper, H. C. Wertenberger, L. Wolf.

This report is submitted as information.

Your committee presents the following bibliography of subjects pertaining to railroad records and accounts for the period August 1951 to September 1952.

1. Construction Cost Control. Handbook by Howard P. Maxton, Arnold O. Babb and Donald J. Leitch.

Increase your profits and eliminate losses by controlling costs. Today's cost-conscious contractor and engineer, small operator or large, will find this comprehensive handbook provides the answers to construction accounting and cost control problems common to all. This book was prepared under the auspices of the American Society of Civil Engineers, and it is written by men who are active in and really know construction.

2. Proof of Economic Issues in a Rate Case: By John Lansdale, Jr., address before Public Utility Law Section of the American Bar Association of New York, September 17, 18, 1951. Public Utilities Fortnightly, Vol. XLVIII, No. 11, November 22, 1951, pp. 782–790.

Mr. Lansdale states in part that every issue in a rate case is economic. The manner in which most of these issues are decided has an important bearing on the extent to which the utility weathers today's economic storms. What are needed today are unimpeachable facts upon the basis of which the effect of current economic trends upon the utilities can be shown. In showing these facts one must keep in mind the distinction between price and value. Most of the increases in the cost of items included in a utility plant are the result of increases in price as distinguished from value. They express in large measure the debasement of our currency.

3. The Impact of Economic Trends on Public Utility Regulations: By Herbert B. Dorau. P.H.D. Address before the Public Utility Law Section of the American Bar Association of New York, September 17, 18, 1951. Public Utilities Fortnightly, Vol. XLVIII, No. 11, November 22, 1951 pp. 757–771.

The address indicates that the economic changes of the past 15 years have been substantial, diverse, and far-reaching. Collectively, these changes constitute a revolution in fact no less drastic than that of other nations where they were accompanied by physical violence and bloodletting. Mention is made of the revolutionary changes in the character of our political-economic system because it could hardly be expected that the institution of utility regulation would be exempt from the impact of the general pressures toward socialization. As is all too evident, it has not been so exempt; in fact, a very presumptive case could be made for the proposition that the earliest symptoms of the socialization of American enterprise appeared in the form of radical changes in the standards and practices of public utility regulation.

4. Retirement Loss Claim of Telephone Company Rejected in Rate Proceeding: Re Southern Bell Telephone and Telegraph Company, File No. 19315, Docket No. 195–U—November 1, 1951.

The Georgia Commission approved a telephone company's statewide application for a rate increase. The company offered a substantial amount of evidence with respect to the "retirement loss" resulting from the necessity for replacing retired property at higher cost levels than those under which the retired property was originally placed. The commission described the company's position on retirement loss as "a novel approach in an endeavor to justify an extremely questionable cost of operation." It would have the effect of computing depreciation expense on replacement cost over a period of years. Public Utilities Fortnightly Vol. XLIX, No. 1, January 3, 1952, pp. 64–65.

5. AAA Proposals Offer Practical Suggestions for Dealing with Price Level Changes in Accounting: By Maurice H. Stans, CPA, Partner: Alexander Grant & Co. Journal of Accountancy, Vol. 93, No. 1, January 1952, pp. 52–59.

The American Accounting Association is making an effort to break the deadlock which has fallen on those who argue—pro and con that accounting procedures should be revised to reflect business in terms of the changing value of the dollar. This article is an interpretation of the AAA's statement by a member of the AAA committee which made the study. The statement recommends experimentation, within stated limits, to see what needs to be done, and what can be done, to remove the weakness in accounting caused by violent changes in dollar value.

6. How to Cut Operating Costs Through Better Budgeting: Budgets should be prepared by finance officer rather than second and third echelon officers. Technique of master and secondary budgets. By R. F. Bauman, Railway Age, Vol. 131, No. 26, December 24, 1951, pp. 38–40.

This article, by a former railroad officer, sets forth a specific plan for railroad cost control by means of annual and monthly departmental and system budgets. It is published to focus attention on latent possibilities in this direction, with the hope that it may inspire constructive comment.

7. Joint Equipment Committee (Report on) Costs of Railroad Equipment and Machinery, July 1, 1952, 20 pages. Association of American Railroads, Finance, Accounting, Taxation and Valuation Department, Transportation Building, Washington 6, D. C.

Brings up to date (through 1951) the report on historical costs of locomotives, freight cars, and passenger cars, and average relationship costs of various types of equipment and machinery.

8. Railroad Construction Indices, 1914–1951: Compiled by the Engineering Section of the Bureau of Valuation of the Interstate Commerce Commission, Washington, D. C., August 1, 1952.

These indices summarize and record the result of studies made by the Engineering Section of the Bureau of Valuation over a period of years. They have not been examined or passed on by the Interstate Commerce Commission.

9. Two requisites for Better Maintenance. Address by C. J. Geyer, vice president, construction and maintenance, Chesapeake & Ohio, in a recent address at a meeting of the New England Railroad Club at Boston. Railway Age, Vol. 132, No. 4, January 28, 1952, p. 49.

Two "fundamental principles that must be followed in maintaining our properties to the desired physical level and at the lowest possible cost" were enunciated by Mr. Geyer.

"The first of these two principles" said Mr. Geyer, "is to have a strong organization."

The second principle is "the establishment of a complete and detailed program for the maintenance of the physical property during a given period of time."

10. How to Compile and To Use a Price Index System for Inventory Valuation by the Lifo Method: By William A. Spurr, Ph.D., Professor of Business Statistics, Graduate School of Business, Stanford University. The Journal of Accountancy, Vol. 93, No. 2, February 1952, pp. 204–209.

Much has been written about the use of price indexes for Lifo, little about their construction. Yet the compilation of a valid, relevant price index solves one of the recurrent problems in the use of Lifo. Such an index should meet the statistical criteria of proper sampling, pricing, weighting and grouping methods, as well as the requirements of accounting theory and Treasury Department regulations. The author presents a statistical technique for computing a price index to use in valuing inventories by the last-in, first-out method.

11. Correspondent Disputes Our Views On Retirement–Reserve Accounting: A review by Mr. Carman G. Blough of a thought-provoking letter received from Mr. H. C. Hasbrouck, accounting director of Edison Electric Institute. Journal of Accountancy, Vol. 93, No. 2, February 1952, pp. 218–221.

Mr. Hasbrouck stated in part "In your Column Current Accounting and Auditing Problems (Journal of Accountancy, June 1951) there is a discussion of the 'retirement–reserve method of accounting' which perpetuates an old misconception now so universal that it may be hopeless to try to correct it. Nevertheless, I propose to keep on trying."

12. Utility Finance and Regulation In an Age of Inflation: By Fergus J. McDiarmid, Second Vice President, Lincoln National Life Insurance Co., Public Utilities Fortnightly, Vol. XLIX, No. 7, March 27, 1952, pp. 399–408.

For a hundred years prior to World War I, people had faith in money, they saved and invested. Today that faith is slipping. How can public utilities expect to obtain capital in competition with unregulated industry, during a prolonged inflationary period, if the utility investor's dollar is trapped and crippled in purchasing power by original cost regulation? A long-experience security analyst and institutional investment official tells us why he thinks it won't work.

13. Three Discussions of Financial Accounting and Inflation: By George O. May. The Journal of Accountancy, Vol. 93, No. 3, March 1952, pp. 294–299.

A discussion of the report of the Study Group on Business Income, just published, together with comments on the recent statement of the American Accounting Association dealing with the relationship of accounting and inflation. The author also touches on discussions of this subject at the last annual meeting of the Controller's Institute, New York, fall, 1951.

14. What Are We Going To Do About Determination of Income Influenced by Inflation? By Samuel J. Broad. The Journal of Accountancy, Vol. 93, No. 3, March 1952, pp. 300–308.

Two new recommendations have been made recently, urging business to state clearly the effect of inflation on its operations. This author, describing the nature and extent of the problem, puts up to the management of some forward-looking companies the job of carrying out some of the recommendations made, so their stockholders, and taxing authorities may know the financial results.

15. College Courses in Railroad Subjects: Pamphlet compiled by the Association of American Railroads. Fourth Edition, 32 pages.

This is a list of colleges and universities offering courses in engineering, transportation and traffic management, with special reference to the railroad field. It contains information also on evening study, technical schools offering courses in engineering, the cooperative plan and home study courses.

16. Impact Of Price Level Changes On Utility Depreciation Costs. Historical Price and Investment Trends by Paul Grady, Public Utilities Fortnightly—Part I, Vol. XLIX, No. 13, June 19, 1952, pp. 819–829. Part II, Vol. L, No. 1, July 3, 1952, pp. 31–40.

The argument that accounting does not need to give recognition to changes in the price levels is carefully but critically examined. Here is an analysis of the impact of price level changes on depreciation costs of public utilities.

17. Inflation—What It Means to Utilities and Investors. By Jackson Martindell, Public Utilities Fortnightly, Vol. XLIX, No. 13, June 19, 1952, pp. 828–839.

Public utilities face a difficult financial future unless an economically sound approach to utility rate making in times of inflation is soon forthcoming.

18. What Others Think: A plan for Easing Inflationary Pains for Utility Depreciation. Public Utilities Fortnightly, Vol. 49, No. 9, April 24, 1952, pp. 578–579.

This feature article by Francis X. Welch, managing editor, calls attention to two steps in the process of determining a public utility depreciation expense for property devoted to the use of the public: (1) the estimation of the whole "service life", as well as the annual "use" quota of the total, and (2) what this means in dollars and cents. The first step is easy, in a theoretical sort of way—something like those age-life tables that insurance companies compile on the basis of acturarial experience. The second is not so easy, especially during a period when dollar values are fluctuating madly, as during the inflation of the past few years. Stating the change in original dollars invested, which is the prevailing regulatory custom, leaves quite a gap between capital restored and replacement investment necessary.

19. Suggestions for Books and Other Material on Railroads in The United States For Students of Current Transportation. By E. O. Cullen, 44 pages, Association of American Railroads, Bureau of Railway Economics. Transportation Building, Washington 6, D. C., 1951.

20. The Accountant Should Be Aware of Today's Possibilities and Limitations on Speeding-Up Plant Write-offs To Minimize Tax Liability. By James J. Mahon. Journal of Accountancy, Vol. 93, No. 3, March 1952, pp. 352–356.

Management's zeal to speed up the write-off of plant investment undoubtedly increases during periods of high tax rates. The accountant therefore should be aware of the changes of sustaining tax deductions for stepped-up depreciation or amortization during wartime. Past experience indicates that most efforts to increase amortization of plant and equipment are doomed to abort.

21. MAPI Replacement Manual, 70 pages, published by the Machinery and Allied Products Institute, Chicago.

The manual discusses the limitations of present replacement policy, introduces MAPI formula, and deals also with the proper organization of equipment policy. The manual offers a check list of questions which equipment users may ask themselves when considering replacement to determine necessity for the expenditure, and the last three chapters include a group of applications of the Institute's formula and a simplified chart solution.

22. Depreciation Policies and Investment Decisions. By S. P. Dobrovolsky. The American Economic Review, December 1951.

This article restates mathematically the general principles of valuation of durable equipment, then discusses the comparative economic effects of accelerated and straight-line depreciation policies, their impact on business-cycle statistics, and their relation to the tax aspects of investment decisions.

23. The Canadian Experiment with Deferred Depreciation (corporate taxation device to offer incentive to certain vital industries for expansion). By H. D. McGurron. Statist, August 25, 1951, Vol. 154, pp. 241–242.

24. Deferred Depreciation (features of the measure to utilize the write-off instrument to discourage certain kinds of capital expenditures, Canada). By H. D. McGurron. National Tax Journal, December 1951, Vol. 4, pp. 299–303.

25. Rate Making and Inflation. By the Honorable John P. Randolph. Public Utilities Fortnightly, Vol. L, No. 1, July 3, 1952, pp. 3–10.

Inflation-rapid rising cost of plant equipment, payrolls, taxes, all other operating expenses—means that State Commissions will have to take a more practical view of the "original cost" concept in utility rate making. What are the factors involved? What can be done? Can the rate of return be used as an escape valve? What is the law involved in this situation.

26. Rate of Return and the Value of Money in Public Utilities: By Professor Walter A. Morton. Land Economics, May 1952, 40 pages.

The article deals with the practical possibilities of a more realistic approach to regulation, in light of present-day inflationary conditions.

27. What Others Think: Do Regulatory Concepts Need Adjustment for Inflation? Public Utilities Fortnightly, Vol. L, No. 1, July 3, 1952, pp. 56–58.

A number of scholars, as well as practitioners, of utility regulation are beginning to wonder whether the accepted "utility formula" for rate fixing may not need some overhauling, here and there, in light of changing economic conditions.

28. Should Fair Return Be Limited to Cost of Money? By Ralph E. Badger. Public Utilities Fortnightly, Vol. L, No. 1, July 3, 1952, pp. 19–30.

How can utilities continue to attract equity capital on the basis of "bare bones" return, limited to the cost of capital in the past, when all immediate prospects point to high prices, including the cost of money?

29. "Percent Variable" Study on Class I Railroads and Basis of Development of "Improvement in the Art:" By John Hansbury, Interstate Commerce Commission Practitioners' Journal. Vol. 19, No. 1, October 1951, pp. 14–33.

The "percent variable" or "out-of-pocket cost" as used in this study expresses the percent variation in total operating expenses related to the percent increase or decrease in gross ton miles per mile of main track operated.

This current study relating to total operating costs has taken into consideration many of the major objections which have been directed against similar studies, but since the conclusions are not at great variance with the results of these prior studies, it is concluded that many of the adjustments considered necessary are offsetting.

30. "Percent Variable" for Investment Study on Class I Railroads: By John E. Hansbury. Interstate Commerce Commission Practitioners' Journal, Vol. 18, No. 7, April 1952, pp. 691–702.

The "percent variable" for investment as used in this study expresses the percent variation in the total investment in terms of a 1910–1914 common dollar related to the percent increase or decrease in the total gross ton miles of traffic per mile of main track operated for the period 1917–1950, incl.

As was the case with a previous study on operating expenses, it was found to be impossible to develop persuasive figures statistically for the percent variable for investment unless the expenditures to effect "improvement in the art" were separated from those expenditures for plant expansion due solely to traffic. Expenditures for plant improvements are continuous, whereas those due to traffic changes may fluctuate.

31. Accounting In the Engineering School: By Ernest H. Weinwurn. New York Certified Public Accountant. Jan. 1952, pp. 30–34.

32. Why Depreciation Reserve Should Not Be Deducted From Utility Plant Account: By Bernard S. Rodney, Jr. New York Certified Public Accountant, March 1952, pp. 157–164.

33. Economic Factors In Selecting Lifo: By Alfred C. Boni. New York Certified Public Accountant, November 1951, pp. 729–738.

34. Has Lifo Raised Or Solved Accounting Problems? By Gregory M. Boni. New York Certified Public Accountant, November 1951, pp. 744–748.

35. Lifo As An Operating Tool: By Henry Keyserling. Controller, February 1952, pp. 59–60.

36. Records Protection: What is being done, by whom, and how. By Paul Haase. Controller, September 1951, pp. 399–401.

37. Depreciation Accounting Controls: joint AGA-EEI committee report. American Gas Association Monthly. January 1952, Vol. 34, pp. 20–22+.

38. Inflation and Public Utility Depreciation: By George B. Tully. Land Economics, February 1952, pp. 63–68.

39. Proposed New NARUC Controls For Depreciation Accounting: Edison Electric Institute Bulletin, December 1951, Vol. 19, pp. 401–407+.

40. The Influence of Depreciation Accounting On National Income: By E. S. Hendriksen. Accounting Review. October 1951, Vol. 26, pp. 507–515.

41. Spend Your Depreciation Allowances. By F. S. Blackall, Jr., American Machinist, Vol. 95, December 24, 1951, pp. 106–107.

Report on Assignment 3

Office and Drafting Practices

W. M. Ludolph (chairman, subcommittee), V. H. Doyle, Benjamin Elkind, D. E. Field, W. A. Krauska, A. H. Meyers, A. T. Powell, H. B. Sampson, R. L. Samuell, J. H. Schoonover, H. A. Shinkle, J. R. Traylor.

Supplementing the recommendations of Subcommittee 1 with respect to the Manual, your committee recommends the reapproval, or reapproval with revisions, of the text and figures appearing on pages 11–121 to 11–161, incl., as follows:

Pages 11–121 and 11–122

Office and Drafting Room Practices.

Reapprove with the following changes:

Withdraw center heading "General" and substitute "General and Text". Paragraph headed "Lettering": In the sixth line withdraw words "left side" and substitute "right hand edge".

Page 11–122—Mechanical Drawing.

Reapprove without change.

Page 11–123—Fig. 1103—Shapes of Drawings.

Reapprove with the following change:

Title—Withdraw "Sizes and Shapes of Drawings" and substitute "Shapes of Drawings".

Page 11–124—Fig. 1104—Sizes of Sheets for Engineering Drawings, Forms and Charts.

Reapprove without change.

Page 11–125—Fig. 1105—Typical Titles.

Reapprove without change.

Page 11–126—Fig. 1106—Lettering.

Reapprove without change.

Page 11–127—Fig. 1107—Lettering.

Reapprove without change.

Page 11–128—Fig. 1108—Lines and Line Work.

Reapprove without change.

Page 11–129—Alphabetical Index.

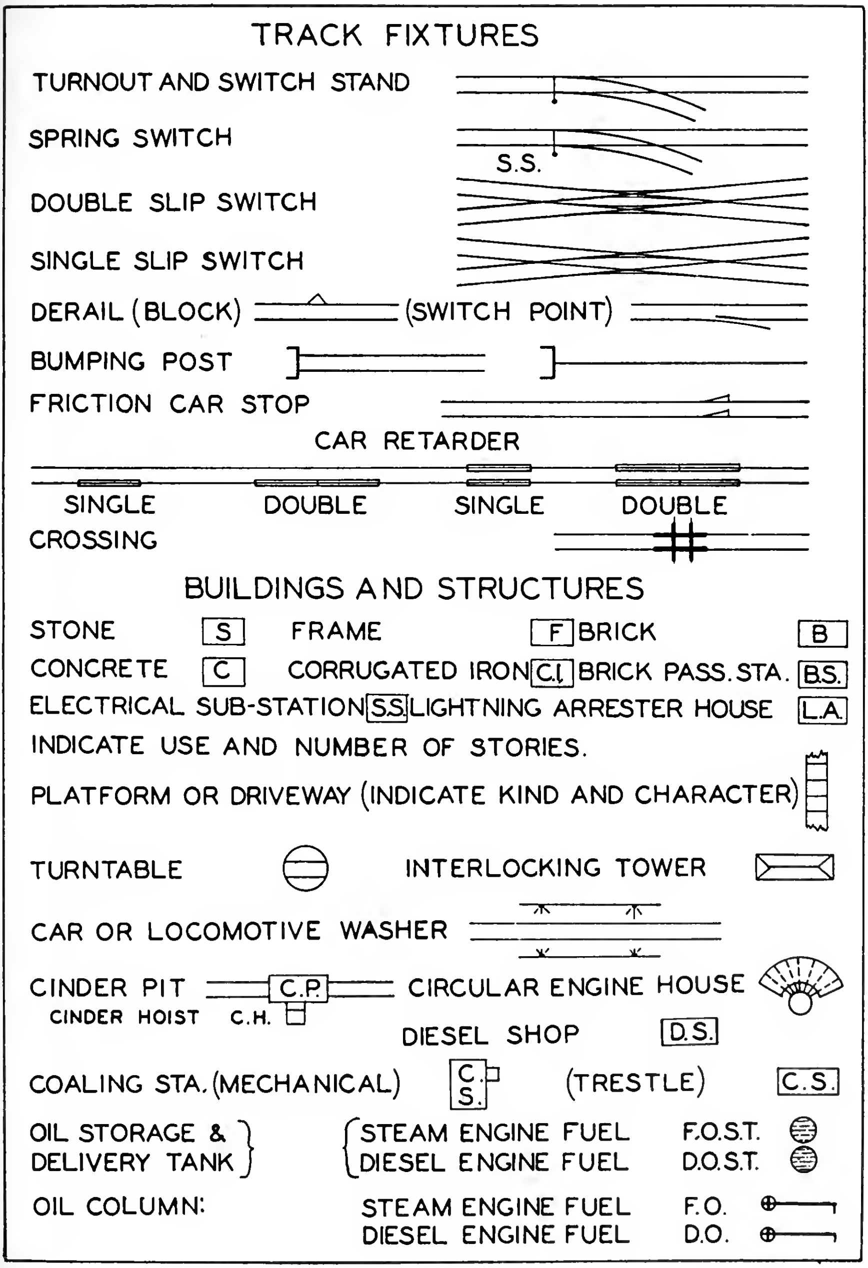
Correct as necessary.

Pages 11–130 and 11–131—(Fig. 1109); 11–132 (Fig. 1112); 11–134 (Fig. 1113); 11–135 (Fig. 1114); 11–137 (Fig. 1116); 11–138 (Fig. 1117); 11–139 (Fig. 1118); 11–140 (Fig. 1119); 11–141 (Fig. 1120).

Reapprove all of these figures without change.

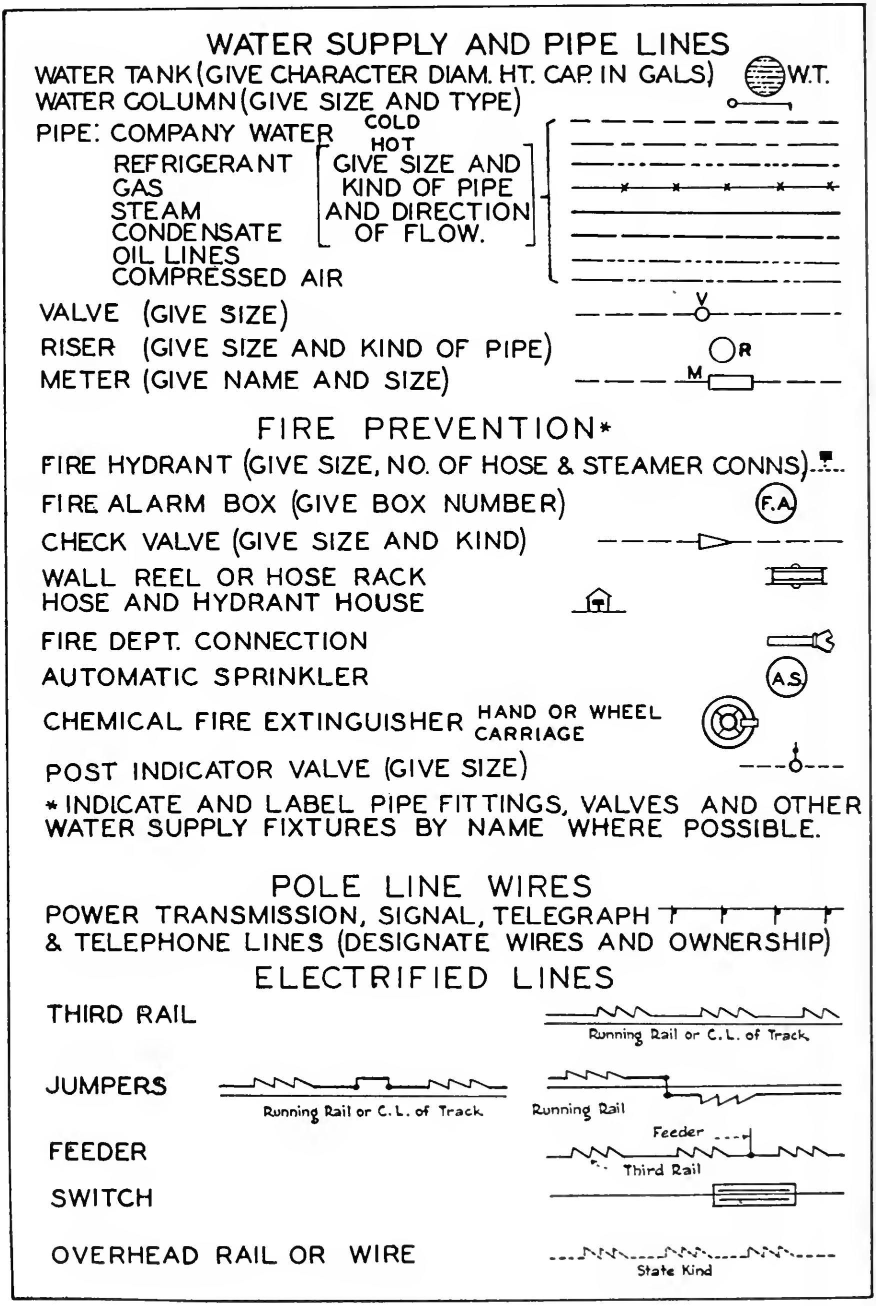
Page 11–133—Fig. 1112—Track Fixtures.

Reapprove with changes shown on new drawing (Fig. 1112) herewith.


TRACK FIXTURES
TURNOUT AND SWITCH STAND
SPRING SWITCH
S.S.
DOUBLE SLIP SWITCH
SINGLE SLIP SWITCH
DERAIL (BLOCK)
(SWITCH POINT)
BUMPING POST
FRICTION CAR STOP
CAR RETARDER
SINGLE
DOUBLE
SINGLE
DOUBLE
CROSSING
BUILDINGS AND STRUCTURES
STONE
S
FRAME
F
BRICK
B
CONCRETE
C
CORRUGATED IRON
C.I.
BRICK PASS. STA.
B.S.
ELECTRICAL SUB-STATION
S.S.
LIGHTNING ARRESTER HOUSE
L.A.
INDICATE USE AND NUMBER OF STORIES.
PLATFORM OR DRIVEWAY (INDICATE KIND AND CHARACTER)
TURNTABLE
INTERLOCKING TOWER
CAR OR LOCOMOTIVE WASHER
CINDER PIT
C.P.
CIRCULAR ENGINE HOUSE
CINDER HOIST
C.H.
DIESEL SHOP
D.S.
COALING STA. (MECHANICAL)
C.S.
(TRESTLE)
C.S.
OIL STORAGE & DELIVERY TANK
STEAM ENGINE FUEL
F.O.S.T.
DIESEL ENGINE FUEL
D.O.S.T.
OIL COLUMN:
STEAM ENGINE FUEL
F.O.
DIESEL ENGINE FUEL
D.O.

Page 11–136—Fig. 1115—Water Supply and Pipe Lines.

Reapprove with changes shown on new drawing (Fig. 1115) herewith.



Page 11–142—Graphical Symbols for Plumbing, Piping, Pipe Fittings and Valves, Heating and Ventilating, Duct Work, Heat-Power Apparatus, Refrigeration and Welding.

Under this heading substitute the following:

For data regarding these symbols refer to the following publications of the American Standards Association and subsequent revisions thereto, entitled:
Graphical Symbols for Plumbing (Z32.2.2—1949).
Graphical Symbols for Pipe Fittings, Valves and Piping (Z32.2.3—1949).
Graphical Symbols for Heating, Ventilating and Air Conditioning (Z32.2.4—1949).
Graphical Symbols for Heat-Power Apparatus (32.2.6—1950).
Graphical Symbols for Welding and Instructions for their use (Z.32.2.1—1949).

Page 11–143—Fig. 1121—Method of Designating Taper, Batter, Cant, Slope, Incline and Grade.

Reapprove without change.

Pages 11–153 and 11–154—Methods of Folding Drawings.

Reapprove without change.

Pages 11–155 to 11–159, incl.

SPECIFICATIONS FOR PREPARATION OF MAPS AND PROFILES

Reapprove without change.

Page 11–160—Fig. 1132—Progress Profile.

Reapprove without change.

Page 11–161—Fig. 1133—Track Chart.

Reapprove without change.

Progress Report on New Office and Drafting Equipment

Your committee has from time to time reported on new materials, methods and processes to aid or improve office and drafting practices.

The following have come to the attention of the committee since its last report:

1. An electrically operated mechanical calculating machine which will extract the square root of any number within the capacity of the machine automatically, as well as perform division and multiplication automatically. The machine can also be used for addition and subtraction.

There are other features of the machine which are useful in accounting, billing, and general calculations, such as being able to lock figures in the various dials and in the keyboard.

In order to extract the square root with this machine, the number whose square root is sought is placed in the main keyboard, then one of a series of buttons just below the main keyboard is pressed. The machine will then automatically work out the square root and place it in one of the upper dials, and also by the pressing of a proper button the square root can be locked in the keyboard for further calculations.

The choice of the proper key below main keyboard to be pressed to extract the square root depends on the location of the decimal point in the square.

2. A typewriter with changeable type. Two fonts can be used at one time and changed from one to another by merely twisting a knob. New fonts are loaded speedily

and easily. Each font contains all the characters, i.e. caps, lower case, figures, punctuation and symbols. The operator selects the style and size specified and makes all of the changes in a matter of seconds without disturbing the copy already in process.

Type faces are available in sizes from 6 to 18 points for all uses, in light, medium and bold faces, including Gothic, Roman, mathematical characters and other choices.

This machine can be used for letters, accounting forms, architectural data, contracts, engineering forms, estimate bids, manuals, maps, office forms and many other uses.

This machine can also be used in connection with the various reproduction processes, such as hectograph, mimeograph, direct to plate duplication, and others.

There are engineering models of this machine which will letter a tracing much faster than a draftsman, and at the same time produce very legible work. These models will handle tracings over 6 ft in width.

Report on Assignment 4

Use of Statistics in Railway Engineering

W. M. Hager (chairman, subcommittee), S. H. Barnhart, H. T. Bradley, V. R. Copp, S. Danby, B. Elkind, M. Friedman, C. C. Haire, L. W. Howard, C. Jacoby, B. H. Moore, J. H. O'Brien, M. G. Pettis, A. T. Powell, H. L. Restall, E. J. Rockefeller, S. M. Rodgers, J. E. Scharper, R. W. Scott, H. C. Wertenberger, J. L. Willcox.

Report on the Methods Being Used in Analyzing and Controlling Engineering Department Expenditures

This report is submitted as information.

The railway engineer of early days is justifiably portrayed in the pages of history as a pioneer and empire builder. He opened the wilderness with ribbons of steel and met and conquered all of nature's elements in the course of building that empire.

The contemporary railway engineer must overcome the same problems, but, in addition, he faces the task of preserving the integrity of the capital invested in that empire through the proper maintenance and improvement of the property. This added responsibility is made the more difficult because of the narrow margin of profit in the railway industry and the peculiar behavior of the maintenance of way ratio as it is affected by lagging rates, rising costs, and sudden unexpected changes in the volume of traffic.

These factors, acting as adverse winds on a sensitive weathercock governing the expenditures available for maintenance and improvement of the property, arise at more frequent intervals in recent years. Engineering officers, ever conscious of their responsibility for maintaining the proper productive capacity of the property to prevent impairment of the invested capital, are also cognizant of the necessity for maintaining a satisfactory relationship between revenues and expenses; although that antiquated and improper yardstick neither reflects the requirements nor does it reveal the efficiency of operation in performance of the work accomplished. Engineering officers realize that the only practicable method for overcoming the sensitive variations in the maintenance ratio is to make the available dollar work harder. With this as their primary goal they have entered upon intensified research in all the fields of engineering, including property behavior, statistics and cost engineering.

Their studies have developed more efficient and more durable materials. Machines were developed to increase the output in maintenance operations.

Recorded statistics on past performances were assembled and analyzed, and cost engineering (with its attendant time studies and statistical processing) was instituted as the means for developing more efficient mechanized mass production techniques on assembly-line methods.

The results obtained have led to wider acceptance of cost engineering and the use of statistics as vital tools in the administration and operation of engineering departments. While much progress has been made, these fields will continue to afford still greater potentialities in effecting further economies and improved methods for reducing and controlling engineering department expenditures.

Realizing the important function of statistics in the operation of engineering departments, the committee has reviewed some of the methods now employed and presents this digest of its findings as a matter of information.

A. ANALYSIS OF RECORDED MAINTENANCE EXPENDITURES

The records of the engineering and accounting departments are being used extensively in the study of past performances and for the control of future expenditures. Many variations are possible in the development of the analysis as will be shown in the discussion on three methods selected for presentation.

1. First Method

A time-tested method that has produced satisfactory results for its purposes has been used by one carrier for many years. The forms developed for the analysis and the instructions for their use were published in the Proceedings, Vol. 37, 1936, pp. 615–620.

Throughout the year these reports permit continuing monthly comparison of expenditures with the amounts authorized in the budget, separating the costs incurred for direct maintenance (covered by the budget) from construction maintenance (authorized under special authority). The analysis also reveals which division or branch of the service has exceeded its allotment and whether the overrun is in the use of labor or material.

This carrier establishes a relationship between maintenance and investment to produce as its unit of measurement the cost of maintenance per dollar of investment, and makes suitable adjustment for fluctuations in traffic to place the various sections, divisions, etc., on a comparable basis for the determination of relative efficiency.

2. Second Method

More widely used in a continuing annual record arranged in compact loose-leaf form showing past accounting results supplemented with additional statistical data collected from the various subdepartments of the engineering, accounting and operating departments. The record has been continued for a period of years to date as a historical and comparative record of recorded statistics containing facts with regard to many things which would provoke penetrating thought in the mind of a cost-conscious engineer. An illustration of the comprehensive presentation of factual data is revealed by the following tabulation of information assembled by two carriers on bridges, ties and rail.

	Carrier X	Carrier Y
Bridges		
1. Annual Maintenance Expense:		
(a) account improvement authorities	x	x
(b) account ordinary maintenance	x	x
(c) total	x	x
(d) chart delineating the above		x
2. Bridges, lineal feet various types of construction and cost of maintenance per linear foot—System	x	x
3. Bridges, lineal feet various types of construction by divisions	x	x
4. Weight of steel bridges by divisions	x	
5. Average Cooper rating all bridges (chart)	x	
Ties		
1. Annual Expenditure:		
(a) chargeable to capital	x	x
(b) chargeable to operating expense	x	x
(c) total expenditure	x	x
(d) chart delineating the above	x	x
2. Cross ties used in renewals:		
(a) total of each kind and number per mile	x	x
(b) chart delineating the above	x	x
3. Bridge tie renewals, quantity and cost	x	x
4. Switch tie renewals, quantity and cost	x	x
5. Ties driven in wet cuts	x	
Rail		
1. Rail anchors and clips applied	x	x
2. Rail anchors and clips purchased	x	x
3. Rail, annual expenditure:		
(a) cost chargeable to capital	x	x
(b) cost chargeable to operating expense	x	x
(c) total expenditure	x	x
(d) chart delineating the above	x	x
4. Rail ends built up by divisions	x	x
5. Operation of detector cars:		
(a) tabular statement, miles inspected, failures found	x	x
(b) chart delineating the above	x	x
(c) cost of operating detector cars	x	x
6. Average weight of rail in main tracks—System:		
(a) tabular statement, miles each weight	x	x
(b) chart delineating the above	x	
7. Average weight of rail in main tracks—Divisions	x	
8. Rail laid in replacement and betterments, new and relay	x	
9. New rail purchased	x	
10. Rail laid in main tracks, new and relay	x	
11. Tie plates applied	x	x

This only partially describes the data presented. Innumerable items of significant information have been collected with respect to all accounts of the accounting classification for the distribution of operating expenses. As a further indication of the scope of these studies, data have been developed on the gallons of water, tons of coal, and gallons of fuel oil consumed annually by locomotives. The costs of maintenance, treatment and handling for the respective items have been assembled and reduced to a cost per unit furnished.

It is evident, therefore, that this method with respect to selected particulars is susceptible of a broad or narrow application depending upon the requirements of the analyst.

The study as presented in its final assembly introduces the reader to the general analysis for all maintenance costs. This general analysis summarizes all maintenance expenses under appropriate groupings of accounts to consolidate related costs. Track labor and track materials are representative samples of the groupings of related accounts. The total costs incurred are then expressed in cost per equated track mile or similar unit. Supplementing the general summary the reader will find selected items of study as previously noted.

Many variations are possible in the design of the forms to be used for presenting the analysis. The requirements, however, will vary with each individual. The following brief description of the more intricate forms noted in the tabulation may be helpful in the development of a similar system.

Rail, annual expenditure. Prepared in tabular form with the years shown vertically. Separation of rail expenditure as noted is made horizontally opposite each year. The same information is delineated in graphic form with coded trend lines for the cost separations.

Operation of detector car. A tabular statement showing for each year the miles of track inspected; the average miles inspected per day; the number of each class of defective rails detected. The chart is a horizontally sectional bar graph which portrays the same information. The years are shown along the abscissa. The quantities are shown by extension of the bar along the ordinates and over the respective years for each horizontal division.

Cost of operating detector car. A tabular statement showing the annual cost of rail inspection (outside rental and company costs for pilot, etc., shown separately) is reduced to show the average cost per track mile inspected and the average cost per defective rail.

3. Third Method

The two methods previously described are studies in which the analysts are restricted to the interpretation of results for the individual carrier.

In another method which has been instrumental in effecting increased efficiency and greater economies over the years, the carrier prepares an annual comparative study of its own results with those of 16 other selected carriers. The form used for this study is substantially the same as Form 1138 in the Proceedings, Vol. 53, 1952, p. 491. The basic data for this study is secured from the carriers' annual reports to the Interstate Commerce Commission.

The results as developed in the form used are carried to a table showing the comparative standings of the 17 carriers for each unit of measurement in each account. Also shown for each account is the average percent of total maintenance expense; the average cost in cents per thousand gross ton miles of traffic, and the average cost per equated mile. The investigating carrier's results are finally expressed in a percentage of each average for the 16 selected foreign roads.

Such a report is beneficial as it reveals the general pattern of the industry and is indicative of the results one might reasonably expect to achieve. Under normal circumstances it is reasonable to assume that the cost per unit of measurement should be within reasonable tolerances of the standard for the industry. Accounts showing unreasonable discrepancies are subjected to a more searching analysis. This analysis is brought out in the form of a critical essay and is supported by tables of variances and other dissections of the accounts to present a concise explanation for the differences.

Additional tables are prepared to show rail and tie replacements for the 17 carriers over a period of years. These tables include all information necessary for an intelligent consideration of the various factors which might exert an influence on the costs incurred and the extent of the annual replacements.

Great emphasis is placed upon the use of labor. A table is prepared to show the number of employees; the hours worked (straight time and overtime); and the average rates of pay, all separated by crafts and reduced to man-hours and dollars per equated mile, and thousand gross ton miles of traffic. These unit costs are further processed to make allowances for traffic variations and changes in the wage level to secure true statistical comparability. The end product of such a processing permits accurate measurement of the trend in the use of labor.

Much additional information in essay form and in tabular arrangement is developed in the narrative presenting the basic tables previously described. It is not intended to describe them all, as the expansion of the basic data would be optional depending upon individual requirements and conditions encountered. This carrier follows no fixed pattern in that respect.

In addition, an ingenious set of compound graphical illustrations form a continuing record of the more important phases of the study. The Proceedings, Vol. 53, 1952, p. 485, outline the possibilities for the construction of similar interesting graphical illustrations.

4. General Comments

It should be remembered that these analyses are a sifting out of past performances from a system of records and reports designed primarily to meet accounting regulations of the ICC. They are not cost accounting systems. The analyses are in the nature of autopsies in which it is endeavored to determine the nature and extent of corrective measures necessary to prevent the recurrence of subpar performances and produce future improvement in the art. The correct interpretation of the data to attain these purposes requires analysis by a well qualified and experienced railway engineer who is familiar with the ICC accounting classification. He must understand the limitations which apply to the use of raw accounting results and he must fully appreciate the necessity for adjusting and supplementing these raw figures with other factual data.

With such proper handling, a retrospective appraisal of our past accomplishments becomes a vital tool for our improvement in the future. Our survey indicates the carriers find these studies to be of material assistance in the administration of their engineering departments' affairs.

B. COST STUDIES AND COST ACCOUNTING SYSTEMS

We find the engineering departments are continually carrying on cost studies, more particularly in the fields involving the contemplated use of new equipment and the adoption of new methods. Accurate procedures have been developed for the meticulous reporting of field data to determine the worth of the new machine or method. These studies may continue for a protracted period of time but are discontinued when the merit of the contemplated change is confirmed by a reduction in cost through increased efficiency.

The establishment of a continuing cost accounting system in the engineering departments as suggested in the Blair Report in AREA Proceedings, Vol. 47, 1946, pp. 286–299, is modern and in keeping with methods used by other industries. The adoption of such a system by the engineering departments under the direct supervision of cost engineers, independent of the accounting department and the records required for accounting purposes, would prove to be as beneficial to the railroads as it is beneficial to other competitive industries.

C. CONTROL OF EXPENDITURES

1. Capital Expenditures

A system for controlling gross expenditures has been instituted and successfully used by one carrier over a period of years. The system for the control of capital expenditures is related to the budget which is under the authority of the vice president operations and maintenance. Compilation of the data and administration of the control on expenditures is the responsibility of the chief engineer. To be eligible for inclusion in the budget, projects must have been granted a formal authority for expenditure. Each job authorized is assigned a budget number.

At the beginning of the year a program is adopted, and the authorized projects are grouped by the departments responsible for the prosecution of the work.

A continuing circulating report form, as attached and identified as Form 1, has been designed for the monthly reporting of the estimated gross cost for each approved project. This gross cost is separated into actual expenditures to the end of each month and the estimated additional expenditures for the balance of the year, as compared to the amount allotted to the project in the budget.

Col. 1. This is the total cost of the project as authorized. Changes are permissible only by proper authority. It is placed above Col. 2 to facilitate comparison with the field engineer's estimate of final cost.

Col. 3. Shows the expenditures prior to the current year as reflected on the books.

Col. 6. Shows the amount authorized in the budget for the current year. Changes made only by issuance of supplementary authority from officer in charge of the budget. It is placed above Col. 7 to facilitate comparison with the field engineer's estimate of expenditures in the current year.

Col. 2. This column should reflect the best judgment of the field engineer as to the probable final cost of the job. It is to be checked each month and changed if necessary to reflect the latest estimate of final cost.

Cols. 4, 5, 7, 8 and 9. These columns are to be filled in each month by the field engineer. The headings are self-explanatory and give directions for the information desired.

Col. 10. Physical status of the work is shown by the engineer in charge. This is not a monetary unit.

The chief engineer prepares a report form for each project authorized in the budget, supplying the information in the masthead and for Cols. 1, 3 and 6. The sheet is then forwarded to the proper departmental heads who forthwith complete the form and return it to the chief engineer. This circulating operation is repeated each month with the same data sheet.

The chief engineer then prepares a condensed monthly departmental summary of the returns showing the estimated probable costs as compared to the budgeted amounts for each project.

The budget for capital expenditures includes a predetermined unassigned sum as a safety factor to provide for the handling of unexpected emergencies and for unforeseen overruns that might occur as a job progresses. On the other hand, it will become apparent in some instances that the final cost will underrun the estimate, permitting a reduction in the budget authorization. Such changes in the budget as appear justified and necessary from time to time are provided for, through the issuance of an executive supple-

NORTH & SOUTH RAILROAD

RECORD OF CAPITAL EXPENDITURES UNDER BUDGET FOR YEAR ____

DEPT.
DIV.
A.F.E. P-
BUDGET NO.

LOCATION
PROJECT

WORK STARTED
WORK COMPLETED
998 - D

1 TOTAL AUTHORIZED			3 PRIOR EXPENDITURE			6 AUTHORIZED CURRENT YEAR		
R&E	OTHER	TOTAL	R&E	OTHER	TOTAL	R&E	OTHER	TOTAL

MONTH	2 PROBABLE FINAL COST			4 CUMULATIVE EXPENDITURE CURRENT YEAR TO DATE			5 ESTIMATED EXPENDITURE REMAINING PERIOD OF YEAR			7 ESTIMATED TOTAL EXPENDITURE CURRENT YEAR (COL. 4 PLUS COL. 5)			8 CURRENT BUDGET ESTIMATED OVERRUN + ESTIMATED UNDERRUN - DIFFERENCE COL.7 AND COL.6			9 ESTIMATED CARRYOVER (COL. 2 LESS COLS. 3 & 7)			10 PHYSICAL % COMPLETE
	R&E	OTHER	TOTAL	R&E	OTHER	TOTAL	R&E	OTHER	TOTAL	R&E	OTHER	TOTAL	R&E	OTHER	TOTAL	R&E	OTHER	TOTAL	
JAN.																			
FEB.																			
MARCH																			
APRIL																			
MAY																			
JUNE																			
JULY																			
AUG.																			
SEPT.																			
OCT.																			
NOV.																			
DEC.																			

Form 1.

ment to the budget as noted in the explanation for Col. 6. When this authority is received the chief engineer makes the necessary correction on the monthly circulating report form.

2. Maintenance Expenditures

This committee, comprised of a representative group of cost-conscious engineers, has long stressed the importance of adequate and proper controls such as are advocated in the Blair Report and as are outlined in the report of this committee in the Proceedings, Vol. 50, 1949, pp. 469–471.

As noted in these reports some carriers have adopted such methods. Our present survey shows that indifference to instituting these new methods results largely from the job of selling the idea because of the additional cost. Many carriers therefore, are required to follow the old established custom under which the control of expenses must depend upon posthumous statements compiled by their accounting departments, whereafter, it is not unlikely that a sudden convulsion occurs in the entire scheme of things.

Cost engineers do not argue against the self-evident fact that a railroad must live within its means. But, application of the maintenance ratio upon completion of the work does not control cost, nor does it result in future improvement of the art. Too much time has elapsed before any comparisons can be made with well-established standards. Corrective measures cannot be applied in time to prevent or stop inefficient methods, unauthorized work, overruns, and other factors resulting in the dissipation of meager funds.

D. PROGRAMMING. AN EFFECTIVE METHOD OF CONTROL

The merits of this procedure are so manifestly apparent, it warrants thoughtful consideration by all engineering officers. Careful and precise scheduling of maintenance operations based upon the total money allotted in the budget has proved a most effective means for increasing the productive capacity of men and machines. A very complete article on the methods used by The Delaware, Lackawanna & Western Railroad appears in Railway Age, Aug. 20, 1951, pp. 40–44.

A representation of this committee visited the Lackawanna's chief engineer, Mr. G. A. Phillips, to learn more about the benefits of this plan. Through experience in actual operation of the method the advantages may be summed up as follows:

The budget and program are founded upon standard costs. Engineering experience, augmented by cost studies to determine the most economical procedures, have resulted in the development of well founded standards—possible of achievement—which have eliminated waste, errors, and ineptness.

The standards set the size and organization of the forces in the program. No variations are permitted except as noted in the program. A report on the daily output which is transmitted through channels by telephone, maintains an immediate and constant control upon expenditures and efficiency. Production is compared with the standard.

The method of control is simple. It is accomplished with the minimum amount of clerical work, which is easily absorbed in the routine work of the existing force. It requires no elaborate forms.

The method of control is effective and has made it certain that expenditures will be within the budget allotments.

The method is elastic. If circumstances warrant, the program may be readily adjusted to meet changed conditions.

It allows for the more effective use of a minimum labor force.

It increases the return from the investment in machines through maximum utilization.

It generates enthusiasm in employees to meet the schedule.

Carefully laid initial plans, beginning with preparation of the budget, form the cornerstone for this method. The cost standards for gang organization may be readily changed when the control indicates a continuing better performance has been attained. It is, therefore, a continuing study of costs and standards, and provides an immediate insight into dangerous turns in the trends in efficiency.

The system combines all the desirable features of cost engineering and cost control at no additional expense.

Report on Assignment 5

Construction Reports and Property Records

Possible Use of Tabulating Machines in Engineering Department Procedures

W. S. Gates, Jr. (chairman, subcommittee), R. B. Aldridge, F. B. Baldwin, W. C. Bolin, V. R. Copp, B. Elkind, M. Friedman, H. N. Halper, W. A. Krauska, M. F. Mannion, C. B. Martin, O. M. Miles, F. H. Neely, J. H. O'Brien, W. F. Sanders, R. W. Scott, R. A. Shinkle, J. N. Smeaton, L. Wolf.

This report is submitted as a progress report, for information.

At the Committee 11 meeting in September 1951, it was suggested that Subcommittee 5 investigate the use of punched card machines in engineering department work. One year is too short a time to complete such an investigation, however, we can report definite progress has been made on this subject.

Information resulting from an experimental installation, being made on the Big Four Division of the New York Central, of a tabulating machine method for the preparation of certain valuation returns to the Interstate Commerce Commission, are being made available to Subcommittee 5 for its study. Considerable progress has been made in this installation and we are very hopeful that they will achieve a useful contribution to engineering record procedures.

Your subcommittee also examined into other record systems that might lend themselves to tabulating machine procedures, but was unable to reach any definite conclusions. It does desire to point out that these machines have a great utility whenever numerous separate items must be combined, or wherever basic data is to be used in a number of different ways. It has been found that, while it takes a great deal of careful planning to set up a tabulating procedure, the possible benefits toward producing fast, accurate results makes it worthy of consideration as a tool to help solve the increasingly heavy burden of clerical work that is now found creeping into the engineering offices.

Report on Assignment 6

Valuation and Depreciation

(a) Current Developments in Connection with Regulatory Bodies and Courts

H. T. Bradley (chairman, subcommittee), R. B. Aldridge, M. A. Bryant, P. D. Coons, Spencer Danby, W. S. Gates, Jr., M. M. Gerber, W. A. Godfrey, H. N. Halper, L. W. Howard, C. Jacoby, E. M. Killough, J. B. Mitchell, B. H. Moore, H. L. Restall, J. H. Roach, E. J. Rockefeller, W. F. Sanders.

This is a progress report, presented as information.

Regulatory Bodies

The Interstate Commerce Commission's allocation of its appropriation for the Bureau of Valuation for the year beginning July 1, 1952, contains approximately the same amount as was expended last year, which was $493,812. This will not permit the expansion of its forces and, as positions are vacated, they will not be filled. Thus, by the process of attrition, the functions of the bureau will be further curtailed and any work arrearage increased due to inability to expand their forces.

During the year the forces of the bureau were engaged in railroad and pipeline work, with emphasis on the pipeline work, as their program contemplates the preparation of tentative valuations on an annual basis for all pipeline companies subject to their jurisdiction.

During 1951 Class I carriers charged to Account 459, Valuation Expenses, an amount of $719,900, contrasted with $679,912 for the year ending 1950.

As of October 1, 1952, the Class I carriers were practically on a current basis in the filing of 588 returns with the bureau (5 carriers not filing for the year 1949, and 20 carriers not filing for 1950). Of the returns due December 31, 1952, 18 carriers had filed. The Accounting Section of the bureau is now 90 percent current in its field check of these returns.* The 588 returns enable the bureau to carry into their continuous inventories and records the changes in property and their costs subsequent to the original valuation.

The Engineering Section of the bureau, having completed revised inventories for practically all carriers through the year 1932, is engaged in bringing its inventories forward to later dates and, as of October 1, 1952, was approximately 80 percent* current (long form method). The work of the Accounting Section in bringing summaries of original cost, other than land, is 94 percent* current; the summaries of original cost of land is 41 percent* current. The Land Section in its work of revising land valuations to current dates has completed 75 percent* of its work. (Except in a few cases, the latest appraisal was made as of 1945. Subsequent revisions have been limited to additions and retirements.)

In measuring the progress made during the year, or even for the past five years, on the railroad valuation work, it will be noted that the bureau is not able to maintain a status quo in its program, and it will be impossible for the bureau to keep abreast of its work load or to make up arrears unless Congress grants sufficient appropriations to sustain properly the bureau's activities. On October 1 the bureau had a total of 76 employees, of which 27 were in the Engineering Section, 27 in the Accounting Section (15 office and 12 field), and 16 in the Land Section (11 office and 5 field).

* Based on 8,750,000 mile-years from basic valuation dates through 1951.

Elements of Value as of January 1, 1952

The Bureau of Valuation is now completing its work in the preparation of its estimates for the Class I carriers covering the standard elements of value as of January 1, 1952. At the time of the preparation of this report, these figures were not yet available.

Ex Parte No. 175—Increased Freight Rates, 1951

In Ex Parte 175—Increased Freight Rates, 1951, further hearings took place during January and February 1952, at which the carriers sought authority to publish the balance of the increased freight rates embraced in their amended petition of March 28, 1951. Considerable testimony was introduced for the carriers by Witness H. T. Bradley, valuation engineer (V.S. 69, V.S. 225 and V.S. 342), pointing out the need for a proper determination of the rate base and the conservative estimates made by the commission's Bureau of Valuation in their elements of value statement prepared as of January 1, 1951, which was introduced as Exhibit 119 in the proceedings. A strong presentation was made by numerous witnesses urging the necessity for an adequate rate of return and of sufficient revenues to enable the carriers to provide the service contemplated by Section 15 (a) of the Interstate Commerce Act. Verified Statement (R.V.S. 79), prepared by B. H. Moore, valuation asst., AAR, was likewise introduced, which showed the rates of return earned on various rate bases by the individual Class I carriers for the five-year period 1946–1950.

In the carrier's brief dated February 23, 1952, the following is said relative to the rate base considerations:

> (a) Rate Base Considerations.
>
> There is no occasion in this proceeding for a determination as to any specific rate base for the railroads since their rates of return fall below a reasonable level under the proposed rates whether net investment or valuation methods previously employed by the Commission are used. However, inasmuch as this subject has been dealt with generally by the Commission in prior general revenue proceedings, a few observations are appropriate.[1]
>
> In the inflationary post-war years, the commission has utilized what it terms an "original cost" approach, which actually is the commission's 1910–1914 estimated cost of reproduction, plus subsequent additions and betterments, less retirements to date. Ex parte 166, *Increased Freight Rates, 1947*, 269 ICC 33, 47, and 270 ICC 403, 435; Ex Parte 168, *Increased Freight Rates, 1948,* 276 ICC 9, 18; Ex Parte 175, *Increased Freight Rates, 1951*, 280 ICC 179, 185, and 281 ICC 557.
>
> Under this approach, the rate of return for the United States would be only 4.95 percent on a rate-base of $24,378.3 million (Tr. 6109), if the proposed rates could have been in effect on interstate and intrastate traffic for the full year 1952. And all of the individual regions would have earned substantially less than 6 percent.
>
> While the valuation approach used by the Commission in post-World War II general revenue proceedings supports the relief sought by petitioners, it does depart from the method followed in pre-World War II proceedings[2] where weight was given to cost of reproduction less depreciation as well as to original cost less depreciation. Having given weight to reproduction cost in the depression years of the thirties, the Commission's failure to accord this element any weight in recent years of greatly inflated costs appears highly inconsistent.

[1] Petitioners' discussion of the commission's prior methods does not constitute an acquiescence in their legality or validity, particularly as related to individual railroads. As indicated in the text, they are referred to for illustrative purposes only and under circumstances which preclude any necessity on the part of the commission or petitioners for a detailed determination of rate-base factors.

[2] Ex Parte 115, *General Commodity Rate Increases, 1937,* 229 ICC 435, 450; Ex Parte 123, *Fifteen Percent Case, 1937–1938*, 266 ICC 41, 61.

A further inconsistency in the Commission's recent approach to the question of a railroad rate-base is reflected by its valuations for rate-making purposes of pipe line carriers subject to the Interstate Commerce Act. In dealing with such carriers—which are competitors of the railroads—reproduction cost less depreciation is weighted with original cost less depreciation in determining value. This was done, for example, in *Ajax Pipe Line Corporation,* 50 Val. Rep. 1, decided December 14, 1949, which involved the value for rate making purposes of a pipe line common carrier owned by Standard Oil Company of New Jersey and two other oil companies. Significantly, the valuation approach previously applied to the railroads in this proceeding would have resulted in a value of $6,098,498 for the Ajax Corporation, whereas the value actually found was $12.3 million or over twice as much. Application of the formula used in the Ajax case to the railroads produces an aggregate value of $28,785 million[3] and an estimated return of 4.20 percent for 1952 under the proposed rates. This singular disparity between carriers subject to its jurisdiction has never been explained by the Commission.[4]

Moreover, failure to recognize reproduction costs conflicts with the economic realities of our times. While all regulated industries are affected in varying degrees by the greatly reduced purchasing power of the dollar, the impact of this situation on the railroads has been heavy indeed. The archaic relationship of 1910–1914 price levels to current costs is indicated by petitioners' showing that the purchasing power of the dollar dropped from a 1914 base of 100 to 35 cents for road property and 29 cents for equipment in 1950 (V.S. 69). It is clear that the measure of adequate railroad earnings should be related to current costs either by recognition of reproduction costs in the rate-base or an appropriate upward revision of rate of return standards. In short, railroads—like agriculture, labor, and industry—must take in dollars which bear a reasonable and practical relation to dollars necessarily paid out.[5]

The commission, in its report of April 11, 1952, (284 ICC 589) confirmed its previous findings as to the rate base and gave no recognition to current reproduction costs. When it is considered that the carriers operate and maintain property which would cost $60 billion to replace, it is ignoring realities to use as a rate base a figure which is based on dollars of widely different purchasing power than those of today.

An extract from the commission's decision is as follows (p. 607–613):

Valuation.—In consideration of the question of the adequacy of the returns of the petitioners, the value of their properties devoted to common carrier service is a necessary factor to be examined. Our report on further hearing, 281 I.C.C. 563, *et seq.,* stated our estimates of the values of the Class I railroad properties, as of January 1, 1950, which, for the purposes of this proceeding, we considered should be based upon our estimates of original cost (except lands and rights), the present value of lands and rights, with an allowance for working capital and materials and supplies computed in the manner in which we estimated such accounts in proceedings under section 19a of the act, less recorded amounts for depreciation and amortization. This method probably somewhat understates the actual depreciation which has occurred. In the recent further hearings, the data used were supplemented by the submission in evidence by the petitioners of similar data as of January 1, 1951, and by estimates of the net increment in investment to be made during the year 1952.

Our deduction of value in the former report on further hearing, $22,138,-013,014, as of January 1, 1950, is criticised by petitioners in testimony and upon argument, as not consistent with methods of estimation employed by us in former

[3] The conservative nature of this valuation is discussed in some detail at pages 42–44 of petitioners' brief of July 9, 1951, in this proceeding.

[4] The method used by the commission currently in regulation of pipe line carriers and during depression years in regulation of railroads comports with *St. L. & O'Fallon R. Co. v. U. S.*, 279 U. S. 461. The Commission's complete disregard of current reproduction costs in railroad general revenue cases since the war conflicts with that decision.

[5] As the late Commissioner Eastman observed in *Fifteen Percent Case, 1937–1938,* 226 ICC 41 145, government regulation does "not enable an industry safely to disregard economic laws."

cases, and as not giving sufficient weight to the present day high costs of reproduction. It is not considered necessary now to analyze the claims in detail. Inflationary processes are and have been so strong that it is clear that estimates of cost of present day reproduction, while useful in measuring inflationary forces, need not be given controlling consideration in estimating value of public service property for rate-making purposes. No prudent man would consider reproducing the properties on the basis of the extremely high reproduction costs estimated. Intention to make such use of the cost of reproduction estimate was disclaimed on the argument. In fairness, to bring about the end result of a reasonable return and reasonable rates which it would be possible to charge, the manner of estimation of value shown in our former report on further hearing should be employed again as the measure of value for the purposes of this proceeding at this stage. The figures so deduced are not far from the amount shown in the investment accounts of the petitioners, and are not far from the total capitalization as of December 31, 1950.

Following that method, the aggregate value as of January 1, 1951, of the properties of the Class I railways is taken as being $22,677,972,933. This figure may be compared with the carriers' present estimate as of the previous day, December 31, 1950, slightly reduced from the former showing, of $24,591,861,642 and with a "grand total debt, stock, and surplus" as of the same day for the Class I line-haul operating companies of $23,028,005,562. Their estimate as of December 31, 1951, was $25,463,300,000, and of the end of the present calendar year (assuming continuance of current rates) $26,225,100,000.

The valuation estimates of the Department of Commerce as of the end of the calendar years 1951 and 1952 are $23,549,600,000 and (assuming current rates) $24,311,400,000, respectively. The difference between these two figures represents the petitioners' estimate of the increment to investment, undepreciated, during the calendar year 1952.[6]

* * *

Judged by any standard shown of record, the rates of return earned or prospectively to be earned by the railroads by the districts and regions specified in our former reports in this case, are substandard. Some important roads are earning little enough that a continuance of the earnings situation will imperil their solvency, while some are in comfortable condition. Neither the strongest nor the weakest lines can control the rate adjustment; and as has been shown, the great body of the rail carriers are in the middle class, with aggregate earnings that for the immediate future must be considered as substandard, and inadequate.

Consideration of these rates of return for their bearing on this proceeding, which relates to the rate level for the future, requires that allowance be made, necessarily in general terms, for the effect of the following factors already referred to. On the revenue side, the interim increase allowed and the additional increases were in effect but portions of the calendar year 1951, and some rates, particularly intrastate rates, have lagged somewhat further behind. On the expense side, important changes in the wage scales became effective during the present calendar year: some moderate increases have occurred in material prices; and as to the operating revenues shown, hereafter (and now in effect) will be marked increase in corporate Federal income taxes, which must be deducted to ascertain net railway operating income. Beyond these factors, which are all ponderable items, is the inevitable uncertainty which must exist as to the amount and nature of future traffic, and the course of wage and price trends in the future. Informed opinions stated in the record tend to narrow the uncertainty as to the probable volume and character of traffic available during the present year, at least; but forecasting the future trend of wages and material prices is a highly speculative process.

[6] The estimates of rates of return yielded in this report may readily be translated by simple proportion to any of the other valuation estimates stated.

THE FEDERAL VALUATION OF THE RAILROADS IN THE UNITED STATES

AREA Bulletin 503, September–October 1952, contains a monograph entitled "The Federal Valuation of the Railroads in the United States", prepared by B. H. Moore, valuation assistant and accountant, Association of American Railroads. This was prepared at the request of Committee 11 and was reviewed by a special committee, consisting of Messrs. J. H. Roach, chairman, F. B. Baldwin, and H. T. Bradley, as well as the members of Committee 11. Separate reprints of the monograph are available upon application to the secretary's office.

COURT DECISIONS

No outstanding cases involving valuation were decided by the U. S. Supreme Court during the year.

Report on Assignment 7

Revisions and Interpretations of ICC Accounting Classifications

H. N. Halper (chairman, subcommittee), S. H. Barnhart, W. S. Gates, Jr., W. A. Godfrey, W. M. Hager, B. H. Moore, J. H. O'Brien, M. G. Pettis, J. H. Roach, H. B. Sampson, J. R. Traylor, J. L. Willcox.

In last year's report we mentioned a proposed order of the ICC relating to units of property and related matters. It is the usual procedure for the ICC to send such proposed orders to the Association of American Railroads, its Accounting Division, for review and report. Cognizant of the important engineering aspects of this order, the division appointed a working committee of engineers and accountants to study and recommend a list of units which would be in conformity with good engineering practice, as well as the existing depreciation rates of railroad property. All four engineers of this working committee are members of the AREA and of its Committee 11. The working committee held several meetings, rendered a tentative report, and later participated in the discussion of this report with the representatives of the Interstate Commerce Commission. This subcommittee will keep the Association advised of further progress.

There were several orders issued by the ICC since January 1, 1952, which may be of interest to engineers, as follows:

1. An order canceling the amortization accounts in Operating Expenses, effective January 1, 1952, for emergency facilities acquired subsequent to December 31, 1949, and certified under Section 124 (a) of the Internal Revenue Code.
2. Cancellation of Accounting Case 183 of Accounting Bulletin No. 15, and revising it under the same number, effective May 1, 1952; and issuance of a circular canceling part (b) of Case A–13 revised. The object of these orders is to provide a uniformity of accounting for construction of industrial side tracks under various conditions.
3. Case A–191, issued May 1, 1952. This case provides for the charging of the cost of treating, storing and delivering water for diesel locomotives to Account 18—Water Stations, and those for fuel for diesel locomotives to Account 19—Fuel Stations. Also, if a facility combines several servicing features, the principle of predominant use is applied.

Report of Committee 24—Cooperative Relations With Universities

C. G. Grove, *Chairman,*
Lem Adams
L. L. Adams
J. B. Akers
M. B. Allen
W. S. Autrey
J. B. Babcock
T. A. Blair
Armstrong Chinn
H. R. Clarke
R. P. Davis
O. W. Eshbach
P. O. Ferris
W. H. Huffman
Clark Hungerford
S. R. Hursh
J. R. Ivey, Jr.
A. V. Johnston
G. A. Kellow
W. S. Kerr
H. E. Kirby
R. B. Kittredge
T. R. Klingel
N. W. Kopp
B. B. Lewis
F. J. Lewis
H. S. Loeffler
E. E. Mayo
C. T. Morris
C. H. Mottier
R. C. Nissen
R. J. Stone, *Vice Chairman,*
L. M. Ogilvie
W. A. Oliver
J. E. Perry
R. B. Rice
J. A. Rust
W. C. Sadler
P. S. Settle, Jr.
H. O. Sharp
D. W. Tilman
E. C. Vandenburgh
Barton Wheelwright
R. C. White
A. D. Wolff, Jr.
Committee

To the American Railway Engineering Association:

Your committee reports on the following subjects:

1. Stimulate greater appreciation on the part of railway managements of

   (a) the importance of bringing into the service selected graduates of colleges and universities.

   (b) the necessity for providing adequate means for recruiting such graduates and of retaining them in the service by establishing suitable programs for training and advancement.

   Progress report, presented as information .... page 878

2. Stimulate among college and university students a greater interest in the science of transportation and its importance in the national economic structure, by cooperating with and contributing to the activities of student organizations in colleges and universities.

   Progress report, presented as information .... page 899

3. The cooperative system of education, including summer employment in railway service.

   Progress report, presented as information .... page 901

The Committee on Cooperative Relations with Universities,
C. G. Grove, *Chairman.*

AREA Bulletin 506, January 1953.

A

Report on Assignment 1

Stimulate Greater Appreciation on the Part of Railway Managements of:

a) the importance of bringing into the service selected graduates of colleges and universities, and

b) the necessity for providing adequate means for recruiting such graduates and of retaining them in the service by establishing suitable programs for training and advancement.

J. B. Akers (chairman, subcommittee), R. J. Stone, M. B. Allen, H. R. Clarke, Clark Hungerford, G. A. Kellow, N. W. Kopp, F. J. Lewis, C. H. Mottier, Dr. R. B. Rice, P. S. Settle, Jr., R. C. White, A. D. Wolff, Jr.

This is a progress report, submitted as information.

As reported at the March 1952 meeting, a letter with questionnaire was sent to the managements of 132 railroad companies in the United States, Canada and Mexico, with the purpose of developing the extent to which the railroads have adopted programs for training technical graduates for supervisory and managerial positions. It was hoped that other valuable data on training programs would develop, and of even more importance, call to the attention of managements the necessity of finding means of *attracting, training* and *holding* technically qualified men for service in the railroad industry. A copy of the questionnaire is presented herewith.

Replies were received from 62 railroads. Fifty-nine of the replies were from railroads in the United States, 2 in Canada and 1 in Mexico.

Seventeen of the railroads which replied have definite programs for training graduates of technical schools. Such programs are under consideration by 8 other lines. Twenty railroads state they have no program, and 17 state that such is impractical for them. No replies were received from 70 railroads.

The number of replies indicates that the importance of the subject is becoming more widely recognized in the industry. A few years ago only 5 or 6 railroads had training programs. Now, at least 17 have a program.

A tabulation, marked Exhibit A, summarizing replies from those railroads which have definite programs, is shown following page 880.

The following stands out in the replies:

Twenty-four railroads have summer programs for employing undergraduates, and 37 railroads comment that, in their opinion, this is an effective way of stimulating interest in railroad employment.

Ten railroads have programs for employing co-op students, and 20 railroads indicate they think this an effective way of stimulating interest.

Forty-two of the 62 railroads replying state definitely that, in their opinion, a background of engineering education and subsequent experience are desirable qualifications for higher positions in the industry.

Salaries paid trainees in these programs are fairly comparable with those paid in other industries. It seems that, in general, salaries paid upon completion of training are adequate to attract desirable candidates.

Information on training programs on the 17 railroads is presented as Exhibit B. The statements are taken from the replies of those railroads.

Pertinent comments of some of the responding railroads which do not have training programs are presented as Exhibit C.

It is observed that a very considerable number of the larger railroads did not answer the questionnaire. This may indicate that there is much more to be done by this committee to interest the railroads as a whole in the importance of recruiting technically qualified men for the filling of supervisory positions. There have been frequent discussions of a means to make this effective. We are agreed that it can be solved only by the technical personnel of each railroad in its dealings with its management. In other words, the technical personnel must sell the idea of its importance to the management of his individual company.

This report contains information as to methods which are operating successfully. Selection of a method can be made that would be applicable to the individual railroad. The committee feels that this matter is of great importance to the future of the industry, and is particularly so in the foreseeable future in which technically trained men will be in great demand throughout all industry. It is a well-known fact that the number of graduates of technical schools is declining, which will be true for several years to come. The graduates that are available will be recruited by the railroads or other industry which goes after them in an aggressive manner.

QUESTIONNAIRE TO DEVELOP THE EXTENT TO WHICH RAILROADS HAVE ADOPTED PROGRAMS OF TRAINING GRADUATES OF TECHNICAL SCHOOLS FOR DEVELOPMENT OF CAPACITIES FOR RESPONSIBLE SUPERVISORY AND EXECUTIVE POSITIONS

(Submitted to railroad managements with letter dated November 22, 1951)

1. Do you have a definite program of training graduates of technical schools for the more responsible positions on your railroad?

2. If you have such a program, please furnish a copy of it to Subcommittee 1 of AREA Committee 24.

3. How long has your program of training been in effect?

4. If you do not have such a program, are you contemplating the establishment of one?

5. How many men are included in your training course?

6. Do you have an established schedule for regular promotions or salary increases during the training period? If consistent with your company's policy, please furnish details of the schedule.

7. What position and salary may the trainee normally expect upon completion of the course?

8. Do you consider that such a program is, or would be, helpful on your railroad?

9. Do you have a program of employing undergraduates of technical schools during the summer months?

10. Do you think this is, or would be, a good way to interest competent technically trained men in the opportunities afforded in the railroad field?

11. Do you have a program of employing co-op undergraduates of technical schools?

12. Do you think this is, or would be, a desirable method of interesting and training men for advanced railroad service?

13. Do you consider that a background of engineering education and subsequent experience in the engineering and maintenance departments of a railroad are desirable qualifications for the higher positions in these or other departments?

14. If you do not have a training program as outlined above:

    (a) What is the policy and practice in effect for training and developing leaders for advanced positions in all branches of the service?

    (b) Have you found this arrangement entirely satisfactory?

EXHIBIT A - SUMMARY OF REPLIES TO QUESTIONNAIRE DATED NOVEMBER 22, 1951, TO DEVELOP THE EXTENT TO WHICH RAILROADS HAVE ADOPTED PROGRAMS OF TRAINING GRADUATES OF TECHNICAL SCHOOLS FOR DEVELOPMENT OF CAPACITIES FOR RESPONSIBLE SUPERVISORY AND EXECUTIVE POSITIONS, SPONSORED BY SUBCOMMITTEE 1 OF COMMITTEE NO. 24.

Questions - Nos.	1	2	3	4	5	6	7	8	9	10	11	12	13	14 A	14 B
Summary of Replies From Railroads Having Definite Training Program.															
Atchison, Topeka & Santa Fe Ry. Sys.	Yes-For Civil, Mech. & Elect. Engineering		6 Yrs. Civ. Engr., 25 " Mech. & Elec. Engr.	-	6—Civ. Engr. 5 to 8 Mech. & Elec. Engr.	Civ. Engr. $290-$330 Others $280-$315	$370 - $505	Yes	No	Yes	No	Yes—But Seniority Sys. Presents Difficulty	Yes	Also Have Supervisory Training	Yes
Atlantic Coast Line R. R.	Yes-For Mech. Dept. only		29 Years	-	7	Yes	Shop Engr. Gang Foreman About $390	Yes	No	Yes	Yes	Yes	Yes	-	-
Baltimore and Ohio R. R. Co.	Yes		2 Years	-	8	$272 - $324	$400	Yes	No	Yes	Yes	Yes	Yes	-	-
Boston and Maine R. R.	Yes		6 Years	-	4	Yes $275-$409	Asst. Supvr. $409	Yes	-	-	No	No	Yes	-	-
(Maine Central Railroad)	Yes		"	-	2	" " "	" " "	Yes	-	-	No	No	Yes	-	-
Central of Georgia Ry. Co.	Yes		Rdwy. Dept. 36 Yrs. Mech. " 5 "	-	Rdy. Dept. 15 Mech. " 8	No	No Definite Limit	Yes	Not as a Program	Yes	No	Yes	Yes	-	Not entirely
Chicago, Rock Island & Pacific RR Co.	Yes		6 Months	-	5 Now, about 25 Later	Yes $310 - $360	Asst. Roadmaster, etc. $375 - $475	Yes	Yes	Yes	No	Yes	Yes	-	-
Denver & Rio Grande Western R.R. Co.	Yes		Many Years Expanded last 2 Yrs	-	MW&S 5 M of E 3	See Exhibit B	-	Yes	Yes	Yes	No	Yes	Yes	-	-
Great Northern Ry. Co.	Yes	See Exhibit "B"	16 Years	-	15 to 20	$305 - $355	$445 - $583	Yes	Yes	Yes	No	Yes	Yes	-	-
Illinois Central Railroad	Yes		6 Years	-	27	Yes	Asst. Supvr., etc. $375	Yes	Yes	Yes	Limited	Yes	Yes	-	-
New York Central System	Yes-For Mech. Dept.		51 Years	-	8 each Yr.	See Exhibit B	$352 - $400	Yes	Yes	Yes	No	Yes	Yes	-	-
Norfolk & Western Ry. Co. (A)	MW&S-No Definite Program		-	-	5	No	$320 - $511	Satisfied as is	Yes	Yes	No	Yes (Qualified)	Yes	Employ Tech. Graduates	Yes
(B)	Mech. Yes		13 Years	-	20	Same as helpers	Shop Inspectors	Yes	Yes	Yes	No	Yes	Yes	-	-
Pennsylvania Railroad	Yes		60 Years	-	124	$316 - $400	$434 - $503	Yes	Yes-MW&S No-M of E	Yes	Yes-MW&S No-M of E	Yes-MW&S No-M of E	Yes	-	-
Richmond, Fredericksburg & Potomac RR	Yes		4 Years	-	5	Yes - $275 - $325	$350	Yes	No	Not for their road	No	No	Yes	-	-
St. Louis-San Francisco Ry. Co.	Yes		5 Years	-	12	Yes - $325 - $385	$425	Yes	Not as a Program	Yes	No	Yes	Yes	-	-
Southern Railway System	Yes		38 Years	-	26	No set schedule	$480	Yes	Yes	Yes	Yes	Yes	Yes	-	-
Virginian Railway Company	Yes		4 Years	-	1	Yes	$525	Yes	No	-	No	-	Yes	-	-
Western Pacific Railroad Co.	Yes		2 Years	-	3	Exhibit B	$400	Yes	No	Yes	No	Yes	Yes	-	-

Exhibit B

ANSWERS TO QUESTION 2 OF QUESTIONNAIRE SUBMITTED WITH LETTER DATED NOVEMBER 22, 1951, GIVING DETAILS OF TRAINING PROGRAMS EMPLOYED BY VARIOUS RAILROADS

ATCHISON, TOPEKA AND SANTA FE

For the civil engineers we endeavor to hire about six graduates each year as chainmen or rodmen, assigning them to division or line-change parties. Shortly before the end of the first year, the chief engineer, system, canvasses the four general managers and asks them to submit the names of those who are the most likely prospects, and from the names so submitted there are selected from two to six to work as roadway assistants for a period of one year. While working as roadway assistants they may work on standards or be assigned to work with the various types of roadway machines, or such other duties as the chief engineer, system, may feel it is necessary for them to familiarize themselves with in order to enhance their value to the company. After they have served one year as roadway assistant they are returned to the operating division from which they came and are thereafter in line for promotion to assistant roadmaster or roadmaster. It is anticipated that on the average one-half of the vacancies in positions of roadmaster or assistant roadmaster will be filled from the ranks of these graduates and the other one-half from the ranks of track men. It is believed that the college graduates will make excellent timber for promotion to division engineers, and eventually to higher engineering positions.

With respect to graduate mechanical engineers, the following program is observed:

9 months, operating various machines
9 months, general floor work, locomotive department
6 months, roundhouse work
3 months, diesel shop
3 months, test department
6 months, special training consisting of some or all of the following:
Boiler shop
Car department (passenger and freight)
With road foremen of engines
In mechanical engineer's office
In engineer car construction department
Inspection department

For graduate electrical engineers, the schedule outlined below is followed:

3 months, inside wiring of cars
3 months, inside wiring of buildings
2 months, locomotive wiring
12 months, car lighting and air conditioning
2 months, outside line work
3 months, test department
3 months, electrical repair shop
5 months, general electrical work
3 months, diesel electrical shop

We also hire college graduates in our mechanical department who do not take the special apprenticeship courses as outlined above. For example, we hire some graduate mechanical engineers who are given courses in draftsmanship. They work in the mechanical engineer's office, in the offices of the engineer of tests and engineer of car construction, which gives them over-all training in our standards, research and other technical phases of mechanical engineering and related matters. They are also assigned to some special inspection work at car manufacturing plants and at other locations for the purpose of inspecting materials and equipment which we purchase.

ATLANTIC COAST LINE RAILROAD COMPANY

For the engineering graduate interested in a railroad career, the Atlantic Coast Line maintains a training course specifically designed to give a thorough foundation in railroad mechanical practice. As a Special Apprentice the trainee receives practical experience in the operation and maintenance of locomotive and car equipment through actual work in the shops and terminals of the company. Graduates interested in diesel-electric locomotives, air conditioning, car or locomotive construction and maintenance, and shop production will find the work is varied and extremely interesting.

During his training period, the special apprentice performs work in the following fields:

Diesel Locomotives: Light and heavy repairs, both mechanical and electrical.

Passenger Cars: Includes work on electrical, air conditioning, and brake equipment, body rebuilding, and truck overhaul.

Freight Cars: Light and heavy repairs.

Machine shop, erecting shop, boiler shop and electric shop experience.

Special Assignments: Chemical laboratory, drafting room, and others.

The program schedule is broad enough to give the graduate an extensive foundation in railroading, yet flexible enough that he may concentrate in his field of interest. The course is designed to cover three years, but at any time after 1 year to 18 months a man is considered for possible promotion, based upon ability and suitable vacancies.

At present special apprentices work five 8-hr days a week. Starting pay is $1.681 an hour, with a $.024 per hour increase every six months during the training period. In addition, the special apprentice enjoys the same privileges as other railroad employees, including free or reduced-rate passes for railroad transportation for himself and his dependents, a retirement plan, a hospitalization plan, and an annual one-week vacation after completion of one year's work.

The training is accomplished by the special apprentice working in the roundhouse and shops with the mechanics and craftsmen doing the work. From time to time, as various tests are conducted on line of road, special apprentices are used as technical assistants. Such work acquaints them with problems involved in the actual operation of locomotives and cars.

The trainee must be interested in railroading in order to succeed. Supervisors in this field have great responsibilities, and their background must be adequate; hence the necessity of providing graduate engineers practical experience to supplement purely theoretical training.

No definite promise of promotion is made, since much depends upon the abilities of the individual; however, opportunities for promotion on the Atlantic Coast Line are excellent. The majority of potential openings lie in supervisory positions in the field—roundhouse foremen, shop foremen in various departments, all of which could lead to general foremanships, master mechanic's positions, etc.

The qualifications for employment as a special apprentice are:

a. Possess an engineering degree, preferably in mechanical or electrical engineering, from an accredited college.

b. Be between the ages of 18 and 26.

c. Be in good physical condition.

The openings for special apprentices are limited, but all applications will receive careful consideration.

BALTIMORE & OHIO RAILROAD

(See pages 884 and 885)

BOSTON AND MAINE RAILROAD

As our training program depends largely on the time of year, work programs, etc., we do not have a rigid schedule, except in a general way, as follows:

(a) Six months with assistant engineer in division office, surveying, estimating, drafting, etc.

(b) Three months with bridge and building supervisor, inspection and planning of work, preparation of small sketches, requisitions, watching crews work on larger operations, etc.

(c) Three months with signal department studying elementary circuits, methods of maintenance, accompanying maintainers and construction crews, estimating, etc.

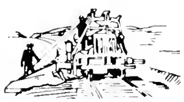
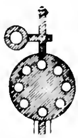
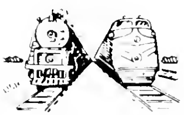
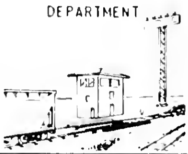
(d) Six months with track supervisors on daily routine, following work of section and extra gangs, spotting ties for renewals, studying work methods and practices.

(e) Balance of three-year period to be assigned to particular projects, such as rail or resurfacing projects, large bridge or building projects, or assigned to operating department for elemental training.

CENTRAL OF GEORGIA RAILWAY COMPANY

Our roadway department has a training program. We take graduate engineers in the engineering department as draftsmen and advance them through the department as their ability, aptitude and other conditions will permit. We endeavor to interest those adapted to line of road work in the work of supervisors for further training in railroad operation. This provides them with experience sufficient to be promoted to division engineers, trainmasters, and further advancement. We have several general officers who have advanced along these lines due to the training program as outlined.

(Continued on page 886)

PRELIMINARY TRAINING - 60 WEEKS OUTLINE - FIVE - 11-WEEKS DEPARTMENTAL ASSIGNMENTS AND GENERAL ORIENTATION		
ENGINEERING DEPARTMENT 	REGIONAL ENGINEER SURVEYING - DRAFTING - PLANS - ESTIMATES - CONSTRUCTION INSPECTION - COMPUTING	
	OFFICE ENGINEER REPRODUCTIONS - MISC. DRAFTING - PLANS - ESTIMATES - TRACK LAYOUTS	
	ENGINEER OF BRIDGES STEEL REPAIR PLANS - RATINGS - CAPACITIES - SIMPLE DESIGN	
	ENGINEER OF BUILDINGS BUILDING PLANS	
	MISCELLANEOUS NATURAL RESOURCES, INVESTIGATIONS, REPORTS, ADMINISTRATION	
MAINTENANCE OF WAY DEPARTMENT 	TRACK SUPERVISOR (3 WEEKS) TRACK AND ROADWAY MAINTENANCE	
	DIVISION ENGINEER (3 WEEKS) TRACK - ROADWAY - BRIDGE - BUILDING - SIGNALS	
	ENGINEER M. OF W. (2 WEEKS) REGIONAL M. OF W. OPERATION	
	CHIEF ENGINEER MAINTENANCE (3 WEEKS) GENERAL ADMINISTRATION	
COMMUNICATIONS AND SIGNAL DEPARTMENT 	COMMUNICATIONS (5 WEEKS)	OFFICE - ORGANIZATION STUDIES (2 WEEKS)
		FIELD - CONSTRUCTION (1 WEEK)
		FIELD -- MAINTENANCE (2 WEEKS)
	SIGNAL (5 WEEKS)	OFFICE - ORGANIZATION STUDIES (1½ WEEKS)
		FIELD - (3½ WEEKS) AUTOMATIC SIGNALS - C.T.C. - RECLAMATION SHOP - INTERLOCKING - CAR RETARDERS - CROSSING PROTECTION + SPRING SWITCHES
	1 WEEK	ELECTRICAL DEPARTMENT
MOTIVE POWER DEPARTMENT 	GENERAL OFFICE & MECHANICAL ENGR. (3 WEEKS) ADMINISTRATION	
	BACK SHOP (4 WEEKS) MACHINE WORK - ERECTING WORK SUPPORTING SHOP - ADMINISTRATION	
	ROUND HOUSE (2 WEEKS) INSPECTION - REPAIRS, ETC. - ADMINISTRATION	
	HEAVY CAR REPAIRS - LIGHT CAR REPAIRS (1 WEEK)	
	RIDING LOCOMOTIVES (1 WEEK)	
OPERATING DEPARTMENT 	ASST. TO V.P. OPERATION & MAINT. (11 WEEKS) ADMINISTRATION STATION SERVICE YARD OPERATIONS TRAIN OPERATIONS - FREIGHT PASSENGER SERVICE	
GENERAL CONFERENCES (1 WEEK) JOB INSTRUCTION HUMAN RELATIONS METHODS PROGRAM DEVELOPMENT CONFERENCE LEADING	GENERAL OFFICES (3 WEEKS) FINANCE, TREASURY & RELIEF GENERAL COUNSEL ACCOUNTING & FREIGHT CLAIMS PERSONNEL TRAFFIC PURCHASING PUBLIC RELATIONS	
VACATION - 1 WEEK		

Technical graduate training course on the Baltimore & Ohio Railroad

(Continued on next page).

INTENSIVE TRAINING - 65 WEEKS				
OUTLINE OF WORK FOR TRAINEE IN ONE OF THE DEPARTMENTS				
ENGINEERING	MAINTENANCE OF WAY	COMMUNICATIONS OR SIGNAL	MOTIVE POWER	MOTIVE POWER
				ELECTRICAL POWER FIELD
REGIONAL ENGINEER (21 WEEKS) SURVEYING PLANS - ESTIMATES SPECIFICATIONS, ETC. CONSTRUCTION INSPECTION CONTRACTOR'S ESTIMATES	ENGINEER OF TESTS (4 WEEKS)	ENGINEER OF TESTS (4 WEEKS)	MECHANICAL ENGINEER (10 WEEKS) PASSENGER & FREIGHT CAR LOCOMOTIVE SHOP AND POWER PLANT	GEN'L SUPT. M. P. & EQ'PT. (6 WEEKS) CAR LIGHTING AIR CONDITIONING DIESEL LOCOMOTIVES ELECTRICAL FEATURES DIESEL INSTRUCTION CAR SELF-PROPELLED DIESEL PASSENGER CARS ELECTRONICS TRAIN CONTROL
ENGINEER OF BUILDINGS (7 WEEKS) PLANS FOR ALTERATIONS BUILDING DESIGN SPECIFICATIONS	ENGINEER M. OF W. (12 WEEKS) SURVEYING PLANS - ESTIMATES INSPECTIONS - REPORTS STUDY OF STANDARDS PRACTICES AND PROGRAMS	COMMUNICATIONS - 61 WEEKS: CONSTRUCTION (16 WEEKS)	ENGINEER OF TESTS (4 WEEKS)	LOCOMOTIVE BACK SHOP MT. CLARE (4 WEEKS) CAR LIGHTING AND AIR CONDITIONING DIESEL MOTOR AND GENERATOR REPAIRS DIESEL LOCO. WIRING
ENGINEER OF TESTS (4 WEEKS)	SUPERVISORS (32 WEEKS) DUTIES AND PROBLEMS OF SUPERVISORS HIGH SPEED TERRITORY - EASTERN REGION SEABOARD TERMINAL HIGH SPEED - TONNAGE TERRITORY - EASTERN REGION MOUNTAIN TERRITORY HIGH SPEED - TONNAGE - CENTRAL REGION PRAIRIE HIGH SPEED - CENTRAL PRAIRIE - MODERATE TRAFFIC LIGHT TRAFFIC - HIGH SPEED PRAIRIE SLOW TONNAGE TERRITORY - HEAVY BRANCH	COMMUNICATIONS - 61 WEEKS: MAINTENANCE (16 WEEKS)	LOCOMOTIVE BACK SHOPS (24 WEEKS) STEAM AND DIESEL LOCOMOTIVE REPAIRS DIESEL SHOP ERECTING SHOP MACHINE SHOP TOOL ROOM AIR BRAKE SHOP BLACKSMITH SHOP ELECTRICAL SHOP POWER PLANT PATTERN & CABINET SHOP WHEEL & AXLE SHOP PIPE & TIN SHOP SUPT. SHOPS - OFFICE	ENGINEER OF TESTS (4 WEEKS)
ENGINEER OF BRIDGES (11 WEEKS) STEEL REPAIR PLANS LOCOMOTIVE RATINGS BRIDGE CAPACITIES BRIDGE DESIGN	MASTER CARPENTERS (4 WEEKS) DUTIES - PROBLEMS - ETC. BRIDGE & BLDG. MAINTENANCE	COMMUNICATIONS - 61 WEEKS: SUPERVISION (14 WEEKS)	CUMBERLAND BOLT & FORGE (4 WEEKS)	ELECTRICAL ENGINEER (51 WEEKS) PLANS, ESTIMATES AND SPECIFICATIONS ELECTRIC LIGHTING DESIGN ELECTRIC POWER SUB-STATIONS AND POWER DISTRIBUTION DIESEL ELECTRIC LOCO. WIRING DIAGRAMS PURCHASED ELECTRICITY POWER FACTOR CORRECTION POWER CONTROL ELECTRICAL EQ'PT. TESTS ELECTROLYSIS MITIGATION INSPECTIONS REPORTS
CHIEF ENGINEER (7 WEEKS) GENERAL ADMINISTRATION	CHIEF ENGINEER MAINT. (13 WEEKS) ADMINISTRATION INSPECTION DUTIES OF ASST. ENGINEER INVESTIGATIONS STANDARDS POLICIES DETECTOR CAR	COMMUNICATIONS - 61 WEEKS: OFFICE (15 WEEKS)	REG. MECHANICAL SUPR. AND MOTIVE POWER INSPECTOR (3 WEEKS)	
OFFICE ENGINEER (15 WEEKS) REPRODUCTIONS CHARTS - DIAGRAMS PLANS - ESTIMATES YARD AND SIDING LAYOUTS		OR	DIESEL INSTRUCTION CAR (2 WEEKS)	
		SIGNAL - 61 WEEKS: CONSTRUCTION (16 WEEKS)	ROUNDHOUSES (8 WEEKS) IN & OUTBOUND INSPECTION FREIGHT & PASS. POWER FORMING & DISPATCHING RIDING LOCOMOTIVES MASTER MECHANICS OFF.	
		SIGNAL - 61 WEEKS: MAINTENANCE (16 WEEKS)	HEAVY CAR REPAIR SHOP (4 WEEKS)	
		SIGNAL - 61 WEEKS: SUPERVISION (14 WEEKS)	AIR BRAKE INSTR'TN. CAR (2 WEEKS)	
		SIGNAL - 61 WEEKS: OFFICE (15 WEEKS)	GENERAL OFFICE (4 WEEKS) ACCT'G. - COSTS - MATERIALS STANDARDS - ADMINISTRATION	

Technical graduate training course on the Baltimore & Ohio Railroad (Continued from preceding page).

CENTRAL OF GEORGIA (Cont'd)

TRAINING OR TRAINEE JOBS AVAILABLE FOR TECHNICALLY TRAINED COLLEGE GRADUATES WITH ADVANCEMENT AND SALARY SCHEDULES

Position	*Pay Rate (40-Hr Wk) Per Month*	*Number Employed Presently*	*Normal Position to Which Promotion Can Be Expected*
Apprentice chemist	$244*	2	Chemist ($373)
Apprentice draftsman	296	1	Draftsman ($356)
Draftsman	356	2	Asst. mech. eng's ($430) or Shop engineer ($420) or Welding engineer ($470)
Asst. mech. engineer	430	1	Mech. engineer ($450)
Welding instructor	406	1	Welding engineer $470)
Welding engineer	470	1	
		8	

* Apprentice rates increase $5 per month each six months for first three years, $10 per month for next six-month period, and $15 per month for last six months.

CHICAGO, ROCK ISLAND AND PACIFIC RAILROAD COMPANY

Two-Year Training Program for Engineering Graduates to Fit Them for Such Jobs as Assistant Roadmaster, Assistant Trainmaster, Transportation Inspector and Similar Positions as Junior Officers

The first six months of the program will be in the engineering and track departments. A man may start in as assistant to the division engineer, working first in the drafting room and on survey parties. He may then be assigned as a laborer on an extra gang or, if no men are cut off, as a laborer on a maintenance gang. Next, he may work as carpenter helper on a bridge and building gang, and in the event of any emergency work on the division to which he is assigned, he may be sent there to get that experience. During the first six months, the rate of pay will be $310 per month.

At the end of six months, the man will be interviewed by the general manager, personally, and the general manager will, at that time, dismiss the man if he definitely does not appear to be officer material.

The second six months will be in the mechanical department as special apprentice. The man may work in one of the roundhouses or diesel shops at Silvis, Ill., a car shop, or some rip track, in one of the power plants, in the coach yard at 47th St., Chicago, in the mechanical drafting room at Silvis, and also spend some time on the road with one of the diesel supervisors. The rate of pay for this second period will be $335 per month. At the end of this period the man will be interviewed by the general superintendent of motive power who, with the general managers, will decide whether he will be retained in service.

The third six months' period would be in the transportation department with the title of transportation assistant. There the man will work with one of the transportation inspectors and spend some time in the transportation office, familiarizing himself with transportation matters.

He will next be assigned to the superintendent of station service and make trips with members of his department on the road, familiarizing himself with the operation of our stations. He may then be assigned to one of our smaller stations to assist the agent and to learn station work.

The next assignment would be with one of the trainmasters. Whenever possible, the man should work two months as either brakeman, fireman or switchman, if we have any terminal or division where we are short of this class of employee.

For the third and fourth six-months' periods of training, the rate of pay will be $360 a month. After the third six-months' period, the man will be assigned to the accounting department for two months and then to the personnel department for one month.

At the end of the third six months' period, the individual will be interviewed by the two general managers.

After the first 21 months of training, the man may be returned to the department where we expect to be able to use him first, unless he is an electrical engineer, in which case he will be sent to the signal or communications department for three months. At the end of two years, we should be ready to assign him to one of the junior official positions.

The foregoing program is very flexible and can be changed, depending on the requirements of service and the abilities of the individual concerned.

The trainee makes a report each month direct to the general manager on whose district he is working, briefly describing his activities during the month and stating what he is getting out of the training he is receiving, with his own views as to how his training is being handled. This report is sent to the general manager under personal cover.

Division superintendents will keep in close touch with each trainee on their division and see to it that they are spending their time properly, familiarizing themselves with all phases of operation, irrespective of what their particular job may be. This, of course, does not mean that their assigned job may, in any way, be neglected. Trainees should be encouraged to confer frequently with the superintendent or appropriate division officer to whom they are assigned.

THE DENVER AND RIO GRANDE WESTERN RAILROAD COMPANY

We are constantly searching for technically trained college graduates to enter our maintenance of way department and maintenance of equipment training programs. Trainees are selected on the basis of scientific selection procedures to insure that they have the proper personality make-up. "On-campus" interviews are conducted each year at technical schools where transportation courses are offered.

Maintenance of Way Department: Training at the present time is one of job rotation where the period of training depends entirely upon the ability and initiative of the individual and, of course, the occurrence of job openings in higher line positions. We hold nothing before these trainees except opportunity. They are started at assistant foreman's rate of pay ($281.50). However, their first work is as laborer on extra gangs in our summer track program with the possibility of their starting in any one of our extra gangs, which would include steel gang, surfacing gang, tie gang, or lining and dressing gang. These men are then advanced to assistant foreman as soon as they become acquainted with the various phases of work in the gang to which they are assigned. In the fall, at the close of the extra-gang work period, they are assigned as track inspectors or some other position in the maintenance of way department, from which promotion is made of those who qualify to assistant roadmaster, assistant supervisor of structures, or assistant trainmaster as opportunity is presented. Roadmaster, division engineer, and trainmaster are all steps that we expect these men to take over a period of years.

Maintenance of Equipment Department: Under our labor contract with the shop crafts organizations we are allowed three special apprentices who must be college graduates of recognized technical schools. Trainees selected receive training in all phases of the work in the maintenance of equipment department and may be moved from place to place in order to secure the benefit of training in all aspects of railroad mechanical work. Trainees receive $276.68 per month to start, with increases in pay every six months. Nothing is held before such trainees except opportunity upon completion of their training period, depending, of course, upon their ability and initiative. The training period is set up for three years, but it is not always required that the entire three years be completed since promotion of outstanding men may be made to supervisory positions at any time during that period, depending upon the occurrence of suitable job openings.

Qualifications: Applicants for trainee positions must be sincerely interested in railroading as a career and must be able to pass a rigid physical examination. We have no definite age limit. We prefer men for these jobs who have taken some railroad courses during their undergraduate work and we give preference to those who have been interested enough in railroading to have worked summer vacations for some railroad.

GREAT NORTHERN RAILWAY

Beginning in 1936 the Great Northern formulated a plan whereunder selected graduates from various colleges and universities were employed as assistants to division officers to acquire practical railway experience. It was first intended to use these men to build up the maintenance of way and mechanical supervisory forces, the purpose being to use them later as transportation officers if they became adapted to such service. However, as the plan developed, several students were put on as assistants to transportation officers at the time they entered the company's service. Their duties as trainees are greatly diversified in order that they will become familiar with the practical aspects of various phases of railroad service.

There, men were carried on the payroll of the division to which they were assigned —not on general office payroll. The rate paid trainees was increased at end of 6 months, and again at end of 18 months, and continued thereafter until appointed to a division officer's position if qualified therefor.

Although most of the trainees were technically trained, not all of them were technical graduates, or even college-educated. They were employed in various branches of the operating department in addition to the technical graduates normally employed by the engineering department. Men were sought as trainees who had high scholastic standing, and who had also indicated qualities of leadership in college activities.

In assigning duties to the trainees, care was taken to avoid infringing upon schedule provisions of the labor organizations' contracts, and, in general, the supervisors, foremen and employees have been cooperative in training the student officers in the practical aspects of railroading. In some cases employees of promising ability have been selected from the ranks as trainees, although holding membership in a labor organization.

In promulgating the training program the fact was impressed upon the officers responsible for its execution that the management desired the plan to prove successful. Trainees have been given opportunity for promotion as they became qualified, and the general officers have been kept informed regarding their progress. The responsibility for the work assigned the trainees—and the details of their training—lies primarily with the division officers.

Trainees were given full opportunity to become familiar with the manifold activities of the operating division where they were employed, and they were transferred to other divisions as their training progressed; they also submitted written reports from time to time to the division superintendents for review by general officers.

Should it appear that a trainee was lacking in iniative, or in willingness to assume responsibility, or in ability to handle men, efforts were made to develop his latent capacity by transferring him to other locations or to a different class of work before withdrawing him from the training program.

There was no guarantee to men selected for training that they would be advanced to official positions or that they would become members of the permanent staff. On the other hand, it was made clear to them that a lot of hard work is involved; that there would be seasons when they would see very little of their families.

For the purpose of a general appraisal of results, we analyzed the records of 93 men at the beginning of the postwar period who had been employed in some phase or other of the training program; 56 were college graduates, 16 had incomplete college education, and 21 only high school or grade school education; 43 of the 56 graduates were technical men.

As to the class of railway service to which successful trainees advanced, 31 were promoted to officers' positions in transportation service, 20 in maintenance of way service, 17 in mechanical-maintenance of equipment, and 6 in engineering service—total 74 promoted to officers out of 93 analyzed; 3 deceased and 16 dropped because of failure to qualify for further advancement.

ILLINOIS CENTRAL RAILROAD

A representative from the engineering department regularly visits selected engineering schools for preliminary interviews with students who are interested in railway engineering. Applicants for our training program are selected from among the graduates of these and other accredited engineering colleges and are given the title of junior engineering aid during the training program, which normally lasts two years.

The training program is designed to provide extensive on-the-job experience which will prepare the men to assume advanced technical, supervisory or administrative positions. The engineering aids are assigned to either the division engineering forces or one of the general office subdivisions, including the bridge, building, signal, communication or water service departments, according to their interest and qualifications, and the needs of the company. Where practicable the trainees are rotated among the several departments or are otherwise handled to obtain the broadest experience possible during the training period.

At the conclusion of the training period those men who have exhibited promising supervisory capacities are promoted to assistant supervisor for an additional two-year training period preparatory to assuming a regular supervisory position. Those trainees who have shown aptitude to engineering and administrative work are progressed along these lines for further experience and promotion to various technical and administrative positions.

NEW YORK CENTRAL SYSTEM

Requisites for Special Apprentice Course

1. Must be graduate of mechanical engineering or electrical course in an accredited college. Some practical experience desirable, but may be waived. Interview required.

2. Age—under 26. Good physical condition, sight and hearing, and good moral character. Must have an earnest desire to enter training course.

3. Course is three years. Consists of experience on the regular work in the shops, engine terminals and repair yards, with a change as nearly in accordance with the program under Par. 4 as circumstances permit.

4. Training schedule for special apprentices is outlined below. Those assignments shown in the first and second years are required, but the order of the assignment may be changed as conditions make necessary, although the order shown is considered to be the desirable sequence:

First Year

Locomotive Shops

Erecting floor	3 months
Machine shop	3 months
Boiler shop	3 months
Blacksmith shop	3 months

Second Year

Passenger car shops	3 months
Freight car shops	3 months
Electric shop (electric locomotive and M.U. car equipment)	3 months
Diesel-electric shop	3 months

Third Year

First Six Months—Optional assignment to engine terminal, passenger or freight repair yard.

Second Six Months—Special assignment with one of the following, including filling of temporary supervisory vacancies, selection to be made in joint conference with student and management:

- Engineer of tests
- Engineer of motive power, rolling stock or electrical equipment
- Master mechanic
- Division general car foreman
- Shop superintendent; either locomotive, car, diesel or electric shop

Those special apprentices, who, prior to starting their special apprenticeship have served time as regular apprentices in any of the shops or capacities outlined above, will be credited for such time on the basis of the number of days actually spent on the work involved.

5. No pay for overtime allowed. Refund for expenditures when on detached duty is permitted. Two weeks vacation per year, with pay, is allowed, after the first year.

6. Rate of pay:

	1st 6 Months	*2nd 6 Months*
First year	$312.50	$320.50
Second year	328.50	336.50
Third year	344.50	352.50

7. At completion of the course, permanent assignment will be made to a place which the graduate can fill for the best interest of the company, and with credit to himself.

NORFOLK AND WESTERN RAILWAY COMPANY

Special Apprenticeship Course Schedule
Mechanical Department

(Name of Apprentice)

SHAFFERS CROSSING (9 Months)	*Time Required (Months)*	*Date Started*	*Date Finished*
Ash pit and coal dock	½		
Packing boxes and lubrication	(2 days)		
Heavy running repairs	4		
Light running repairs	1½		
Air and stoker repairs	¼		
Pipe and electrical repairs	¼		
Boiler repairs	½		
Boiler inspecting	¼		
Engine inspecting	¼		
Freight car repairs	1½		

ROANOKE SHOPS (27 Months)			
Foundry	2		
Smith shop	2		
Machine shop	4		
Boiler shop	2		
Welding shop	2		
Sheet iron and pipe shop	1		
Air brake shop	1		
Erecting shop	2		
New engines	4		
Electrical department	1		
Wheel shop	1		
Freight car repairs	2½		
Passenger car work			
Body repairs	¾		
Trucks	¼		
Sheet metal work	½		
Paint	¼		
Terminal passenger yard	½		
Lacquering plant	¼		

REMARKS:

PENNSYLVANIA RAILROAD

(See insert following this page)

ST. LOUIS–SAN FRANCISCO RAILWAY COMPANY

Student Apprentice Training Program

The student apprentice training program has been developed for the purpose of developing supervisory officers in the maintenance of way and operating departments of this railroad, and consists normally of a 2½-year program.

Appointments to these positions are open only to certain selected civil engineering graduates of approved universities.

In order for applicants to be appointed to these positions it is necessary that they be interviewed by the undersigned, and after being approved by him they must be personally interviewed by vice president R. J. Stone.

Applicants accepted for training will be initially assigned to one of the division engineers and their assigned headquarters will then be the headquarters of that division engineer.

Division engineers will assign these men to work successively in section gangs, extra gangs, both wood and steel bridge gangs, house carpentry gangs, paint gangs, water service gangs, etc. Also, they will from time to time be assigned to work in the division engineer's office and in the field with the engineering staff.

These work assignments have been selected with a view to giving the student apprentice a good coverage of railway experience in the shortest time possible.

Each month the division engineer prepares a report showing the number of days of experience in each of the selected assignments and his estimate of the development and adaptability of the student apprentice on a grade point basis.

Usually these students are kept on one division for one year, following which they are transferred to a different type of division. At the completion of their second year of training they are designated as student supervisors and given a three to six-months course of observation in various staff departments, such as traffic, accounting, personnel, mechanical, and transportation. They are then assigned to assistant roadmaster positions in their own right, and from then on their promotion and development is entirely dependent upon their individual abilities.

These men are paid at the rate of $325 a month, plus expenses when away from assigned headquarters, during the first year. This rate is increased automatically to $355 a month, plus expenses when away from assigned headquarters, during the second year, and increased to $385 a month during the student supervisor period.

It is expected that men promoted to assistant roadmaster positions through this channel will successively develop through the operating and track departments so as to render them available for supervisory positions in either of the two mentioned departments.

SOUTHERN RAILWAY SYSTEM

Student Apprentice System on Southern Railway

As early as 1912 the need was recognized for special training of engineering graduates for supervisory and official positions on the railroad. Engineering graduates are selected not only on the basis of scholarship, but also on their extra-curricular activities and qualities of leadership. Selections are made on the basis of interviews and the advice of members of the faculty.

GENERAL DETAILS OF COURSES, PENNSYLVANIA RAILROAD TRAINING PROGRAM FOR JUNIOR ENGINEERS

6 MONTHS | 12 MONTHS | 18 MONTHS | 24 MONTHS | 30 MONTHS | 36 MONTHS

TRACK WORK — ROAD ENGINEERING — INSPECTION — LABORATORY ASSIGNMENTS — SPECIAL ASSIGNMENTS — ENGINEERING HEADQUARTERS ASSIGNMENTS

TRACK WORK
- SUB-DIVISIONAL
  - SAFETY RULES AND USE OF TRACK TOOLS
  - TRACK SPECIFICATIONS AND CONSTRUCTION

The first four months of this course are spent on roadway repairs involving track and interlocking switches and the use of track tools.

Duty on a rail train for experience in track construction.

ROAD ENGINEERING
- DIVISIONAL
  - STRINGING CURVES
  - USE OF MAINTENANCE OF WAY EQUIPMENT
- REGIONAL
  - TRACK WORK TECHNIQUE
  - REGULATIONS MAINTENANCE OF WAY

In this period the Junior Engineer gains experience in practically every operation in the construction and repair of track. By stringing curves, reestablishing grade lines, laying out track and switches, the Junior Engineer acquires first hand experience in the problems he will have to meet when he is on his own.

INSPECTION
- SIGNALS — INTERLOCKING SWITCHES & SIGNALS
- BRIDGES — FOUNDATIONS & SUPERSTRUCTURES
- TRACK — TRACK & SWITCH LAYOUTS

Because tracks and switches are directly linked to signals and interlocking facilities, including installations at drawbridges, the Junior Engineer spends this period working on signals and bridges as well as track.

LABORATORY ASSIGNMENTS WITH ENGINEER OF TESTS—M. W.
- MAINTENANCE OF WAY MATERIALS
- AIR BRAKES

This laboratory experience with the Engineer of Tests—M. W. is necessary to a thorough understanding of maintenance materials and air brakes.

SPECIAL ASSIGNMENTS
- ACCOUNTING AND CORRESPONDENCE

Two months in the office learning how records are kept.

ENGINEERING HEADQUARTERS ASSIGNMENTS
- DIVISION ENGINEER — REVIEW OF RULES, SUPERVISORY ASSIGNMENTS
- ENGINEER—MAINTENANCE; CHIEF ENGINEER—M. W. — TRACK AND OPERATING PLANS, ESTIMATES, REAL ESTATE PROBLEMS AND SPECIAL ASSIGNMENTS

After a review of regulations the Junior Engineer gets his first supervisory assignments under the guidance of the Division Engineer.

In this final period the Junior Engineer receives the personal guidance of top engineers in Maintenance of Way. Opportunities are open for the application of engineering knowledge and experience gained in the course.

PERIOD OF ORIENTATION — SIGNALS AND COMMUNICATIONS — MAINTENANCE OF EQUIPMENT — SUPERVISORY ASSIGNMENTS — OPERATING EXPERIENCE — TRACK EXPERIENCE — ELECTRIC TRACTION

PERIOD OF ORIENTATION

A general introduction to the course.

SIGNALS AND COMMUNICATIONS
- SIGNALS AND INTERLOCKING FACILITIES — CONSTRUCTION AND REPAIRS
- COMMUNICATIONS — CONSTRUCTION AND REPAIRS

In this period the Junior Engineer learns something about practically every operation involved in the construction and repair of signals, switches and interlocking facilities that control the safe operation of trains.

This time is spent with another road crew repairing and renewing telegraph and telephone lines.

MAINTENANCE OF EQUIPMENT
- SIGNALS
- TELEPHONE AND TELEGRAPH
- TESTING — SIGNALS AND COMMUNICATIONS
- CIRCUIT DESIGNING

Technical problems associated with the maintenance of frogs, switches, interlockings, automatic signals, interlockings at drawbridges, telegraph, telephone and teletype are covered.

Part of this interval is spent in testing electrical equipment, part in circuit designing.

SUPERVISORY ASSIGNMENTS
- SIGNALS
- TELEPHONE AND TELEGRAPH

To give the Junior Engineer experience in handling men, he is placed with a foreman.

OPERATING EXPERIENCE IN TRANSPORTATION DEPT.
- WITH DIVISION OPERATOR
- WITH TRAIN MASTER
- WITH YARD MASTER

To better understand the importance of signals and communications, the Junior Engineer is assigned to Transportation for 4 months.

TRACK EXPERIENCE
- WITH TRACK SUPR.
- WITH DIVISION ENGINEER

Two months on repairs to track, switches and interlocking facilities.

ELECTRIC TRACTION
- WIRE TRAIN OPERATION — DAY OPERATION; NIGHT OPERATION
- POWER & TRANSMISSION — SUBSTATION REPAIRS; DISTRIBUTION
- SUPERVISORY ASSIGNMENTS
- REGIONAL ACCOUNTING OFFICE — ACCOUNTING PROCEDURES
- CHIEF ENGINEER MAINTENANCE OF WAY — PLANS, ESTIMATE AND PROBLEM ANALYSIS

The Junior Engineer is now assigned to wire trains servicing the power supply system in electrified territory.

This period is spent on substation and power distribution maintenance necessary to uninterrupted power supply—to observe repairs.

Responsibilities increase with each new assignment.

CONSTRUCTION AND REPAIR OF BRIDGES — BUILDINGS — ENGINEERING HEADQUARTERS ASSIGNMENTS

CONSTRUCTION AND REPAIR OF BRIDGES WITH MASTER CARPENTER
- ROAD CREW MASONRY
- ROAD CREW SUPERSTRUCTURES

In this course the Junior Engineer begins his training with a road crew engaged in bridge masonry, repairing foundations, abutments and piers. Work on bridge superstructures provides experience in steel and timber and opportunities for observation of conditions requiring correction.

HEADQUARTERS CHIEF ENGINEER AND ENGINEER MAINTENANCE OF WAY
- PLANS, ESTIMATES BILLS OF MATERIALS

The Junior Engineer is assigned to headquarters for personal guidance, special assignments and close association with experienced engineers.

STRUCTURAL WELDING
- BRIDGES, BUILDINGS AND WAYSIDE STRUCTURES

Here is acquired a basic knowledge of structural welding.

CONSTRUCTION AND REPAIR OF BUILDINGS
- ENGINE HOUSES, SHOPS, WAYSIDE STRUCTURES AND OFFICE BUILDINGS
- WATER STATIONS AND PIPING
- PAINTING

This period provides opportunities to observe repairs to buildings, new construction, plumbing work of all types, and the chemistry and application of interior and exterior paints.

CONSTRUCTION EQUIPMENT MAINTENANCE
- HEAVY AND LIGHT REPAIRS

Devoted to maintenance of special work equipment.

WATERWAY PROBLEMS

Waterway problems and soundings at bridge crossings.

ENGINEERING HEADQUARTERS ASSIGNMENTS
- MASTER CARPENTER — PLANS, ESTIMATES, BILLS OF MATERIAL, ACCOUNTING AND ORGANIZATIONAL PLANNING; BRIDGE INSPECTION
- ENGINEER OF BRIDGES AND BUILDINGS — MASONRY AND SUPERSTRUCTURAL DESIGNING; GENERAL INSPECTION ALL STRUCTURES

Returning to engineering headquarters, the Junior Engineer is assigned to a division for duty with the Master Carpenter. A wide variety of new experience is gained at this time.

In this final period the Junior Engineer works directly with the Engineer of Bridges and Buildings, acquiring additional knowledge of design, and applying his own knowledge and experience to inspection.

STEAM LOCOMOTIVES — LIGHT AND HEAVY CAR REPAIRS — DIESEL-ELECTRIC AND ELECTRIC MOTIVE POWER AND EQUIPMENT

STEAM LOCOMOTIVES
- RUNNING REPAIRS — HEAVY REPAIRS; LIGHT REPAIRS; INSPECTION; BOILERS
- OVERHAULING AND REBUILDING — ERECTING SHOP; MACHINE SHOP; BOILER SHOP; AIR BRAKE SHOP

At the start of this course the Junior Engineer works shoulder to shoulder with skilled craftsmen in a modern enginehouse. This period affords an intimate introduction to steam locomotives: regular inspections and minor repairs between runs, also the heavy repairs customary at 30-day intervals.

This period is spent in overhauling and rebuilding steam locomotives, a most important phase of maintenance. Locomotives are torn down to the frames. Parts are repaired or replaced and locomotives returned to service in practically new condition. Definite periods are scheduled for each phase of the operation.

LIGHT AND HEAVY CAR REPAIRS
- FREIGHT — RUNNING REPAIRS TO WOOD AND STEEL CARS; INSPECTION; TRUCK AND WHEEL SHOP; PROCESS REPAIR SHOP
- PASSENGER — TERMINAL INSPECTION AND REPAIRS

This period is devoted to light and heavy repairs on freight and passenger cars. The work includes wheels, trucks, heavy structural and sheet metal parts of car bodies, repairs to the fine interior trim of modern passenger cars.

DIESEL-ELECTRIC AND ELECTRIC MOTIVE POWER AND EQUIPMENT
- DIESEL-ELECTRIC LOCOMOTIVES — GENERAL MAINTENANCE
- ELECTRIC LOCOMOTIVES AND CARS (DC) — ENGINE REPAIRS; CAR REPAIRS
- POWER AND TRANSMISSION
- ELECTRIC LOCOMOTIVES AND CARS (AC) — CAR REPAIRS; ENGINE REPAIRS; MOTORS AND TRANSFORMERS

A 3-months' period devoted to the maintenance of Diesel-electric locomotives.

Final months of the training course in the maintenance of motive power and equipment are devoted to the problems of electric operation, the repair of electric locomotives, electrically operated passenger cars, and power and transmission lines.

STEAM LOCOMOTIVES — FREIGHT CARS — FLOATING EQUIPMENT — HARBOR OPERATIONS — HEADQUARTERS MECHANICAL ENGINEER

STEAM LOCOMOTIVES
- RUNNING REPAIRS — HEAVY REPAIRS; LIGHT REPAIRS; INSPECTION; BOILERS
- OVERHAULING AND REBUILDING — ERECTING SHOP; MACHINE SHOP; BOILER SHOP

At the start of this special course, the Junior Engineer is assigned first to a modern enginehouse for practical experience in the maintenance of steam locomotives. The work includes regular inspections and minor repairs between runs, also heavy repairs necessary at regular intervals.

This period is spent in overhauling and rebuilding steam locomotives. Parts are repaired or replaced as needed and locomotives returned to service in new condition. Definite periods are scheduled for each phase of this basic experience.

FREIGHT CARS
- RUNNING REPAIRS WOOD AND STEEL

A short course in the maintenance of all kinds of freight cars.

FLOATING EQUIPMENT
- REPAIR AND INSPECTION — BARGES; CAR FLOATS; SELF PROPELLED LIGHTERS; TUGS; FERRIES
- DRYDOCKING — WOOD FLOATING EQUIPMENT; STEEL FLOATING EQUIPMENT; STEAMERS AND TUGS

The Junior Engineer is assigned to the marine facilities—an extensive and important part of the Pennsylvania System. Experience is gained in the repair of barges and floats.

The Junior Engineer works in tidewater shops on repairs to many types of self-propelled floating equipment, an unusual opportunity to learn the maintenance of marine motive power equipmen

The first 4 months of this period are devoted to drydocking and repair work in New York Harbor; another month to the repair of Chesapeake Bay steamers and tugs at Norfolk, Virginia.

HARBOR OPERATIONS
- DISPATCHING
- FLOAT BRIDGE AND PIER WORK

HEADQUARTERS MECHANICAL ENGINEER
- MARINE ENGINEERING SUPERVISORY ASSIGNMENTS

In this final training period the Junior Engineer is readied for a supervisory position in the Marine Department.

6 MONTHS | 12 MONTHS | 18 MONTHS | 24 MONTHS | 30 MONTHS | 36 MONTHS

Usually a student apprentice starts with a section gang where he works as a laborer and learns the use and feel of tools. He also obtains valuable insight into the viewpoint of the men whose work he will probably direct in the future. He is then placed with a bridge and building gang. Usually these phases take a year or more.

When his knowledge and experience of railroad work have increased sufficiently, he is promoted to assistant supervisor. In this position he works under the direction of and with the advice of experienced men.

Before completion of the course (usually two to three years), he spends some time in freight agencies, with trainmasters, in the personnel office, and in the mechanical department, to get a broad view of railroad operation.

The extended training consists of:

- Six weeks in office of chief engineer, MW&S, including surveys on line.
- Two weeks in the accounting department with traveling auditor, or in the general accounting office, as desired by Mr. Seay.
- One month in the mechanical department shops and on line.
- Two weeks with traffic representative and in a freight office.
- One week at some large freight transfer point.
- Two weeks in superintendent's office in connection with personnel matters, investigations, timekeeping, etc.
- One week in chief dispatcher's office.
- One week in the yard office at a larger terminal.
- Two weeks with the trainmaster on the road and in terminals, including rule classes.

At the end of the training course he is usually promoted to the rank of supervisor, either of track or of bridges and buildings. During all of this time he is required to submit monthly papers covering his work and what he has learned.

From this point his further advancement will depend entirely upon himself. Men with a special aptitude for transportation are transferred to that department, usually starting as assistant trainmaster.

Southern Railway has 104 graduates of the student apprentice system who now hold positions from supervisor to vice president, including 2 general managers, 2 chief engineers maintenance of way, and 9 superintendents. There are now 19 men taking this training course.

(The above description if the student apprentice system was prepared in connection with a trip of student members, ASCE, November 2, 1949).

THE VIRGINIAN RAILWAY COMPANY

Junior Officer Training Program

Title—Junior Engineer

Salary:

Initial salary	$250.00	month
Second six months	325 19	"
Third six months	354 75	"
Fourth six months	384.32	"
Third year	413 87	"

Training Program:

Five months—
Assigned to staff of engineer maintenance of way
Three months—
Assigned to staff of chief engineer
Two months—
Assigned to staff of superintendent of telegraph and signals
Five months—
Assigned to staff of superintendent of motive power
Seven months—
Assigned to staff of division superintendent
One month—
Assigned to personnel manager
One month—
Assigned to cost engineer
Third year—
Assigned to department in which employee is expected to be permanently assigned.

At the end of training period assignment would be made as follows:

1. Transportation department—Transportation inspector or assistant trainmaster.
2. Engineering department—Assistant engineer—civil.
3. Maintenance of way—Assistant engineer—maintenance.
4. Motive power department—Assistant engineer—mechanical, or assistant engineer —electrical.

THE WESTERN PACIFIC RAILROAD COMPANY

Thirty-Nine-Month Training Program

Outlined in the following is a 39-month training program for use with outstanding college graduates and present employees.

	Months	
I. *Engineering*		
1. Field		
(a) Surfacing gang	2	Laborer's rate, approximately $209 per month
(b) Steel gang	2	
(c) B&B gang	2	
(d) Off-track grading equipment	1	
(e) Tunnel gang	1	
(f) Signal gang	1	
(g) One month winter season in canyon	1	
	10	
2. Office		
Engineering office, S. F.	3	Rodman's rate, $290 per month
II. *Mechanical Department*		
1. Office		
(a) Special assistant	4	$325 per month
2. Field		
(a) Assistant diesel supervisor	3	$325 per month
III. *Operating Department*		
Special assistant to division superintendent	11	$360 per month
IV. *Accounting Department*		
Student traveling accountant	4	$369 per month
V. *Traffic Department*		
Special assistant	4	$375 per month

The program is designed to offer rather a stiff hurdle to trainees for the first 10 months, in order that the sincerity of purpose and attitude of the trainee can be observed.

Each department head is expected to outline a specific program for approval covering the period the trainee is in his department.

In addition, department heads, or, in the case of field work, immediate supervisors, will submit observations on the trainee. Once a merit rating system is approved by the Evaluation committee, this system will be used with trainees at frequent intervals.

Additional Comments on Program

a. It is our feeling that we, as a segment of the railroad industry, must give more cooperation to the various colleges and universities in our area—through lectures and field trips. We hope during 1952 to be able to offer such a program to these colleges and universities, and that we will be able to begin to give the kind of cooperation we should.

b. We do not generally advertise our training program because we have found that in so doing we attract too many prospects who are interested in "training" and not in the long-range picture.

We have purposely set the toughest part of our training program as the first hurdle for the students to overcome. We do this as a check on our selection procedure, because we feel that if our selection technique fails in any given case the initial part of the program will quickly point this out.

c. As you know, the Western Pacific has recently placed all of its non-schedule positions under a position evaluation program which allows grade ranges for any given job. We feel that such a program is highly desirable and will certainly assist the property in attracting technical talent.

Exhibit C

PERTINENT COMMENTS FROM RAILROADS NOT HAVING DEFINITE TRAINING PROGRAMS

CLINCHFIELD RAILROAD COMPANY

Questions 11 and 12 can lead to lost time, lost motion, and considerable expense in training a prospective employee. Until the cooperative schools allow the employer to screen their students, pick the desirable ones and continue their outside training, I cannot subscribe to this method of training. My experience has been that when one must accept the students for outside training in their order as set up by the schools, little is to be gained either by the student or the employing railroad.

THE DELAWARE AND HUDSON RAILROAD

Question 13—We do consider that a background of engineering education and subsequent experience in the engineering and maintenance departments of a railroad are desirable qualifications for the higher positions in these or other departments.

The president of our railroad is an engineering graduate. The vice president and general manager is an engineering graduate, and the assistant general manager is an engineering graduate.

Question 14-A—We are a small railroad and, of course, by reason of such, our requirements for graduate engineers are limited. We do have occasion to hire two or three each year and choose mostly graduates who have taken a civil engineering course. These men are obtained by interviews. They are usually placed in our engineering corps as rodmen or levelmen, and their advancement is generally through promotion to positions of transitmen, assistant engineers, track or B&B supervisors, division engineers, etc., to the top of the engineering department or, in some cases, into the operating department.

Question 14–B—We have found this arrangement entirely satisfactory, although I might say, by reason of being a small railroad, their advancement is not as rapid as we would like to have it for men who are qualified for such advancement.

However, our main idea and policy is to prepare them so that they will fit into any branch of our service when the opportunity presents itself.

LEHIGH AND NEW ENGLAND RAILROAD COMPANY

Question 13—We most assuredly consider that a background of engineering education and subsequent experience in the engineering and maintenance departments of a railroad are desirable qualifications for the higher positions in these and other departments.

Question 14 (a)—On the Lehigh and New England we make it a practice of employing men capable of advancement, then training those men to the best of our ability consistent with existing circumstances, so that when the opportunity presents itself these men may advance. We have in the neighborhood of 800 on the payroll, including every one from top to bottom in every kind of service. With such an organization one would not have much success, in our judgment, if certain individuals were earmarked for advancement over their co-workers.

Our engineering department consists of eight engineers, with two vacant positions. Our engineer maintenance of way is a graduate in civil engineering from Lafayette College, Easton, Pa. Our assistant engineer maintenance of way graduated in civil engineering at Lafayette College. Of our three supervisors, one is a non-college man, who has been in the service for a great number of years, while the other two are college graduates, one having graduated from Lafayette College in 1949, with B.S. degree in administrative engineering, and the other having graduated from Lehigh University, Bethlehem, Pa., in 1947, with an A.B. degree in geology.

Our office engineer and transitman are not college men.

Our levelman was graduated from Lehigh University in civil engineering in 1950.

Our bridge engineer retired due to age and our signal engineer died, both more or less recently. Due to the condition of our property and our inability to find the right men to fill these positions, these positions have not been filled and our work has not suffered.

With such a small organization it is very difficult to retain in the service college graduates when the number of chances for advancement are relatively small.

We have one very definite policy, namely, that of informing every one working for the Lehigh and New England, no matter in what capacity, that we will be very happy to see him improve himself by accepting employment elsewhere, if in his judgment, by so doing, he will better his condition.

On a property such as the Lehigh and New England we endeavor to train the men who have had the experience and are capable of advancement for the next possible step. I, for instance, have in my possession at all times the more or less current judgment of every department head as to what organization changes should be made in the event of the sudden death of a department head.

I graduated in civil engineering at Bucknell University, Lewisburg, Pa., took post-graduate work at Harvard in engineering, and am a firm believer in engineering and business administration college graduates being exceedingly capable in analyzing conditions and reaching logical conclusions, whether they be in solving engineering problems or otherwise.

Our vice president and general manager, while not a graduate, pursued civil engineering courses at Cornell University, Ithaca, N. Y.

Whenever an opening occurs we always give first consideration to those on the property, endeavoring to promote the man who is most entitled, in our judgment, to the job. In the event that we do not have a competent man on the payroll at the time, we endeavor to obtain the best man available elsewhere, giving consideration to engineering graduates.

Question 14 (b)—My best answer to this question, "Have you found this arrangement entirely satisfactory?", is the fact that our operating ratio in 1950 was 56.28. At the present time we are, without question, operating more efficiently than ever before, doing about twice as much business as we used to do, with little over half as many on the payroll. To the best of my knowledge we have no one in a responsible position who I would want to replace with any one else known to me.

MANUFACTURERS RAILWAY COMPANY
SAINT LOUIS AND O'FALLON RAILWAY COMPANY
SAINT LOUIS REFRIGERATOR CAR COMPANY

The railroads are now, and have been, very lax in competing for promising young talent, not only in the engineering department but in others.

Very definitely, college boys are not railroad-minded.

Our railroad executives are not giving the attention to this very important subject that they should.

Of course, in so many of our departments, union agreements prevent the proper entrance into, encouragement of, and development of college-trained boys.

To my mind, in many respects, this is one of the greatest obstacles the railroads confront, but, nevertheless, there are still several accepted positions under the contracts to warrant the employment of promising young men.

Our companies are small, and we would not really be benefited by having a definite program of training graduates.

Nevertheless, so far as our engineering department is concerned, we have strengthened it materially, only within the last 30 days.

We have been on the lookout for a promising young college man for several years.

We were not able to secure one of satisfactory stature.

We were compelled to wean away from another industry a promising youngster.

The development of our engineering staff, as well as that of our other departments, comes under my personal supervision, and I have given a great deal of effort, time, and thought to it.

SOUTHERN PACIFIC COMPANY

Southern Pacific Company, through its general officers and division and general shops representatives, maintains cooperative relations with various universities and colleges in the territory which it serves. Our program for the training of undergraduate engineering students during vacation periods, as described in reply to Question 6, has opened a field of opportunity for promising students and provides a method for the student to supplement his academic training with practical railroad experience. This practical experience helps the student decide on railroading as a career, and also enables the railroad to determine whether the student has been wisely chosen for further development.

While recognizing the needs of the Armed Services, not only as to men within the age group of liability for military service, but also as to trained engineers, we feel that the vulnerability of these students to military service upon graduation is an influence which detracts from the success of our training program. In recognition of the growing scarcity of technically trained engineers, it would appear that the railroad associations, in cooperation with appropriate governmental agencies and the colleges, should sponsor the formulation of policy that will minimize the incidence of induction into the Armed Services of graduates who have been jointly trained for engineering responsibilities by the technical schools and industry through such cooperative programs as are in operation on the Southern Pacific.

6. Do you have an established schedule for regular promotions or salary increases during the training period? If consistent with your Company's policy, please furnish details of the schedule.

Question 6—We do not have a formal training program for engineering graduates. We do, however, have an agreement with the Association of Railway Technical Employees (representing technical employees on SP's Pacific Lines) which provides that the railroad may take into its service a limited number of students who are following a course of study in engineering in a college or university of recognized standing after the student has completed one academic year. Under this agreement the undergraduate is permitted to enter the service during his first vacation period and work during that vacation. As long as he is following his specified course in the school he can retain his standing as a technical student in railroad employ and return each year during his vacation, until he graduates.

Under this program and provisions of the agreement, he can enter the service during his first vacation period under Grade 2 position, paying $285 per month. On his second year he can be advanced to a Grade 3 position if he is considered qualified, at a rate of $320 per month. After the completion of three academic years, he can enter Grade 4, paying $340 per month. Upon completion of B.S. degree he can enter Grade 5 at a rate of $345 per month. If he were to remain in this grade, he would receive a $5 per month increase for each of the second and third years occupying that position, and after three years his rate would become $360 per month; however, agreement provides that after this technical student has remained in Grade 5 for one year, he can be appointed to the next new position or the next vacancy on existing position of junior engineer or engineer inspector in Grade 6, regardless of his seniority, which position would have a starting salary of $370 per month, and after the third year, $385 per month. His advancement from this Grade 6 position to positions of higher responsibility as vacancies occur would depend largely upon his initiative and ability to perform the work of the higher position; seniority would be a limiting factor under certain circumstances.

TERMINAL RAILROAD ASSOCIATION OF ST. LOUIS

Question 14 (a)—When we find a young man in our service who indicates he has ambition, energy and intelligence, and shows willingness to be developed we try to give him the opportunity in various jobs to develop whatever qualities he may have and he is moved along as he shows development and the opportunity to do so presents itself. For instance, we have sent one of our officers to the Harvard University Advanced Management Program and have others lined up to go if we can get them accepted.

I believe some have the idea that if a definite and fixed program can be developed for training young men, all that is necessary is to put the man on one end of the belt and when he drops off the other end he is going to be a finished product, and no allowance seems to be made for the differences in personality and other human characteristics inherent in every one. Training programs have their value, but a silk purse cannot be made out of a sow's ear, and those in charge of such programs should, in my opinion, use some pretty good judgment in selecting the individuals to be given training. Otherwise, the program will be cluttered up with people who are not susceptible to such training and who will not be benefited by it.

(b) So far the arrangement used on the Terminal has proved satisfactory for our needs. Our greatest trouble is in finding the young men who have capacity for development.

Report on Assignment 2

Stimulate Among College and University Students a Greater Interest in the Science of Transportation and Its Importance in the National Economic Structure

By Cooperating with and Contributing to the Activities of Student Organizaions in Colleges and Universities

R. P. Davis (chairman, subcommittee), L. L. Adams, W. S. Autrey, T. A. Blair, S. R. Hursh, J. R. Ivey, Jr., H. E. Kirby, B. B. Lewis, H. S. Loeffler, E. E. Mayo, C. T. Morris, J. E. Perry, J. A. Rust, W. C. Sadler, H. O. Sharp, D. W. Tilman, Barton Wheelwright.

This is a progress report, submitted as information.

During the past year Subcommittee 2 continued to aid the National Railway Appliances Association in circulating among engineering colleges lantern slide sets of the historical exhibit prepared by the American Railway Engineering Association and the National Railway Appliances Association in 1949. The following schools have used these slides since November, 1951:

Georgia Institute of Technology
State University of Iowa
Norwich University
University of North Dakota
Rutgers University
University of South Carolina
Wayne University

The following schools purchased sets of slides:

Norwich University
University of Toronto
University of Washington

To date the slides have been shown before student groups in 20 colleges and universities and 5 institutions have purchased sets of them.

Among the speaking engagements before student groups by members of Committee 24 during the past year were the following: one by C. H. Mottier, vice president and chief engineer, Illinois Central Railroad, who spoke on Civil Engineering as a Career, at the All University of Illinois Career Conference on March 31, 1952; a second by Mr. Mottier on the Reconstruction of the Cairo Bridge, given on March 4, 1952, before the student chapter of the American Society of Civil Engineers at Purdue University; and one by S. R. Hursh, assistant chief engineer-maintenance, Pennsylvania Railroad, before the student chapter of the American Society of Civil Engineers at Princeton University on February 13, 1952. An address was also given before this group by J. P. Newell, vice president, operation, Pennsylvania Railroad.

Active contacts were made with technical schools through visits by railroad personnel for the purpose of securing young engineers. The list of visits is too long to be included in this report. However, as typical examples, we note the 20 or more visits made by D. W. Tilman, senior assistant engineer, Baltimore & Ohio Railroad, in the interests of the Technical Graduate Course of that railroad; the many interviews conducted by E. E. Mayo, chief engineer, Southern Pacific Company; and the trips made by P. S. Settle, division engineer, Pennsylvania Railroad, to Union College, Cornell University and Bucknell University.

Your subcommittee believes that progress is being made in stimulating a greater interest on the part of students in the science of transportation, but much still remains to be done.

In an article in the July 1952 issue of Railway Progress entitled The College Graduate and the Railroad Industry, appears the following statements:

"Asked how students rated railroads jobs in comparison with other prospective employment, 48 institutions . . . reported that railroad careers are rated equally desirable by their students . . .

"However, the contrary view is held by students at 76 colleges and universities, . . . who believe a railroad career less desirable than other types of prospective employment. In fact, at 17 of these campuses, railroading is judged the least attractive employment."

The engineering colleges are finding it difficult to meet the needs of the railroads for young graduates partly because of the rather general student attitude as expressed above and partly because of the shrinking number of graduates available to industry. Dean O. W. Eshbach, in his paper entitled The Manpower Problem, presented at the 1952 annual meeting. (see Proceedings, Vol. 53, 1952, page 1006), clearly shows that for some years to come the demand for young engineers will greatly exceed the supply.

Engineering schools are doing everything possible to stimulate interest in engineering on the part of high school students. Professor Frank Kerekes, assistant dean at Iowa State College, personally attended 16 "Career Day" programs of a total of 33 held during the year by Iowa State College. Most of these were held on a county-wide basis.

As another example of the activities of the schools in seeking more students, we quote Dean Fred J. Lewis of Vanderbilt University: "I have met with dozens of high school student groups and vocational guidance gatherings to which I have presented the field of engineering, our extreme shortage of qualified engineers, and opportunities and demands in various areas, in which I have included quite prominently the possibilities for young men in the railroad field."

Report on Assignment 3

The Cooperative System of Education, Including Summer Employment in Railway Service

O. W. Eshbach (chairman, subcommittee), Lem Adams, J. B. Babcock, Armstrong Chinn, P. O. Ferris, W. H. Huffman, A. V. Johnston, W. S. Kerr, R. B. Kittredge, T. R. Klingel, R. C. Nissen, L. M. Ogilvie, W. A. Oliver, R. J. Stone, E. C. Vandenburgh.

This is a report of information on the topic assigned and on current information relative to the engineering manpower shortage.

Attention is called to an article published by McGraw–Hill in "Factory," November 1952, entitled, "If you want to know more about Co-ops". It is an interesting summary of the operations of the plan and the extent of participation by the colleges and industry. The table included here is taken from the article.

During recent years a number of the large engineering schools have started optional cooperative programs for selected engineering students. The companies participating have been limited in number and chosen with regard to particular curricula. The total number of students, over 12,000, enrolled in cooperative courses (about 10 percent of the total engineering enrollment), is of interest. On the average the 29 schools are regularly cooperating with 100 firms. A survey a few years ago indicated satisfactory participation and experience in the railroad industry.

The shortage of technical talent has resulted in increased activity in summer employment of undergraduates. While no comparative figures are available, it may be anticipated that competition will be particularly acute during the next few years.

The situation regarding the supply of engineering graduates and its relation to the defense effort was presented at a Manpower Conference in Chicago, in September, 1952, in connection with the Centennial of Engineering. Members of Committee 24 were invited and the proceedings of the convocation made available to them.

At the present time estimates of the demands for engineering graduates is approximately 40,000, compared to 23,000 graduates in 1953. Most of the graduates will either be called to military service as reserve officers or inducted into the army for two years of service. Thus, few will be available for industry.

School	*No. of Co-op Students*	*No. of Co-op Companies*	*No. of Co-op Engrg. Courses Offered*
University of Akron, Akron, Ohio	268	36	2
Antioch College, Yellow Springs, Ohio	827	64	1
Alabama Polytechnic Institute, Auburn, Ala.	360	137	6
University of Bradley, Peoria, Ill.	8	2	2
University of Bridgeport, Bridgeport, Conn.	2	2	
University of California, Berkeley, Cal.	21	8	
University of Cincinnati, Cincinnati, Ohio	1294	325	7
Cornell University, Ithaca, N. Y.	48	5	2
University of Denver, Denver, Colo.	11	5	5
University of Detroit, Detroit, Mich.	1000	325	6
Drexel Institute of Technology, Philadelphia, Pa.	2400	500	6
Evansville College, Evansville, Ind.	80	18	3
Fenn College, Cleveland, Ohio	306	430	7
General Motors Institute, Flint, Mich. (all GM plants and divisions)	1300	105	3

School	No. of Co-op Students	No. of Co-op Companies	No. of Co-op Engrg. Courses Offered
Georgia Institute of Technology, Atlanta, Ga.	566	134	7
University of Houston, Houston, Tex.	365	121	10
Illinois Institute of Technology, Chicago	85	54	2
Los Angeles State College, Los Angeles, Calif.	30	45	
University of Louisville, Louisville, Ky.	200	75	4
Marquette University, Milwaukee, Wis.	94	30	3
Massachusetts Institute of Technology, Boston, Mass.	125–150	8	2
University of Minnesota, Minneapolis, Minn.	80	15	6
Northeastern University, Boston, Mass.	1463	600	5
Northwestern Technological Institute, Evanston, Ill.	800	125	5
Renssalaer Polytechnic Institute, Troy, N. Y.	71	2	3
Rochester Institute of Technology, Rochester, N. Y.	184	36	3
Southern Methodist University, Dallas, Tex.	60	22	6
University of Tennessee, Knoxville, Tenn.	37	21	7

As a result of the efforts of the Manpower Commission of the Joint Engineer's Council, it appears that effective efforts are being made to conserve technical talent in industry. Also, the educational program acquainting the nation with the facts regarding shortages has had its effect upon freshmen enrollments in the colleges. From incomplete returns it appears that 4.6 percent of the 1952 high school graduates have enrolled in engineering compared with 2.9 percent in recent years. Thus, freshmen enrollments in engineering will be about 50,000 or more, nearly 30 percent over last year, whereas total freshmen enrollments were up only 11 percent in all colleges and curricula.

The present rates of graduation of engineers have been predicted as follows:

1953 graduates	23,000
1954 graduates	19,000
1955 graduates	22,000
1956 graduates	29,000

With the effect of increased birth rate and more high school graduates in the future the problem of long-term supply becomes less acute.

The most serious situation is that of the supply of technical manpower in the next few years. Under existing programs of the Services, the number of graduates receiving commissions will more than double. It is estimated that by 1955, 60 percent of the engineering graduates will be obligated for service as reserve officers. Thus, at the earliest date, these men would not be available for industry until 1957. In the event of all-out mobilization, their services would be extended and recall of other reservists would greatly deplete the engineering forces in industry at a time when they would be needed most. These are problems of present concern to the Manpower Commission, as is also the most effective means of establishing contacts between discharged personnel and employers in industry.

Your committee is keeping contact with this situation and will report further developments as they arise.

Report of Committee 15—Iron and Steel Structures

J. L. Beckel, *Chairman,*
P. E. Adams
Raymond Archibald
R. C. Baker
H. A. Balke
F. Baron
J. E. Bernhardt
E. S. Birkenwald
R. T. Blewitt
M. Block
H. F. Bober
J. C. Bridgefarmer
R. N. Brodie
E. E. Burch
V. R. Cooledge
R. P. Davis
W. E. Dowling
C. E. Eckberg
E. M. Glaros
G. V. Guerin, Jr.
O. E. Hager*
Shortridge Hardesty
A. R. Harris
S. C. Hollister
N. E. Hueni
M. L. Johnson
B. G. Johnston
Jonathan Jones
R. L. Kennedy
J. C. King
W. B. Kuersteiner
M. B. Lagaard
C. T. G. Looney
F. H. Lovell
F. M. Masters
D. V. Messman
K. L. Miner
N. W. Morgan
Cornelius Neufeld
N. M. Newmark
O. K. Peck
J. F. Marsh, *Vice Chairman,*
R. E. Peck
A. G. Rankin
W. S. Ray
C. A. Roberts
G. E. Robinson
M. A. Roose
C. H. Sandberg
T. C. Shedd
L. L. Shirey
C. E. Sloan
C. B. Smith
H. F. Smith
G. L. Staley
E. K. Timby
J. P. Walton
C. Earl Webb
A. J. Wilson
L. T. Wyly

Committee

* Died July 15, 1952.

To the American Railway Engineering Association:

Your committee reports on the following subjects:

1. Revision of Manual.

   Revisions of Specifications for Steel Railway Bridges; rewritten Specifications for Movable Railway Bridges; and rewritten Specifications for Steel Railway Turntables, submitted for adoption and publication in the Manual .... page 905

2. Fatigue in high-strength steels; its effect on the current Specifications for Steel Railway Bridges.

   No report.

3. Design of expansion joints involving iron and steel structures, collaborating with Committee 29.

   Final report, including new material and revisions of Principles for Detailed Design of Flashing, Drainage, Reinforcement and Protection for Waterproofing Purposes, submitted for adoption and publication in the Manual . page 915

4. Stress distribution in bridge frames:

   (a) Floorbeam hangers;

   (b) Counterweight trusses of bascule bridges.

   Progress report, published in Bulletin 502, Vol. 54, June–July 1952 .... page 915

5. Design of steel bridge details.

   Progress report on fatigue failures in railway bridges, presented as information .... page 916

6. Preparation and painting of steel surfaces.
   Progress report, presented as information .... page 917

7. Specifications for cold riveted construction.
   Final report, presented as information .... page 917

8. Specifications for design of corrugated metal culverts, including corrugated metal arches.
   Progress report, presented as information .... page 918

9. Use of high strength structural bolts in steel railway bridges.
   Progress report, including specifications submitted for adoption .... page 929

10. Substitutes for paint for preservation of steel bridge structures.
    No report.

11. Means of conserving labor and materials, including the adaptation of substitute noncritical materials, and specifications for the reclamation of released materials, tools and equipment, collaborating with Committee 3-A, General Reclamation, Purchases and Stores Division, AAR.
    No report.

THE COMMITTEE ON IRON AND STEEL STRUCTURES,
J. L. BECKEL, *Chairman.*

AREA Bulletin 506, January 1953.

MEMOIR

Otto Ernest Hager

Otto Ernest Hager, a member of the Association since 1937, died at Detroit, Mich., on July 15, 1952. Born at Dresden, Germany, Mr. Hager came to this country with his parents in his early boyhood, graduating from high school in Wilkes-Barre, Pa., in 1911, and receiving his B.S. in C.E. degree from Lehigh University in 1915.

Mr. Hager entered the service of the Pennsylvania Railroad after graduation, starting as chainman, advancing to transitman, and was assistant track supervisor, when he resigned in 1920 to work for several consulting engineers. In 1922 he become assistant professor of civil engineering at the University of Nebraska for a year, after which he reentered railroad service as assistant engineer with the Nickel Plate. He was appointed designing engineer in 1932, and was responsible for the design of structures affecting the Nickel Plate in connection with the Cleveland Union Terminal Improvement, involving numerous grade separations and track depressions. In 1940 he assumed the duties of bridge engineer of the Pere Marquette Railroad, in which capacity he served until his death.

As a member of the Association Mr. Hager served actively on Committee 8—Masonry, and Committee 15—Iron and Steel Structures, where he made numerous constructive contributions. He was also a member of the American Society of Civil Engineers.

Report on Assignment 1

Revision of Manual

E. S. Birkenwald (chairman, subcommittee), J. L. Beckel, R. P. Davis, Jonathan Jones, J. F. Marsh, Cornelius Neufeld, C. H. Sandberg, G. L. Staley.

15–1 to 15–48.2, incl.

SPECIFICATIONS FOR STEEL RAILWAY BRIDGES

(To and including Appendix A)

Reapprove with the following revisions:

Page 15–4, Art. 102.

Change the present text to read:

Types of Bridges

102. The preferred types of bridges are as follows:

Rolled beams for spans up to 50 ft.

Plate girders for spans up to 125 ft.

Riveted trusses for spans 100 ft or longer.

Pin-connected trusses for spans 300 ft or longer may be used where conditions warrant.

Page 15–21, Art. 443.

Change the present text of the second paragraph to read:

Bearings and ends of spans shall be secured against lateral and vertical movement.

Pages 15–21 and 15–22, Arts. 444 and 445.

Change the present text to read:

Shoes and Pedestals

444a. Shoes and pedestals shall be designed on the assumption that the load is distributed uniformly over the entire bearing surface. They shall be made preferably of cast steel, with no part less than 1 in. in thickness. Built-up shoes and pedestals, if used, shall have material not less than ¾ in thick in load-carrying portions, and may have plates and shapes welded together, provided the welding serves primarily to make the component parts function as a unit, with the vertical load being carried directly in contact bearing. Diaphragms shall be provided between web surfaces.

The difference in width or length between top and bottom bearing surfaces shall not exceed twice the vertical distance between them. For hinged bearings, the vertical distance shall be measured from the center line of pin.

Base and Masonry Plates

444b. Base and masonry plates shall be designed on the assumption that the load is distributed uniformly over the entire bearing surface, except where modified by eccentricity caused by rocker travel.

The distance from bearing line of rocker or bearing line of end roller to edge of base plate shall not be greater than two times the thickness of the plate. The base plate shall not project more than its thickness beyond the end of rocker or roller.

For spans designed to slide on bearings with smooth surfaces, the distance from center line of bearing to edge of masonry plate, measured parallel with the track, shall not be more than two times the thickness of the plate plus 4 in.

Rockers or Rollers

445. Rockers shall be used in preference to rollers where conditions permit. The upper surface of rockers shall have a pin or cylindrical bearing. The lower surface shall be cylindrical with its center of rotation preferably at the center line of rotation of the upper bearing surface. If the centers of rotation of the upper and lower bearing surfaces do not coincide, the center of rotation of the upper bearing surface shall lie below that of the lower bearing surface and the resulting longitudinal force shall be provided for. The length of rocker shall not be greater than the length of upper bearing surface plus the hieght of rocker. Each end face of the rocker shall make a right angle with its upper and lower bearing surfaces, and these vertical portions of the end face shall not be less than 1½ in deep. No part of an end face of the rocker shall lie inside a straight line, which has a slope of not more than 1 horizontal to 1½ vertical and connects the bottoms of the lower and upper vertical faces. The rocker shall be geared to the base plate.

Rollers may be either cylindrical or segmental and shall not be less than 6 in. in diameter. They shall be secured to insure parallelism and geared to the upper and lower plates. The roller nest shall be so designed that the parts may be readily cleaned.

Page 15–26, Art. 535, fourth line.

Change the word "tension" to "compression".

15–49 to 15–92, incl.

SPECIFICATIONS FOR MOVABLE RAILWAY BRIDGES

The committee recommends the withdrawal of these specifications and the substitution therefore of the Specifications for Movable Railway Bridges as published in AREA Proceedings, Vol. 53, 1952, pages 522 to 591, incl., modified by the following revisions:

Page 523, item 26.

Substitute a comma for the word "or" following the word "manual".

Page 526, Sec. A, Art. 14, first paragraph.

Change the last line, after the word "under", to read: "the appropriate machinery items."

Page 526, Sec. A, Art. 14, second paragraph, second and third lines.

Omit the words "shim plates for adjustment of the machinery,".

Page 535, Sec. C, Art. 9.

Third paragraph, second line, insert the word "speed" after the numeral "6".

Page 539, Sec. C, Art. 17.

Change the last paragraph to read:

If a shaft, trunnion, or axle has one or more keyways at the section where the maximum stresses occur, *f* and *S* shall be increased by the following percentages:

	Percent
For one keyway having a width not more than ¼ and a depth not less than ⅛ the shaft diameter	17
For two such keyways, 120 deg apart	20
For two keyways, 120 deg apart, having a width not more than ⅙ and a depth not more than $\frac{1}{12}$ the shaft diameter	12

Page 548, Sec. D, Art. 16, fifth paragraph, first line.

Insert "preferably" after the word "pinions".

Page 552, Sec. D, Art. 33, first paragraph, first line.

Change the word "commercial" to "combined".

Page 555, Sec. D, Art. 48, first paragraph, second line.

Insert ", steel forgings", after the word "castings".

Page 555, Sec. D, Art. 48, formula.

Change "1200" to "12000".

Page 555, Sec. D, Art. 48, fourth paragraph.

Delete the first sentence and substitute the following:

The unit bearing of the tread plates on the web plate shall not exceed one-half the yield point of the material in tension. In calculating the unit bearing, the length of the area in bearing shall be taken as twice the least thickness of the tread and the width as the thickness of the web plus the effective thickness of the side plates.

Page 555, Sec. D, Art. 48, fifth paragraph.

Delete and substitute:

Tread plates may be flange-and-web castings. The edge thickness of the rolling flange shall be not less than 3 in and the flange thickness at the face of the web of the casting shall be such that the unit bearing on the web of the casting shall not exceed one-half the yield point of the material in tension, the length of bearing being taken as twice the depth from the rolling face to the plane under consideration.

Page 558, Sec. D, Art. 63.

Delete the first two words, "cast iron".

Page 562, Sec. E, Art. 13.

Add the following paragraphs:

The contractor shall verify the exact lengths to which the counterweight ropes shall be manufactured.

Each rope shall have a stripe painted on one side along its entire length at the time the measurement of length is made, to assure the correct twist of the rope during the erection of the bridge.

Ropes shall be suitably marked or tagged for identification for proper erection.

Page 569, Sec. F, Art. 18.

Insert the following sentence after the first sentence:

"Motors whose frames tilt during the operation of the bridge shall have ball or roller bearings."

Page 585, Sec. H, Art. 4.

Change the first sentence to read:

All shaft journals, including their shoulders, shall be accurately machined and polished.

Page 585, Sec. H, Art. 8.

Change last line, first paragraph, to read, "next to the bearing shall be machined and polished."

Pages 15–109 to 15–114.1, incl.

SPECIFICATIONS FOR STEEL RAILWAY TURNTABLES

Withdraw these specifications and substitute the following redraft of these specifications.

SPECIFICATIONS FOR STEEL RAILWAY TURNTABLES

1953

CONTENTS

A. INFORMATION TO BE GIVEN BIDDERS

	Section	Article
1. Plan showing general information for designing the table, including:		
a. Type of table	C	1
b. Length of table	C	2
c. Type of floor	C	1
d. Clearance diagram	C	3
e. Diagram of live load	D	2
f. General dimensions for and type of pit construction	I	5
g. Type of support for circle rail, rails for table and approach	I	1
h. Size of circle rail and rails on table and approaches	I	1, 2 & 3
i. Size of tie plates on table, under approach rails, on pit wall, and under circle rail as will be used if the rail supports are to be timber	I	1 & 3
j. Locations where tie and other pads are to be installed	I	4
k. Type of locking device	C	5
l. Type of end wheel bearings	H	3
m. Type of brakes	H	4
n. Normal time for turning the table	C	4
o. Type and material for operator's house		
p. Special steels, if any, to be used		

2. Power for Tractors
   a. Kind of fuel for internal combustion engine
   b. Electric power service characteristics
   c. Point at which purchaser will deliver power
   d. Number of motors
   e. Type of electric control
3. Will there be separate contracts for the different parts of the table?
4. Material to be furnished by the purchaser
5. Shop paint specifications
6. Will the purchaser erect the table?

B. OTHER SPECIFICATIONS

1. The current Specifications for Steel Railway Bridges and the current Specifications for Movable Railway Bridges, American Railway Engineering Association, shall apply, except as otherwise provided herein.

2. Special materials which are not covered by the specifications named above shall be in accordance with the current specifications of the American Society for Testing Materials.

C. GENERAL FEATURES OF DESIGN

1. Type of Turntables

These specifications cover the following types of turntables:

(a) Balanced

(b) Continuous three-point support

Tables shall be preferably of deck construction, but they may be made with through girders or trusses.

2. Length

The nominal length of the table is the over-all length of the girders. The length shall be preferably a multiple of 5 ft.

The length shall be such that no part of the locomotive to be turned will project beyond the ends of the table.

3. Clearances

The clearances shall be in accordance with diagram prepared and submitted by the purchaser with information to be given to bidders. If specification is not submitted by the purchaser, the clearances shall not be less than those shown in Fig. 1.

All clearances shall conform with legal requirements for tables erected in localities having clearance laws.

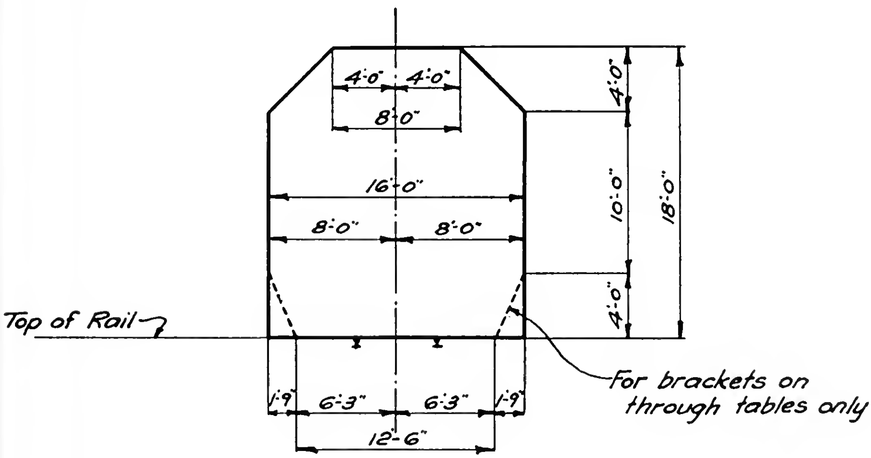


FIGURE 1

4. Power Operation

Tables shall be power operated unless otherwise specified. The power equipment shall be the kind specified by the purchaser and shall conform with the applicable requirements of the current AREA Specifications for Movable Railway Bridges.

For the calculation of power requirements and the forces for turning or braking, the position of the live load on three-point-support tables shall be the one most unfavorable.

The maximum speed at the circle rail shall be 200 ft per min.

A

5. Locking Device

A locking device system shall be provided, preferably at each end of the table, which will hold the table in line with any approach track. The locking device may or may not be connected to a signal.

D. LOADS

1. Loads

The table shall be proportioned for the following loads and forces:

(a) Dead load
(b) Live load
(c) Force required to start, rotate, and stop the table, including overcoming inertia.

The stresses from these loads and forces shall be shown separately on the stress sheet.

2. Live Loads for Design

The table shall be designed for the live load and length of table as specified by the purchaser in information to be given to bidder. Recommended live loads for tables of various lengths are shown in Fig. 2. The live load specified shall be placed on either one or both arms of the table in such positions as will produce maximum stresses in each component part of the table, maximum reactions on the center pivot and end carriages, and maximum end uplift for continuous three-point-support tables.

The ends of the table, including main girders, end floorbeams, trucks, and other parts above the foundation similarly affected, shall be proportioned for an axle load of 150,000 lb (in addition to the specified live load) placed in the most effective position.

The center pivot shall be proportioned for the specified live load plus 25 percent. The center cross girder assembly with its connections to the main girders, down to and including the bearing of the cross girder on the top of the center casting, shall be proportioned for the specified live load plus 75 percent.

In considering the loads to be turned on the table, the 150,000-lb load and the 25 and 75 percent additions to the live load mentioned in the preceding two paragraphs shall not be included.

E. UNIT STRESSES AND PROPORTIONING OF PARTS

1. Unit Stress and Deflection

The unit stresses shall be as given in the specifications named in Sec. B, except for parts which determine the deflection of balanced tables. Such parts shall be so proportioned that the live-load deflection at the ends will not exceed ½ in for an 80-ft table; and for longer tables, ⅛ in more for each 10 ft of length in excess of 80 ft.

Three-point-support tables shall be designed for a variation of 1 in either way in the relative elevations of the circle rail and the center support.

In three-point support tables, vertical stiffness is not essential; rather a degree of flexibility is desirable. Such tables shall be proportioned to provide positive reactions at all three supports, i.e., to avoid uplift, regardless of the position of the live load.

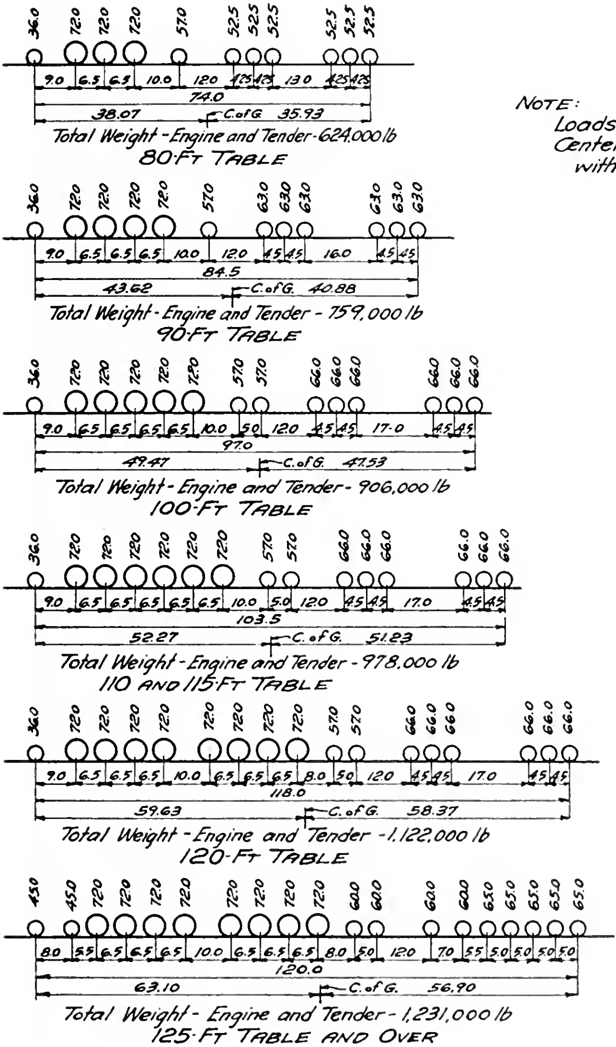


FIGURE 2

NOTE:
Loads given in kips.
Center of gravity computed with tender full.

F. DETAILS OF DESIGN

1. Center Cross Girders

The center cross girders shall be as deep as practicable, and their webs shall be made to bear over the center, to minimize their deflection and insure uniform bearing over the full length of their contact on the center.

2. Bracing

Horizontal bracing shall be provided to allow for turning the table by means of power applied at either end. There shall be both top and bottom lateral bracing systems where practicable. Balanced tables shall be braced to prevent warp. The bracing shall be of such pattern that the center cross girders cannot be stressed in torque.

The thickness of bracing material shall not be less than ½ in.

3. Footwalks

There shall be footwalks along both sides of the track. On deck tables they shall be protected by railings.

4. Collector Ring Support

If the feed wires of an electrically operated table are over the pit, there shall be a structural steel frame attached to the main girders to support the wires and the collector ring over the center.

5. Protection of Parts

The center, center cross girders, and machinery shall be protected (preferably by metal housing) against the entry of water, cinders, dirt, etc.

The thickness of any full-length top cover plate of deck girders, stringers, floor-beams, and center cross girders shall be increased ⅛ in over the computed thickness. The section of other parts subject to excessive corrosion shall be increased over the computed section.

6. Inspection

Tables shall be so designed as to facilitate inspection and making repairs. Jacking brackets on the steel superstructure, and also foundations in the pit paving, shall be provided for raising the table off the center and the circle rail. A pair of stiffeners shall be provided on the outside of each main girder near one end. Their outstanding legs shall be 3 in apart and shall extend at least 1 in beyond the girder flange to provide non-slip sling position for lifting the end of the table with a crane.

G. CENTER

1. Type of Pivot

The center pivot shall be of the disk type.

2. General Features

The point of application of the load on the pivot shall be directly over the center of the pivot. The rotating portion of the center pivot shall be equipped with a saddle or pin to allow longitudinal rocking of the main girders. The center cross girder assembly shall be secured to the center in such a way as to prevent the table from being forced off the center by a blow of the locomotive wheels on the ends of the turntable rails, and when this force is resisted by a pin in a half-round bearing, the pin shall be 4 in. in diameter or less. The whole center, including the foundation, shall be constructed to resist any unbalanced lateral force resulting from turning the table.

The entire unit shall be as nearly dustproof and waterproof as practicable. It shall be equipped with substantial and effective lubricating devices and be so designed that it may be readily removed, taken apart, inspected, cleaned, repaired, lubricated and replaced. There shall be means of adjustment for height.

3. Materials

The disk pivot shall be one disk of phosphor bronze or be comprised of two disks, one of phosphor bronze and one of hardened steel, set in oil-tight recesses. The disks shall be so secured that sliding will take place only at the surfaces of a single disk or the contact surfaces between two disks.

Sliding surfaces shall be finished accurately and polished.

H. END TRUCKS

1. General Features

The end trucks shall be of substantial construction. They shall be braced to hold the axles of the wheels in lines radiating from the center of rotation. The end trucks shall be completely assembled in correct alinement on the main girders and the correct length of braces determined. The braces then shall be connected. The braces shall be of such design that small adjustments can be made in their length, preferably by shims.

Bolts connecting trucks to balanced tables shall be high-tension, heat-treated bolts in accordance with current ASTM Specifications, designation A 325.

There shall be either two or four wheels at each end of the table. If there are only two, they shall be placed outside the main girders and mounted in a single truck frame connected rigidly to the main girders. If there are four wheels, they shall be mounted in pairs in separate trucks so attached to the main girders that the loads transmitted to the wheels will be equalized.

Trucks having either traction equipment built in them or separate tractors connected to them shall be adequately connected to the main girders to transmit the traction force.

There shall be means of adjustment for height.

2. Wheels and Axles

Wheels shall be AAR multiple-wear wrought steel wheels or equal of as large diameter as practicable, except that the treads shall not be flanged and the webs preferably shall be straight. The wheels shall be bored for tight fit and mounted on steel axles by heavy pressure. In addition, wheels used as drivers shall be keyed to the axles. The wheels shall not be conical.

Wheel material shall conform to current ASTM Specifications, designation A 57, Class C. The rims only shall be heat treated. Axle material shall conform to current ASTM Specifications, designation A 236, Class G.

3. Bearing Boxes

The bearing boxes shall be of cast or rolled steel with removable phosphor bronze bushings or bearings, or other type as may be specified.

Bearing boxes shall be compact, with lids which can be opened readily, and of such construction as will provide for effective lubrication and prevent the entrance of water and dirt.

Bearing boxes of continuous three-point-bearing tables shall be preferably equipped with roller bearings.

4. Brakes

A braking system shall be installed on the end trucks, and controls shall be located in the operator's house.

I. PIT AND TRACKS

1. Circle Rail

The circle rail shall be of a section not less than the heaviest standard rail used by the purchaser and preferably not less than 132 lb per yd.

There shall be provisions for adjustment of the elevation and the radius of the circle rail and for drainage under it.

All or most of the joints in the circle rail shall be preferably butt welded. If bolted rail joints are used, they shall be such that they will not interfere with rail anchorage. The top of the circle rail shall be in a horizontal plane.

The circle rail shall be preferably supported on steel beams embedded in the concrete foundation or on bearing plates not less than 2 in thick set directly on the concrete foundation. If timber ties are used for supporting circle rails, they shall be treated hardwood, sized to the same dimensions, and they shall be held in position while the concrete is being placed. The circle rail shall be securely anchored to its support to hold it in proper line and to prevent it from creeping due to traction of the power operating equipment.

2. Radial Tracks

A track layout with tangents extending from the face of the pit wall a distance at least equal to the locomotive wheel base is desirable. Anything less will result in side kick at the end of the table.

Radial track rails ending at the circle wall shall not be less than 39 ft and be anchored securely against longitudinal movement.

The top of the rails of the radial tracks shall be at the same elevation as the top of rails on the ends of the table with the end truck wheels bearing. The ends of the rails in the radial tracks shall be held securely in line and elevation. Where wood supports are used over the circle wall under ends of radial tracks, adequate steel bearing plates shall be provided.

There shall be a clearance of ¾ in between the ends of the radial track rails and the rails on the table.

3. Rails on the Table

The rails on the table shall be held in line and elevation and anchored to prevent longitudinal movement. The purchaser's heaviest standard rail and steel tie plates may be used throughout, except at ends of table where there should be larger steel bearing plates with sufficient depth to prevent bending.

The rails at the ends of the table shall be preferably full length.

4. Pads

Consideration shall be given to the use of pads at locations subject to impact from live loads and to improve rail bearing conditions for the rails on the table, approach track rails, and circle rail.

5. Pit

The bottom of the turntable pit preferably shall be paved. Ample clearance for snow shall be provided between the steelwork of the table and the paving. Suitable drainage shall be provided for the pit, and where conditions warrant there shall be an adequate drainage system back of the circle wall. An inspection pit shall be provided in the circle wall, of sufficient size to permit removal of a truck.

There shall be a clearance of not more than 3 in between the circle wall and the ends of the table.

Report on Assignment 3

Design of Expansion Joints Involving Iron and Steel Structures
Collaborating with Committee 29

A. R. Harris (chairman, subcommittee), P. E. Adams, H. A. Balke, M. Block, R. N. Brodie, V. R. Cooledge, R. P. Davis, M. L. Johnson, R. L. Kennedy, K. L. Miner, Cornelius Neufeld, R. E. Peck, H. F. Smith, A. J. Wilson.

A report of progress in the study of the design of expansion joints, involving iron and steel structures, embracing Figs. 1 to 16, incl., was submitted last year as information for review by association members before offering it for adoption and publication in the Manual (see Proceedings, Vol. 53, 1952, pages 591 to 600, incl.).

Your committee recommends for adoption and publication in the Manual the material now appearing in the Proceedings under the heading "Design of Expansion Joints for Iron and Steel Structures", with a few editorial changes.

Your committee also recommends for reapproval the Principles for Detailed Design for Flashing, Drainage, Reinforcement and Protection for Waterproofing Purposes, pages 15–101 to 15–108, incl., with the elimination of certain features which are in conflict with the above proposed Design of Expansion Joints for Iron and Steel Structures.

Report on Assignment 4

Stress Distribution in Bridge Frames

(a) Floorbeam Hangers
(b) Counterweight Trusses of Bascule Bridges

C. H. Sandberg (chairman, subcommittee), J. E. Bernhardt, E. S. Birkenwald, J. C. Bridgefarmer, J. F. Marsh, F. M. Masters, N. M. Newmark, G. L. Staley, C. Earl Webb, L. T. Wyly.

Your committee submits the following report of progress in the study and investigation of the causes and remedies of failures in floorbeam hangers in railway bridges and counterweight trusses of bascule bridges. This research project is being conducted at Purdue University Engineering Experiment Station under the direction of L. T. Wyly, research professor of structural engineering and head of department. Administration is by Dr. A. A. Potter, director of the Engineering Experiment Station and dean of engineering, and by Professor R. B. Wiley, head of the School of Civil Engineering and Engineering Mechanics.

The project is sponsored financially by the Association of American Railroads. The program was initiated upon the recommendation of AREA Committee 15—Iron and Steel Structures, and is supervised by the Subcommittee on Stress Distribution in Bridge Frames—Floorbeam Hangers. This is a cooperative project, and the research office of the Association of American Railroads, under the general direction of G. M. Magee, director of engineering research, and E. J. Ruble, research engineer structures, assists in and advises regarding the work.

A general method of analysis of rigid frames composed of members having a variable section, such as that found in floorbeam hangers and counterweight trusses of bascule bridges, is given in Bulletin 502, pages 3 to 64, incl. The report in this Bulletin also includes the results of laboratory studies on bridge frame models of floorbeam hangers, pages 65 to 147, incl., and the results of field tests on bascule bridges, pages 148 to 173, incl.

Report on Assignment 5

Design of Steel Bridge Details

G. L. Staley (chairman, subcommittee), P. E. Adams, H. A. Balke, F. Baron, R. P. Davis, W. E. Dowling, G. V. Guerin, Jr., S. Hardesty, J. C. King, W. B. Kuersteiner, M. B. Lagaard, D. V. Messman, A. G. Rankin and H. F. Smith.

Fatigue Failures in Railway Bridges

D. V. Messman (chairman, subcommittee), J. C. Bridgefarmer, S. C. Hollister, R. E. Peck, C. H. Sandberg, C. E. Sloan, L. T. Wyly.

This report summarizes the replies to a questionnaire sent to all Class I railroads in 1951 asking for information on failures in bridge main material subject to fatigue. Failures in floorbeam hangers and counterweight trusses of bascule bridges are subjects of other studies and are excluded from this report.

Replies were received from 20 railroads, with a total mileage of about 101,000 miles. Seventy-five failures were reported in 32 bridge spans, by 9 railroads, the other 11 railroads reporting no failures.

In tabular form the reported failures are as follows:

Type of Failure	*Spans*	*Failures*
Fillet of stringer flange angle under ties	1	40
Stringer web	1	3
Floorbeam web	13	13
Bottom chord of truss	13	15
Bottom flange of girder	2	2
Truss eyebar	1	1
Channel of truss tension diagonal	1	1
Totals	32	75

Discussion of Failures

Stringer flanges having cracked fillets of angles under ties consisted of two 6-in by 4-in by ½-in angles with the 6-in legs outstanding, the heaviest axle load being 64,800 lb. No information as to corrosion was given, but may have been a contributing factor.

Cracks in webs of stringers were immediately below and parallel with relatively wide thick top flanges of rolled beams, occurring under 70,900 lb axle load on a 3 deg 30 min curve. Lateral forces probably contributed to these failures.

Occurrence of cracks in webs of floorbeams was limited to two railroads, one reporting 12 failures at the end of floorbeams near ends of multiple-track skewed through girder spans, where severe distortion occurs under unequal live load deflection, and the other railroad reporting 1 web crack near the curved end of an interior floorbeam fabricated in 1902 for installation in a single-track truss span fabricated in 1885 and reinforced in 1902.

Cracks in bottom chords of riveted trusses occurred in 12 instances close to the bearing, and in 1 instance near the first panel point. In all spans for which details were given the end pin was below the center line of the bottom chord and any horizontal forces on the pin would bend the bottom chord. The failures may be assumed to result from lack of free movement of bearings, a condition actually reported for several of the failures.

Failures at ends of first cover plates not extended the full length of girders, two instances of which were reported, have been predicted by several test programs, but existing specifications guard against failures of first cover plates by requiring one cover plate on each flange to be extended full length.

The eyebar reported broken was one of two bars in a diagonal member of a deck pin-connected truss, but no other information is available.

The failure at the reentrant cut on a channel in a tension diagonal of a truss is attributable to the presence of a severe stress raiser.

Conclusions

The replies to the questionnaire indicate no widespread occurrence of failures which are unexplainable or which need special study beyond test programs already under way or consideration. However, they do indicate the need for keeping truss bearings in proper working condition, and the need for designing skewed spans to minimize the effect of unequal deflections. The replies are also of value in pointing to locations on bridges where close inspection should be made to find cracks in their early stages.

Report on Assignment 6

Preparation and Painting of Steel Surfaces

M. A. Roose (chairman, subcommittee), R. N. Brodie, E. M. Glaros, A. R. Harris, Jonathan Jones, J. C. King, F. M. Masters, K. L. Miner, N. W. Morgan, R. E. Peck, A. G. Rankin, W. S. Ray, C. A. Roberts, L. L. Shirey, C. E. Sloan, C. Earl Webb.

This is a progress report, submitted as information.

The committee is cooperating with the Steel Structures Painting Council and has, during the past year, approved Chapter 10, entitled "Field Painting of Railroad Bridges and Structures" of the Painting Manual to be published by this council. In addition, the committee has reviewed the council's tentative specifications for surface preparation methods.

A test will be conducted early in 1953 on Missouri Pacific Railroad Bridge 69, at Roots, Ill., to determine a paint system which will afford the greatest protection to steel bridges against the corrosive action of brine drippings. The test will be under the direction of the council, in which the railroad and the committee are cooperating.

Report on Assignment 7

Specifications for Cold Riveted Construction

K. L. Miner (chairman, subcommittee), P. E. Adams, Frank Baron, J. C. King, F. H. Lovell, F. M. Masters.

This is a final report, submitted as information, which is based on the report of an investigation conducted under the direction of Professor Frank Baron at Northwestern Technological Institute. A digest of this report, entitled "The Effect of Grip on the Fatigue Strength of Riveted and Bolted Joints", was published in AREA Bulletin 503, September–October, 1952, page 175 and will appear in the proceedings, Vol. 54, 1953, beginning on page 175.

This report shows that cold-driven rivets may have as great a fatigue strength as hot-driven rivets for short grips not over $1\frac{3}{16}$ in, but that for longer grips the fatigue strength of cold-driven rivets diminishes, whereas that of hot-driven rivets increases. It is the increase in the clamping force of a fastener which results in an increase in the fatigue stress of a joint. Likewise, hole-filling obtained with usual cold-driving procedures is not sufficient to prevent appreciable slippage from occurring in joints fabricated with cold-driven rivets, especially where grips exceed $1\frac{3}{16}$ in.

Under the circumstances, your committee recommends against adopting specifications for cold-riveted construction or revising existing Art. 517 of the AREA Specifications for Steel Railway Bridges to permit the use of cold-driven rivets.

Report on Assignment 8

Design of Metal Culverts of 60-In Diameter and Larger, Including Corrugated Metal Arches

J. F. Marsh (chairman, subcommittee), R. Archibald, F. Baron, H. F. Bober, R. N. Brodie, V. R. Cooledge, C. E. Ekberg, N. E. Hueni, D. V. Messman, C. Neufeld, O. K. Peck, L. L. Shirey, C. E. Sloan, H. F. Smith, G. L. Staley.

This is a progress report, presented as information. It deals with the verification or modification of the design data (gage tables for pipe) in the Specifications for Corrugated Structural Plate Pipe as adopted by Committee 1 in 1944, and as now printed in the Manual, and includes the presentation of new tentative specifications.

The report does not include corrugated metal arches because it was decided that further study should be made before specifications are proposed for these structures.

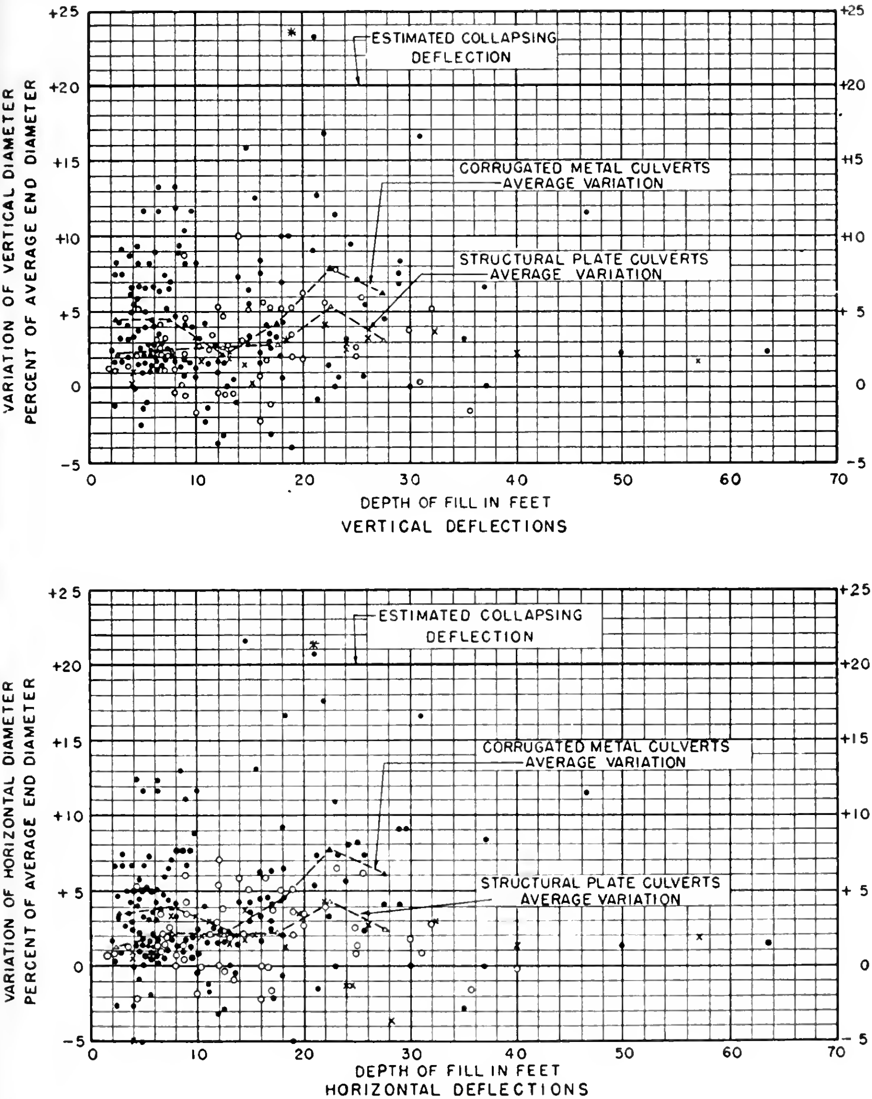
The committee's 1949 report (see Proceedings, Vol. 50, pages 449 to 451, incl.,) presented data on two theoretical approaches and gave consideration to a rational approach developed by M. G. Spangler on the Structural Design of Flexible Pipe Culverts.

Having carefully examined the theoretical possibilities, the committee turned its attention towards the structural performance of existing field installations with the hope that their performance would show either that the present design practice is sound or that it should be revised. On August 22, 1949, G. M. Magee, director of engineering research, AAR, at the request of this committee, wrote the chief engineers of all Member Roads asking each to report the vertical and horizontal deflections of a representative number of structures 5 ft or more in diameter, along with all other pertinent information. Data from this questionnaire have been assembled herein. The following six charts show the structural performance in terms of change in vertical and horizontal diameter of approximately 300 corrugated metal pipes of riveted and bolted construction installed with and without strutting, in compacted and non-compacted embankments. Approximately one-fourth of the structures were installed by jacking or tunneling the structure through the existing embankment, while the remainder were installed prior to building the embankment. Fig. 1 indicates the vertical and horizonal deflections of all pipes under all installations and service conditions. In general, the average vertical deflection supports the design criteria for flexible structure that has been in common use. Excessive deflection in a few cases has been checked and satisfactorily explained by unusual installation conditions. The other charts show a more detailed study of the data secured. Figs. 2 and 3 show the variation between compacted and un-compacted backfill. Fig. 4 covers the pipe placed by jacking or tunneling through the embankment.

A separate study was made on 60-in diameter culverts as this is the lowest size limit in the committee's assignment, and also is in a range where the transition from riveted to bolted construction occurs. The upper diagram of Fig. 5 indicates the deflection for the various gages where the culverts were placed under projection conditions.

The three diagrams on Fig. 6 show the deflection for structures, as plotted against years in service, under fills from 0–10 ft, 10–20 ft, and 20 ft and over, respectively.

(Text continued on page 925)



ALL CULVERTS

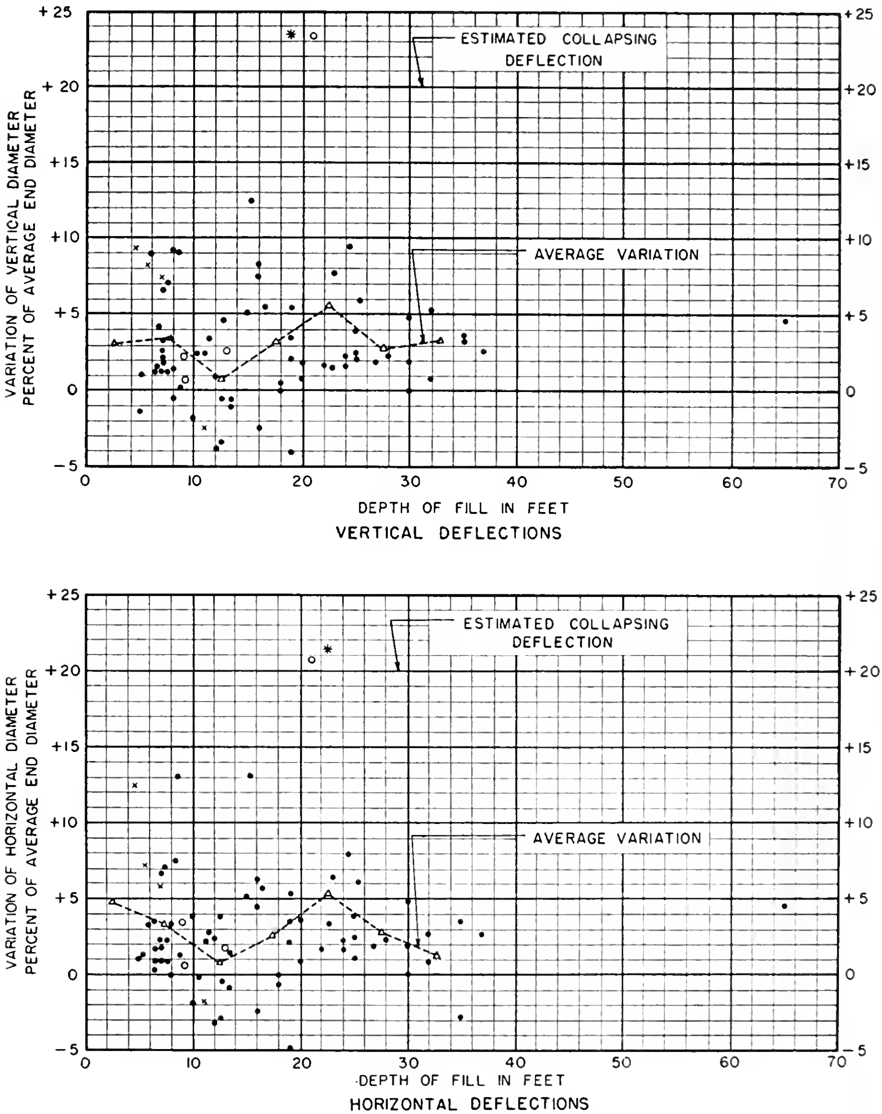
NOTE: * FILL IS WET, WATER SEEPING THROUGH JOINTS. LOSS OF LATERAL RESISTANCE HAS RESULTED IN EXCESSIVE DEFLECTION BUT COMPLETE FAILURE NOT IMMINENT.

• – CORRUGATED METAL CULVERTS
o – STRUCTURAL PLATE CULVERTS
× – TUNNEL LINER
▲ – AVERAGE VARIATION - CORRUGATED METAL CULVERTS
△ – AVERAGE VARIATION - STRUCTURAL PLATE CULVERTS

FIG 1

STUDY OF METAL CULVERTS

ASSOCIATION OF AMERICAN RAILROADS
OFFICE OF RESEARCH ENGINEER
CHICAGO, ILLINOIS SEPT., 1952



CULVERTS WITH COMPACTED FILL

NOTE. * FILL IS WET, WATER SEEPING THROUGH JOINTS. LOSS OF LATERAL RESISTANCE HAS RESULTED IN EXCESSIVE DEFLECTION BUT COMPLETE FAILURE IS NOT IMMINENT

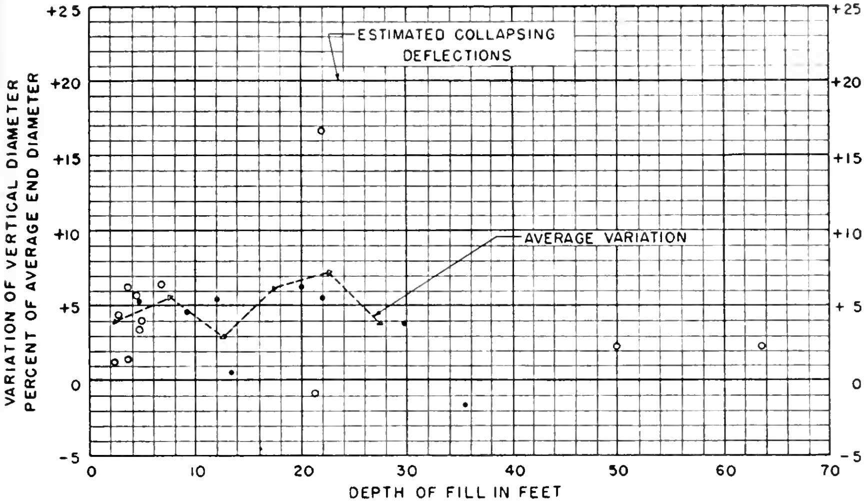
USE OF STRUTS:

• – CULVERTS STRUTTED
o – CULVERTS NOT STRUTTED
x – UNKNOWN

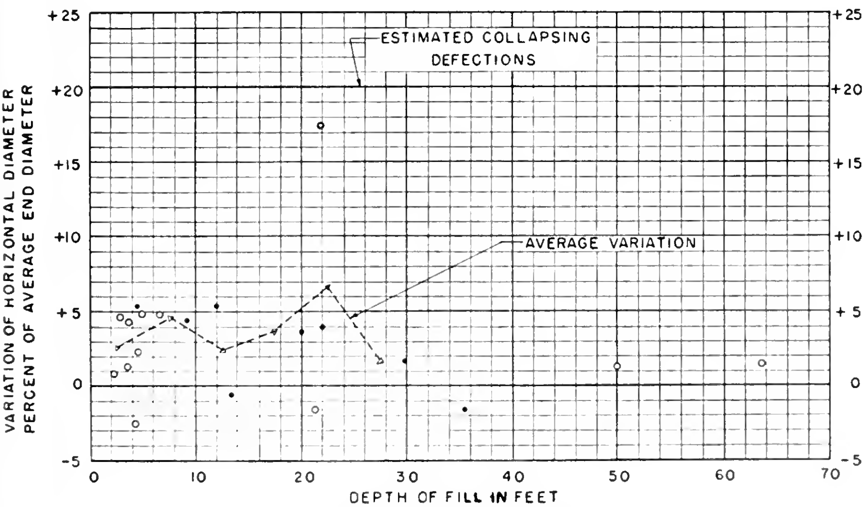
FIG. 2

STUDY OF METAL CULVERTS

ASSOCIATION OF AMERICAN RAILROADS
OFFICE OF RESEARCH ENGINEER
CHICAGO, ILLINOIS SEPT., 1952



VERTICAL DEFLECTIONS



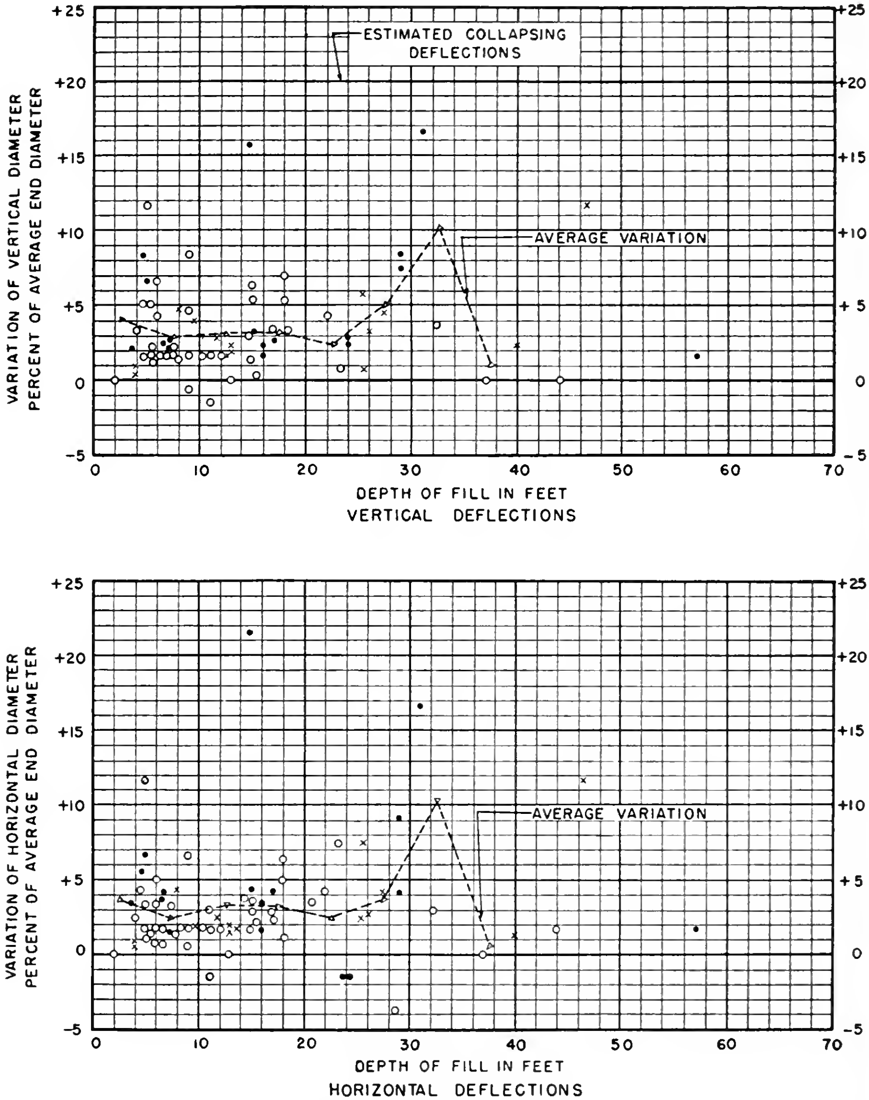
HORIZONTAL DEFLECTIONS

CULVERTS WITH FILL NOT COMPACTED

USE OF STRUTS
•-CULVERTS STRUTTED
o-CULVERTS NOT STRUTTED
×-UNKNOWN

FIG 3

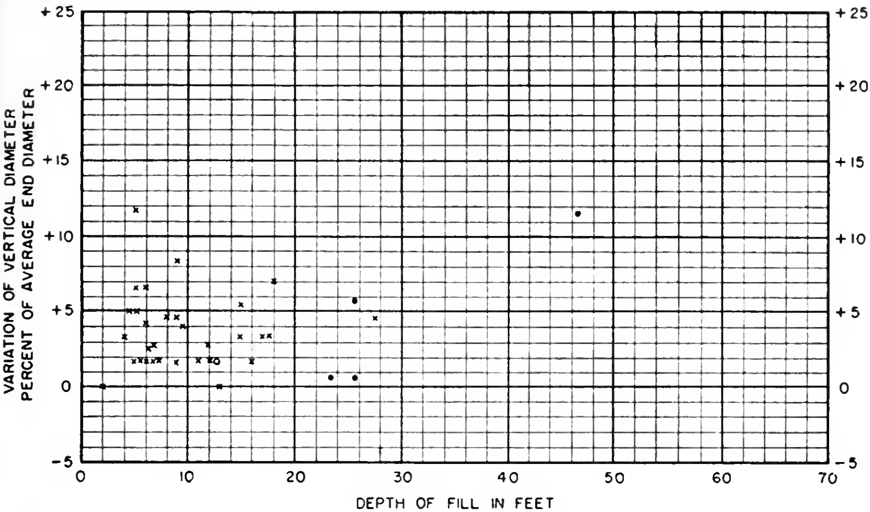
STUDY OF METAL CULVERTS
ASSOCIATION OF AMERICAN RAILROADS
OFFICE OF RESEARCH ENGINEER
CHICAGO, ILLINOIS SEPT., 1952



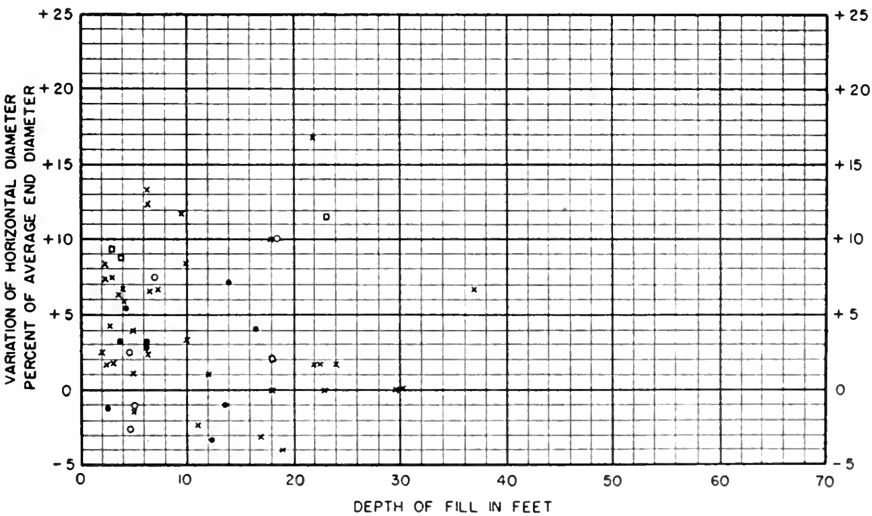
CULVERTS JACKED THROUGH FILL

USE OF STRUTS:
•-CULVERTS STRUTTED
o-CULVERTS NOT STRUTTED
x-UNKNOWN

FIG. 4
STUDY OF METAL CULVERTS
ASSOCIATION OF AMERICAN RAILROADS
OFFICE OF RESEARCH ENGINEER
CHICAGO, ILLINOIS SEPT., 1952



CULVERTS JACKED THROUGH FILL



CULVERTS BACKFILLED

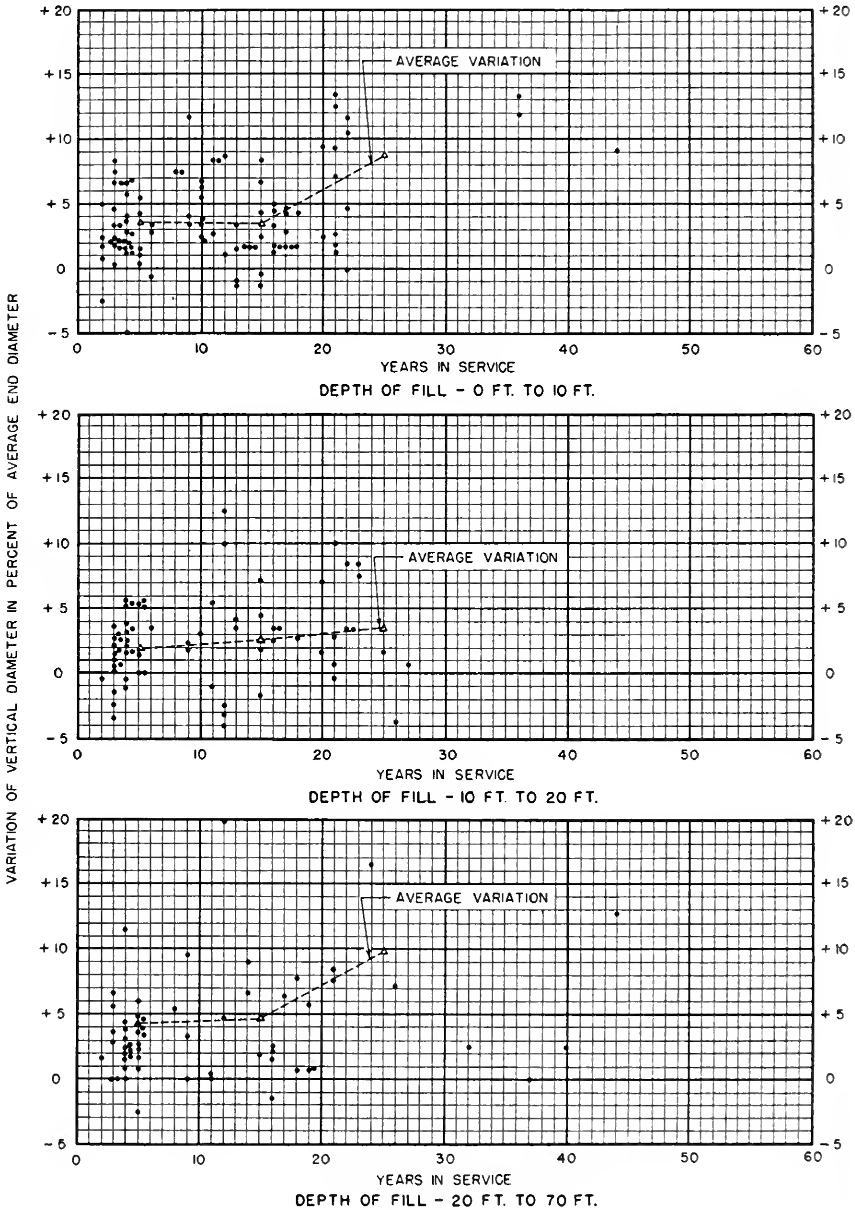
60-IN. CULVERTS

SYMBOL • – GAGE · 11 – $\frac{I}{c}$ · 0.01280
o – " 10 – " · 0.01407
x – " 8 – " · 0.01650
□ – " 7 – " · 0.01770

FIG 5

STUDY OF METAL CULVERTS

ASSOCIATION OF AMERICAN RAILROADS
OFFICE OF RESEARCH ENGINEER
CHICAGO, ILLINOIS SEPT, 1952



ALL CULVERTS

FIG. 6
STUDY OF METAL CULVERTS
ASSOCIATION OF AMERICAN RAILROADS
OFFICE OF RESEARCH ENGINEER
CHICAGO, ILLINOIS SEPT., 1952

As to the modification of the specifications, a new factor has to be considered. In 1944 when the subject specification was adopted by the Association, there were three manufacturers making the same 6-in by 1½-in corrugation. Since then the original corrugation has been abandoned and the manufacturers are all now making 6-in by 2-in corrugation.

Comparative section moduli between the two corrugations can best be expressed by the following table:

Gage	*Section Modulus in Inches** *6 In By 1½ In*	*6 In By 2 In*
12	0.0371	0.0574
10	0.0467	0.0732
8	0.0561	0.0888
7	0.0606	0.0989
5	0.0696	0.1147
3	0.0784	0.1303
1	0.0900	0.1458

* Per inch of horizontal projection.

It is the recommendation of your committee that the following Specifications for Structural Plate Pipe be held over for one year before adoption as Manual material. Sec. E covering construction, and Sec. F covering payment, have not been revised as they are now contained in Chapter 1 of the Manual, and are under the jurisdiction of Committee 1.

This specification is intended eventually to replace those sections of the Specifications for Corrugated Structural Plate Culverts and Arches dealing with General, Material, Fabrication and Design now contained in Chapter 1.

References on design data are as follows:

Iowa Engineering Experiment Station, Bulletin 153.
Illinois Engineering Experiment Station, Bulletin 22.
AREA Proceedings, Vol. 50, 1949, pages 449 to 451, incl.
AREA Proceedings, Vol. 27, 1926, Culvert Load Determination, page 794.
AREA Proceedings, Vol. 29, 1928, Theory of Culvert Loads, page 128.
Proceedings, ASCE, February 1947, page 268.
Proceedings, ASCE, March 1947.
Michigan State College Tests by AASHO, Lansing, Mich.
Trans., Assoc. of Civil Engineers of Cornell University, June 1896.

SPECIFICATIONS FOR CORRUGATED STRUCTURAL PLATE PIPE

FOREWORD

Design of culverts is based on empirical rules.

A. GENERAL

1. Scope

These specifications cover corrugated structural plate culverts 60 in or more in diameter.

B. MATERIAL

1. Description of Plates

Plates shall consist of structural units of galvanized corrugated metal. The corrugations shall run at right angles to the longitudinal axis of the structure and shall have a pitch of 6-in, with a tolerance of ¼ in and a depth of 2 in, with a tolerance of ⅛ in. The radius of the inside of the corrugation shall be at least 1$\frac{1}{16}$ in. Single plates shall weigh not more than 750 lb and shall be furnished in standard sizes to permit structure length increments of 2 ft. Plates shall have approximately a 2-in lip beyond each end crest.

The gage of plates and radii or curvature shall be as specified. The plates at longitudinal and circumferential seams shall be connected by bolts. Joints shall be staggered so that not more than three plates come together at any one point. Each plate shall be curved to a circular arc.

2. Base Metal

The base metal of the corrugated plates shall be made by the open-hearth process and shall conform in chemical properties to the requirements of Table 1, as follows:

TABLE 1—CHEMICAL COMPOSITION BY LADLE ANALYSIS

	Kind of Base Metal	
Elements	*Pure Iron*	*Copper Molybdenum Iron*
Carbon, Max Percent		
Manganese, Max Percent		
Phosphorus, Max Percent	0.015	0.015
Sulfur, " "	0.040	0.040
Silicon, " "		
Copper, Min "		0.400
Molybdenum, " "		0.050
Sum of first 5 elements, Maximum percent		0.250
Sum of first 6 elements, Maximum percent	0.100	

3. Spelter Coating

A coating of prime western spelter, or equal, not less than 1.1 oz per sq ft on each surface, shall be applied by the hot-drip process. If the average spelter coating as determined from the required samples is less than the amount specified above, or if any one specimen shows a deficiency of 0.2 oz, the lot sampled shall be rejected. Spelter coating shall be of first-class commercial quality, free from injurious defects, such as blisters, flux and uncoated spots.

The corrugated plates may be fabricated from galvanized sheets or plates and no further galvanizing will be required after fabrication if the spelter coating has not been injured in the fabrication process.

4. Sampling

For testing the weight of the spelter coating and for chemical analysis of the base metal, when required, a sample approximately 3 in square, or a sample of equivalent area, shall be cut from the corner of one plate in each 100 plates of a shipment or fraction thereof, or coupons approximately 6 in square of the same gage and base metal as the material sampled shall be attached to the center of one edge of the plates before galvanizing. If the result of a weight of coating test for any coupon does not conform to the requirements specified, retests of two additional samples cut from the product plates for the order shall be made, each of which shall conform to the requirements specified.

5. Chemical Analysis and Tests for Spelter Coating

When required, the chemical analysis of the base metal shall be made in accordance with current ASTM Specification, designation E 30.

The test for weight of the spelter coating shall be made in accordance with the hydrochloric acid-antimony chloride method, as described in current ASTM Standard Method A 90.

6. Identification

No plates shall be accepted unless the metal is identified by a stamp on each plate showing:

1. Name of base metal manufacturer.
2. Name of brand and kind of base metal.
3. Gage number.
4. Weight of spelter coating.
5. Identification symbols showing heat and pot numbers.

The identification brands shall be so placed that when the pipe or arch is erected the identification will appear on the inside of the structure.

7. Bolts

Bolts for connecting plates shall be not less than ¾ in. in diameter, of proper length to accommodate the number of plate laps, and the bolts and nuts shall be hot-dip galvanized. The threads shall be American Standard Coarse Thread Series, Class 2, free fit. Bolt and nut materials shall conform to the requirements of the current ASTM Specification, designation A 325.

The bolts may be sampled and tested before erection is commenced or the bolts may be accepted on the manufacturer's certification.

Bolt heads and nuts shall be shaped to provide adequate bearing, or special washers shall be used.

8. Gage Determination and Tolerance

The gage shall be determined by the weight of fabricated galvanized plates. The average weight of any one lot of plates shall not underrun the theoretical weight by more than 5 percent, and no individual plate weighed shall underrun the theoretical weight by more than 10 percent.

9. Field Inspection and Acceptance of Plates

The field inspection shall be made by the engineer. The manufacturer shall furnish an itemized statement of the number and length of the plates in each shipment.

Each plate included in a shipment failing to meet the requirements of these specifications shall be rejected, and if 25 percent of the plates fail to meet the requirements the entire shipment may be rejected.

C. FABRICATION

1. Forming and Punching Plates

Plates shall be formed to provide lap joints. The bolt holes shall be so punched that all plates having like dimensions, curvature, and the same number of bolts per foot of seam, shall be interchangeable. Each plate shall be curved to the proper radius so that the dimensions of the finished structure will be as specified.

Unless otherwise specified, bolt holes along those edges of the plates that will form longitudinal seams in the finished structure shall be staggered in rows 2 in apart, with one row in the valley and one in the crest of the corrugations. Bolt holes along those edges of the plates that will form circumferential seams in the finished structure shall provide for a bolt spacing of not more than 12 in. The minimum distance from center of holes to the edge of the plate shall be 1¾ times the diameter of the bolt. The diameter of the bolt hole in the longitudinal seams shall not exceed the diameter of the bolt by more than ⅛ in.

Plates for forming skewed or sloped ends shall be cut so as to give the angle of skew or slope specified. Flame cut edges shall be free from oxide or burrs and shall present a workmanlike finish. Legible identification numerals shall be placed on each part plate to designate its proper position in the finished structure.

D. DESIGN

1. Minimum Gage of Plates for Structural Plate Pipe

TABLE 2—STRUCTURAL PLATE PIPE, STRUTTED

Maximum Height of Cover in Feet	*Diameter of Pipe in Inches**										
	60	*72*	*84*	*96*	*108*	*120*	*132*	*144*	*156*	*168*	*180*
5	12	12	10	8	8	8	---	---	---	---	---
10	12	12	12	12	10	10	10	8	8	8	8
15	12	12	12	12	10	10	10	10	8	8	8
20	12	12	12	12	10	10	10	10	8	8	8
25	12	12	12	12	10	10	10	8	8	8	8
30	12	12	12	10	10	10	8	8	8	7	5
35	12	12	12	10	10	8	8	7	5	5	3
40	12	12	10	10	8	7	7	5	3	3	1
45	12	10	10	8	7	5	5	3	1	1	---
50	12	10	8	7	5	5	3	1	1	---	---
55	10	8	8	7	5	3	1	1	---	---	---
60	10	8	7	5	3	1	1	---	---	---	---
70	8	7	5	3	1	---	---	---	---	---	---
80	7	5	3	1	---	---	---	---	---	---	---
90	5	3	1	--	---	---	---	---	---	---	---
100	5	1	--	--	---	---	---	---	---	---	---

TABLE 3—STRUCTURAL PLATE PIPE, UNSTRUTTED

Maximum Height of Cover in Feet	*Diameter of Pipe in Inches**										
	60	*72*	*84*	*96*	*108*	*120*	*132*	*144*	*156*	*168*	*180*
5	10	8	7	5	5	3	---	---	---	---	---
10	12	10	10	8	8	7	7	5	5	3	3
15	12	10	10	10	8	8	7	5	5	5	3
20	12	10	10	8	8	7	7	5	5	3	3
25	12	10	10	8	8	7	5	5	3	3	1
30	10	10	8	8	7	5	5	5	3	1	1
35	10	10	8	8	7	5	5	3	3	1	---
40	10	8	8	7	5	5	3	3	1	---	---
45	10	8	8	7	5	3	3	1	1	---	---
50	10	8	7	5	5	3	3	1	---	---	---
55	8	8	7	5	5	3	1	---	---	---	---
60	8	7	5	5	3	1	1	---	---	---	---
70	8	7	5	3	1	---	---	---	---	---	---
80	7	5	3	1	---	---	---	---	---	---	---
90	5	3	1	--	---	---	---	---	---	---	---
100	5	1	--	--	---	---	---	---	---	---	---

*Structural plate pipes of intermediate diameter in increments of 6-in. may be specified.

2. Gage of Bottom Plates for Pipes Subjected to Erosive or Corrosive Conditions

For pipes having a lighter gage than No. 1, the bottom plates shall be specified of heavier gage than shown in Tables 2 or 3.

3. Number of Bolts

Four bolts shall be used per foot of longitudinal seam, except that in No. 1 gage plates six or eight bolts per foot of longitudinal seam may be specified.

4. Headwalls

Headwalls and wings shall be designed in accordance with current AREA Specifications for Concrete and Reinforced Concrete Railroad Bridges and Other Structures. The end plates shall be anchored to the headwalls with not less than ¾-in diameter hook bolts on approximately 19-in centers. Where concrete headwalls are not specified, light gage galvanized interlocking steel sheet piling headwalls, capped with a galvanized channel, may be used.

5. Skewed Structures

Whenever the skew angle exceeds 30 deg for pipes provided with headwalls, the end plates shall be anchored to the headwalls with not less than ¾-in diameter hook bolts on approximately 18-in centers. When the skew angle exceeds 20 deg and the pipe has the ends cut to fit a slope, the ends shall be reinforced with masonry.

6. Length of Pipe

Length of pipe shall be as specified. The 2-in lip beyond each end crest will result in the actual length being approximately 4 in longer than nominal length, except where skewed or beveled.

7. Minimum Height of Cover

The height of cover measured from base of rail to top of pipe shall be not less than half the diameter of the pipe.

8. Construction and Payment

Specification and payment shall be in accordance with Chapter 1 of the AREA Manual.

Report on Assignment 9

Use of High-Strength Structural Bolts in Steel Railway Bridges

A. G. Rankin (chairman, subcommittee), R. C. Baker, F. Baron, J. E. Bernhardt, W. E. Dowling, N. E. Hueni, C. T. G. Looney, E. K. Timby.

Your committee submits, as information, the following report of additional field test installations of high-strength structural bolts. These test installations were made by the research staff of the Engineering Division, AAR, at your request to determine if such bolts will retain their clamping force in structural joints subjected to vibrational loads in a climate where extremely low temperatures occur.

Northern Pacific Railway Company Bridge 78.1, Miles City, Mont.

High-strength bolts were installed in the bridge noted above during November 1950 by the bridge and building forces of the Northern Pacific under the general direction of H. H. West, structural assistant, research staff, Association of American Railroads.

The bolts used in these tests were American Standard, heat treated, semi-finished hexagonal head bolts with American Standard, heavy, semi-finished hexagonal nuts. Two flat, carburized washers, approximately 11/64 in thick were used on each bolt, one under the nut and one under the head of the bolt.

The locations for the bolts were in the floorbeam hanger at the point where it frames into the gusset at the hip joint, as shown in Fig. 1. Two joints were bolted in each span; the floorbeam hangers in both north and south truss at the west end of span 1, and floorbeam hangers in north and south truss at the east end of span 1. The bolts were placed in the inside (trackside) and outside (river side) of each hanger. Bolts were placed only in that portion of the joint where the hanger was riveted to the gusset plate and not in the part which frames into the top chord or end post.

Rivets were removed by burning off the head and driving out the shank with a punch. To insure that there was no slippage in the joint and to keep the members of the joint more rigid only three or four rivets were removed at a time and replaced with bolts. After the rivets were removed all joint and burning scale was cleaned from the area around the holes.

After all bolts were in the joint a ratchet wrench was used to tighten them to a torque slightly below that required. A torque wrench was then used to tighten the bolts further to the desired torque of 470 ft lb. Each bolt was then checked again with the torque wrench to be sure that it was at this prescribed torque and that the last bolts tightened had not relieved the first of any of their tension.

The 470 ft-lb torque will produce a unit stress of approximately 72,000 psi, which is 85 percent of the elastic proof load of the bolt. At 72,000 psi stress a resulting clamping force of 32,300 lb is attained by the bolt.

An attempt was made to burn out the shank of one rivet in the outside of the hanger on the south truss of span 2. In doing this a hole was cut through the gusset plate alongside the rivet hole. This hole was in the shape of a semicircle approximately ¼ in. in radius. To correct this situation and prevent the washer from deflecting into the hole, relieving the bolt tension, an extra washer was used on the bolt.

Elastic Stop Nuts were used on two bolts in the inside of the hanger on the north truss of span 2. These were used in the test to secure data on the performance of lock nuts.

The bolts, nuts and surrounding steel were painted with black bridge paint to protect them from rust and to facilitate inspections at a later date.

Great Northern Railway Bridge 10, Lurgan, N. D.; Bridge 23.3, Rogers, Minn.

High-strength bolts were installed in these two bridges during November 1950, by the steel bridge forces of the Great Northern Railway under the general direction of A. H. Bueger, structural engineer, Great Northern, and H. H. West, structural assistant, Association of American Railroads.

Bolts used in this test were American Standard, heat treated, hexagonal head, semi-finished with American Standard, heavy, semi-finished nuts. Flat, carburized washers, approximately 11/64 in thick were used under the head of the bolt and the nut.

The location of the bolts, as shown in Fig. 2, were in the floorbeam hangers at the connection of the hanger to the top chord and gusset at the hip joint U_1 and U_3. At bridge 10, Lurgan, N. D., the inside and outside of the joint U_1 were bolted and the outside only at joint U_3, both joints being on the north truss. At bridge 23.3, Rogers, Minn., the hip joint U_1 on the east end of both north and south trusses, and joint U_3 of the north truss were bolted. Both inside and outside of the hangers at the hip joints were bolted and the outside only at joint U_3.

Rivets were removed by burning off the head with an acetylene torch and driving out the shank with a punch. To insure that there would be no slippage in the joint and that the joint would remain rigid only three or four rivets were removed a time. The

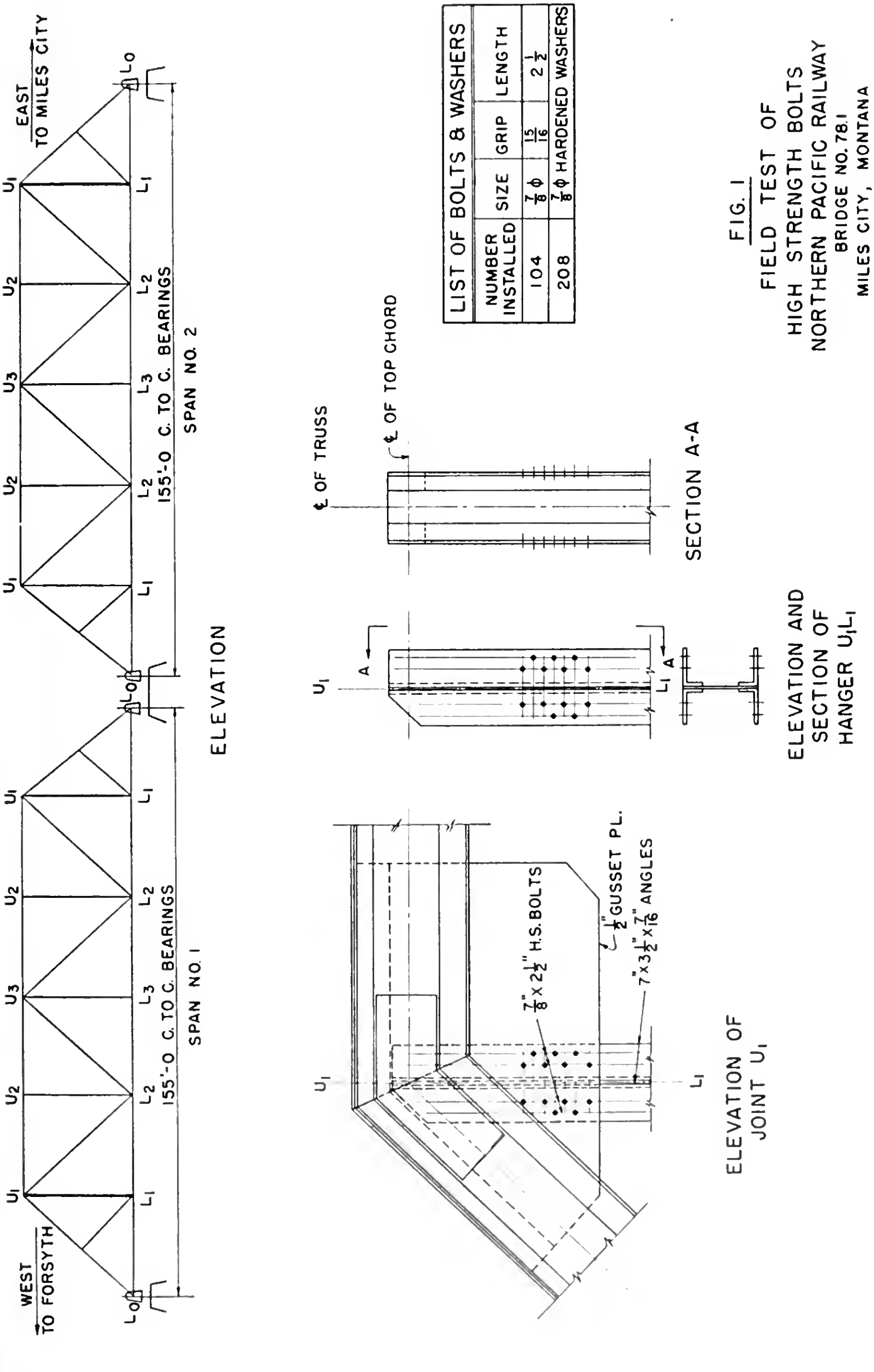
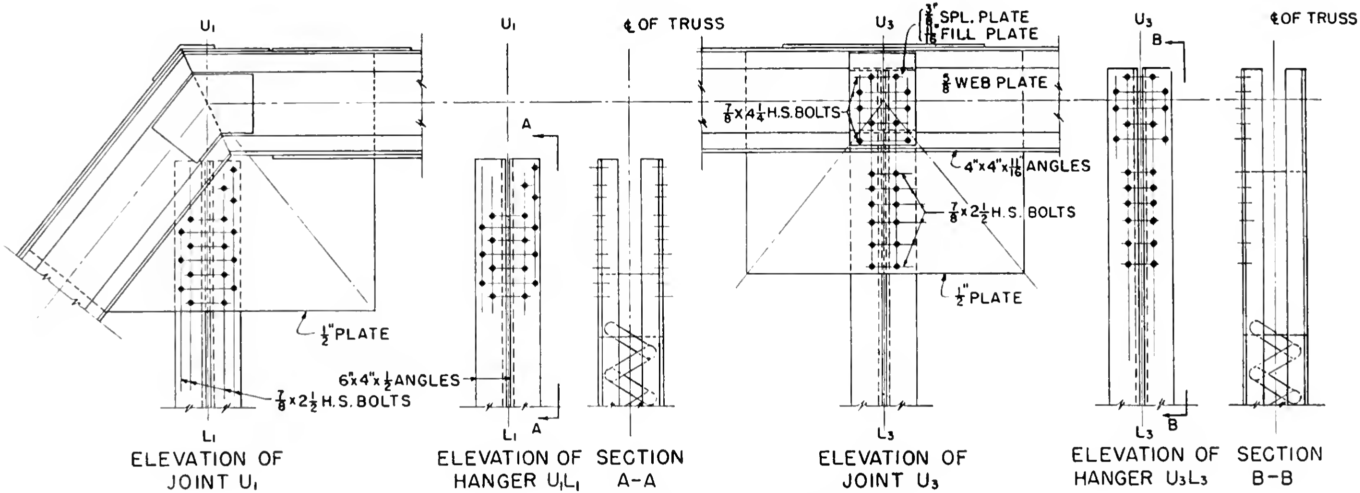
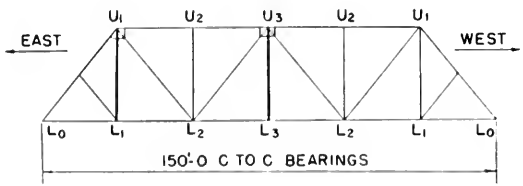


FIG. 1
FIELD TEST OF
HIGH STRENGTH BOLTS
NORTHERN PACIFIC RAILWAY
BRIDGE NO. 78.1
MILES CITY, MONTANA





BRIDGE NO. 10.0 LURGAN, N. DAK.

LIST OF BOLTS & WASHERS			
NUMBER INSTALLED	SIZE	GRIP	LENGTH
46	$\frac{7}{8}\phi$	1	$2\frac{1}{2}$
10	$\frac{7}{8}\phi$	$2\frac{11}{16}$	$4\frac{1}{4}$
112	$\frac{7}{8}$ HARDENED WASHERS		

BRIDGE NO. 23.3 ROGERS, MINN.

LIST OF BOLTS & WASHERS			
NUMBER INSTALLED	SIZE	GRIP	LENGTH
80	$\frac{7}{8}\phi$	1	$2\frac{1}{2}$
10	$\frac{7}{8}\phi$	$2\frac{11}{16}$	$4\frac{1}{4}$
180	$\frac{7}{8}$ HARDENED WASHERS		

NOTE: BRIDGE NO. 10.0 LURGAN, N. DAKOTA BOLTS INSTALLED IN FLOORBEAM HANGERS AT U_1 AND U_3 OF NORTH TRUSS ONLY.

BRIDGE NO. 23.3 ROGERS, MINNESOTA BOLTS INSTALLED IN FLOORBEAM HANGERS AT U_1 IN NORTH AND SOUTH TRUSS AND U_3 IN NORTH TRUSS ONLY.

FIG. 2

FIELD TEST OF
HIGH STRENGTH BOLTS
GREAT NORTHERN RAILWAY
BRIDGE NO. 10.0 LURGAN, NORTH DAKOTA
BRIDGE NO. 23.3 ROGERS, MINNESOTA

surfaces adjacent to the holes were all cleaned of paint and scale from burning to provide smooth even bearing surfaces for the washers.

After the bolts were all in the joint they were tightened with a ratchet wrench to a torque slightly below that desired. The bolts were each tightened with the torque wrench to 470 ft-lb torque. All bolts were then gone over a second time with the torque wrench to insure that they were at this torque and that none of them had been relieved of any tension due to tightening subsequent bolts.

The 470 ft-lb torque produces a unit stress in the bolt of 72,000 psi, which is 85 percent of the elastic proof load of the bolt. At 72,000 psi a clamping force of 32,300 lb is attained by the bolt.

At joint U_3 in bridge 10, Lurgan, N. D., the holes were not perpendicular to the surfaces. This condition was of sufficient magnitude that when the nut was turned on far enough that one edge touched the washer, the opposite edge of the nut was between ⅛ and 3/32 in away from the washer. As the bolt was tightened the bolt bent enough to allow the bearing surfaces of the head and the nut to come into contact with the washers. One of these bolts was removed for inspection and the permanent bending was noticeable. Also, the threads under the nut had been deformed considerably.

In the inside of joint U_1 North truss of bridge 23.3, Rogers, Minn., the same condition existed as mentioned in the previous paragraph, but not as bad, inasmuch as the grip was not as great. When these bolts were tightened there was a loud rasping or clattering noise and the action of the nut turning was jumpy rather than a smooth motion. It was thought that this was due to the poor distribution of load on the threads and that the threads were yielding rather than the bolt bending, as was the case in the bolts with a longer grip.

The bolts, nuts, and adjacent steel were painted with black bridge paint to protect them from rust and to facilitate inspections at a later date.

The test installations reported above and those previously reported in AREA Proceedings, Vol. 51, 1950, page 506, together with the dates of each inspection, are summarized in Table 1.

Comments on recent inspections of all the test installations are contained in the following.

Pennsylvania Railroad, Ohio & Western Pennsylvania Dock Company, Ashtabula, Ohio

The high-strength bolts in the ore bridge of the Ohio & Western Pennsylvania Dock Company, were inspected on Aug. 15, 1951.

The bolts in this structure were used to connect stringers to a plate at the panel point and to connect gusset plates to the posts.

Approximately half of the bolts were checked with a torque wrench and none turned when a torque of 470 ft-lb was applied. There is no evidence of these connections coming loose in any way.

At the stringer connection one of the angles has developed a crack since the last inspection. Maintenance forces have welded the angle and also welded small triangular shaped plates to the angles to reinforce them. These small plates were placed between some of the bolts and prevent the bolts from being tightened in the future.

Pennsylvania Railroad, Ohio & Western Pennsylvania Dock Company, Cleveland, Ohio

The high-strength bolts in the ore unloaders of the Ohio & Western Pennsylvania Dock Company, were inspected on Aug. 15, 1951.

TABLE I

TEST INSTALLATIONS

HIGH STRENGTH BOLTS

Railroad	Bridge No.	Location	No. of Bolts	Diam.	Date Installed	Date Inspected
Penn.	Runway Ore Dock	Ashtabula, O.	24 7	7/8" 3/4"	*Mar. 48	May 48, Dec. 48 Sept. 49, Aug. 51
"	"	Cleveland, O.	39	7/8"	*Mar. 48	May 48, Dec. 48 Sept. 49, Aug. 51
"	21.98	Bellevue, Del.	93	3/4"	*Oct. 48	Sept. 49, Aug. 51
"	60.07	Perryville, Md.	32	1"	*Oct. 48	Sept. 49
"	18.58	Naaman, Del.	35	3/4"	*Oct. 48	Sept. 49, Aug. 51
C.B. & Q.	307.32	Albia, Iowa	46	7/8"	*Sept. 48	Sept. 49, Aug. 51
"	284.12	Ottumwa, Ia.	88 30	7/8" 3/4"	*Sept. 48	Sept. 49, Aug. 51
C. & N.W.	711	Beaver, Iowa	30	7/8"	*Nov. 48	Sept. 49, Aug. 51
C.M.St.P.&P	2312	Byron, Ill.	231	7/8"	*Nov. 48	Sept. 49, Oct. 50 Aug. 51
N. Y. C.	73.63	Ade, Ind.	26	7/8"	*Oct. 48	Sept. 49, Aug. 51
Santa Fe	121A	Wilbern, Ill.	64	7/8"	*Aug. 48	April 49, Sept. 49 Aug. 51
Southern	151.4	Mt. Carmel, Ill.	320	7/8"	*Oct. 48	Sept. 49, Oct. 51
No. Pacific	78.1	Miles City, Mont.	104	7/8"	Nov. 50	Sept. 51
Gt. Northern	10.0	Lurgan, No. Dak.	56	7/8"	Nov. 50	Sept. 51
"	23.3	Rogers, Minn.	90	7/8"	Nov. 50	Sept. 51

* Installations reported in A R E A Proceedings Vol 51, 1950 page 506

The bolts in the Hulett ore unloader were used to fasten the crane rail to the top flange of the girder and in the lateral bracing system of the leg braces.

Approximately 35 percent of the bolts were checked with a torque wrench during this inspection. The bolts in the lateral system of the leg brace have not lost their tension. Several of the bolts in the crane rail girder were loose, and some have dropped out completely. The loose bolts are those that are adjacent to the rail joints and, as was noted during previous inspections, these rail joints are very loose, subjecting the bolts to additional stress.

During Dec. 1950, 30 more bolts were placed in the crane rail girder, of which half of them were tightened with a torque of 470 ft-lb, and the other half with a torque of 600 ft-lb. The 600-ft-lb torque will result in the tension being at or slightly above the yield point of the bolt. This was done to find out if it would be satisfactory to use bolts near or above the elastic limit.

The bolts that are described in the previous paragraph were checked with the torque wrench and the results were similar to those found in the other bolts. The bolts near the rail joint have lost some of their tension, while those farther away are still tight. It was noted, however, that the bolts tightened to 600 ft-lb torque were proportionally higher than those that had originally been subjected to 470-ft-lb torque.

During the winter of 1950–1951 the maintenance forces of the dock company completely bolted all four crane rails on the four unloaders at this dock. To eliminate the trouble at the rail joints the dock company engineers and the railroad engineers are discussing the possibility of welding the rails to provide continuous rails on these machines.

Pennsylvania Railroad, Bridge 21.98, Bellevue, Del.

The high-strength bolts in Pennsylvania Railroad bridge 21.98, Bellevue, Dela., were inspected Aug. 30, 1951.

This bridge consisted of beam spans, the beams being connected to each other by diaphragms. The diaphragm consists of either channels bolted or riveted to the web of the beam or channels fastened to angles which are fastened to the web of the beam. High-strength bolts were used to fasten channels to angles, channels to web of beam, and angles to web of beam.

Approximately 35 percent of the bolts were checked with a torque wrench and none was found that turned at a torque less than 295 ft-lb, which was the torque used to tighten them at the time of their installation.

The remaining bolts were examined and none was found which seemed loose. One bolt was missing from a hole that had been enlarged considerably at the time the rivet was burned out. At the time the bolts were put in service two washers were placed under the nut and head of the bolt to compensate for the enlarged holes. Of the six bolts which were treated this way, this is the only one which had failed, the others have not lost their tension.

In this test only the loose rivets were replaced in some connections, and in others all rivets were removed. There are now many more loose rivets and some of the connections which were not bolted have rust at edges of angles, indicating slippage.

Pennsylvania Railroad, Bridge 18.58, Naaman, Del.

The high-strength bolts in Pennsylvania Railroad bridge 18.58, at Naaman, Dela., were inspected on Aug. 30, 1951.

This structure consists of beam spans, the beams being connected by diaphragms which are made up of angles and channels or channels alone. The bolts were used to connect the channels to the web of the beams or to connect angles to the web of the beams. Beveled washers were used to compensate for the slope of the channels.

Approximately half of the bolts were checked with a torque wrench to determine how much of their tension they have retained. No bolts were found which tightened at a torque of 295 ft-lb, which was the torque used when they were installed. On several bolts the torque was increased to determine when they would start tightening. The results of this were that 2 bolts started tightening at 300 ft-lb, 6 at 390 ft-lb, and 2 at 420 ft-lb.

One bolt had broken and fallen out of a section where an angle and channel were bolted to the web of a beam. It is possible that the beveled washers may have been used improperly, increasing the bending in the bolt, rather than eliminating, it as they are designed to do.

There was no evidence that the bolted joints were loose; however, numerous loose rivets were noted and several of the riveted joints were definitely loose.

New York Central System, Bridge 73.63, Ade, Ind.

The high-strength bolts in the New York Central bridge 73.63, Ade, Ind., were inspected Sept. 28, 1951.

This bridge is a through girder span with three skewed girders carrying two tracks. The high-strength bolts were used to fasten knee braces to web stiffeners on the center girder.

All of the bolts were checked with a torque wrench and only one was found which turned when subjected to a torque of 470 ft-lb. This bolt started turning when a torque of 390 ft-lb was applied and could only be tightened to a torque of 420 ft-lb as there was not sufficient clearance for the wrench.

AT&SF Railway System, Bridge 121A, Wilbern, Ill.

The high-strength bolts in the Santa Fe bridge 121 A at Wilbern, Ill., were inspected on Aug. 6, 1951.

In this beam span bolts were used to connect the diaphragm plates to angles, which are in turn riveted to the webs of the beams. None of the bolts appeared to be loose and the paint around the bolts showed no cracks or rust that would indicate the bolts or connections had slipped any. Along the edges of the angles where they were riveted to the beam webs new rust is showing on the lower third of the angle, indicating that there is some movement or slippage of the riveted connection.

The bolts at one diaphragm were checked with a torque wrench and none would tighten when a torque of 470 ft-lb was applied.

In this structure of four spans, one span is bolted with high-strength bolts, one is bolted with fitting-up bolts, and the other two are riveted. In a general inspection of the other three spans, no loose rivets or bolts were found in the locations comparable to that where the high-strength bolts were used. In these three spans the rust was found between the diaphragm angles and the web of the beams as it was in the span bolted with high-strength bolts.

Chicago, Burlington and Quincy Railroad, Bridge 284.12, Ottumwa, Iowa

The high-strength bolts in the Chicago, Burlington and Quincy Railroad bridge 284.12, Ottumwa, Iowa, were inspected on Aug. 7, 1951.

The bridge consists of girder spans and truss spans. The bolts were used in the bottom lateral bracing on the girder span and at several locations on one of truss spans. These locations on the truss span consisted of cross frames between stringers, stringer connections to floorbeams, stringer lateral bracing, and bottom lateral bracing at the chord, point of intersection, and the intersection of lateral bracing with stringers.

Approximately 80 percent of the bolts were checked with a torque wrench and only in the stringer connections to the floorbeams were any bolts found that would turn when a torque of 470 ft-lb was applied. At these stringer connections the bolts on the outside of the stringers had been checked and retightened at the first inspection in 1949, but the bolts on the inside had not been checked. The bolts on the outside of the stringers had tightened at an average of 360 to 400-ft-lb torque during the first inspection, but at this inspection they had not lost any of their tension and did not tighten further when subjected to a torque of 470 ft-lb. The bolts on the inside of the stringers which were checked at this second inspection showed the same results as those on the outside did at the first inspection; that is, they tightened at approximately 360 to 400-ft-lb torque. It is interesting to note that the loss of tension was not progressive with time; that is, the loss of tension was no more after three years of service than after one year.

In one of the stringer connections a bolt was used to replace a missing rivet that was not a part of the planned installation. This bolt had broken and fallen out since the last inspection in September 1949. At the time this bolt was put in the rivets on either side were inspected and seemed to be tight; however, now two rivets on either side of the bolt are definitely loose and others were questionable.

All of the bolts in the bottom laterals of the girder span were checked with the torque wrench and none would tighten when subjected to the 470-ft-lb torque.

Chicago, Burlington and Quincy Railroad, Bridge 307.32, Albia, Iowa

The high-strength bolts in the Chicago, Burlington and Quincy Railroad bridge 307.32, Albia, Iowa, were inspected Aug. 7, 1951.

This bridge is a through girder bridge and the bolts were placed in the stringer connections to the floorbeam and bottom diagonals at the lateral plate and at their point of intersection.

All of the bolts in the test were checked with a torque wrench and none was found that would tighten under a torque of 470 ft-lb. A few of the bolts were subjected to torques slightly higher, 500 to 530 ft-lb, and even at this torque only about half of the bolts would tighten further.

The position of the nut with respect to the bolt was marked on two bolts and then the nut was backed off a full turn. A torque of 450 ft-lb was required to loosen the nut and a torque of 470 ft-lb brought the nut and bolt back into their same respective positions. This would indicate that the bolt had not been stressed beyond its yield point and that the clamping force indicated by the 470-ft-lb torque had been maintained.

Chicago and North Western Railroad, Bridge 711, Beaver, Iowa

The high-strength bolts in the Chicago and North Western Railroad bridge 711, Beaver, Iowa, were inspected on Aug. 8, 1951.

This bridge consists of two deck plate girders and the high-strength bolts were used to fasten the cross frame gusset plates to the web stiffeners, three bolts being used for each gusset.

All of the bolts were checked with a torque wrench and only one bolt turned when a torque of 470 ft-lb was applied.

When this structure was inspected two years previous it was found that one or two bolts at each point would start tightening at a low torque and the remaining bolt was tight. It was thought at the time that this was caused by the fact that the bolts were not tightened evenly and that the last bolt tightened relieved the tension in the first bolts tightened. During this first inspection all of the bolts were retightened to the 470-ft-lb torque and this seems to have corrected the situation.

CMStP&P Railroad Bridge Z312, Byron, Ill.

The high-strength bolts installed in the CMStP&P RR bridge Z312, Byron, Ill., were inspected Aug. 10, 1951.

This bridge consists of five through truss spans. The majority of the bolts are used to fasten lug angles supporting bottom lateral bracing to the stringers. Others are used in the top lateral system and in connecting bottom laterals to plates at the bottom chord. The bolts in two spans of this structure were tightened originally with a torque wrench and in the other three spans with a pneumatic impact wrench.

Approximately 20 percent of the bolts were checked with a torque wrench at this inspection. Half of these bolts had been retightened at previous inspections and the other half were bolts which had been undisturbed since their installation. The bolts that had been checked previously had retained their tension and would not tighten further when a torque of 470 ft-lb was applied. The bolts that were checked with the torque wrench for the first time at this inspection showed the same results as were found in previous inspections at this bridge, namely, that the nut started turning on the bolt when a torque 15–20 percent below the design torque was applied. This follows the same pattern that has been found in other tests, that is, the bolts that have lost some tension do not lose it again after being retightened.

Four bolts were found in this test which tightened at very low torques—120–180. In each of these cases it was found that the angle had been deformed when backing out the rivet and that the faying surfaces had not been brought into contact with each other when the bolt was tightened. It is interesting to note that this situation has not been found in bridges that were tightened with hand wrenches, but only in this one structure where the bolts were tightened with an impact wrench. When the bolts were tightened to a torque of 470 ft-lb the faying surfaces were brought together. Three bolts were found at a previous inspection similar to those just described and they, too, were tightened to a torque of 470 ft-lb by hand wrenching. Upon being rechecked at this time they had retained their tension. This would seem to indicate that if power wrenches are used in bolting, a good inspection will be necessary to ascertain the condition of the members to be bolted and whether the bolt has actually drawn the members together.

One thing of interest is the fact that in the bolts which had lost tension so that they tightened when a torque of 120–180 ft-lb was applied, there was still no apparent indication that they were loose, and their looseness could not have been detected by a visual examination. The nuts had not backed off the bolt, even though the lug angles are subject to considerable vibration and have a history of working rivets loose.

Southern Railway System, Bridge 151.4, Mt. Carmel, Ill.

The high-strength bolts in the Southern Railway's bridge 151.4, Mt. Carmel, Ill., were inspected Oct. 1, 1951.

This bridge consists of five through truss spans and a draw span. The high-strength bolts were used to fasten reinforcing plates on the floorbeam hanger at the point where they frame into the pin plates at the top chord. The railroad has had one failure in a floorbeam hanger at this point and repaired it by welding. When the weld failed the railroad decided to reinforce the point, and in so doing moved the point of the stress raiser to a new location.

The bolts in 5 of the 20 bolted hangers were checked with a torque wrench to determine if they had lost their tension. One bolt of 62 so checked tightened when a torque of 440 ft-lb was applied; the remaining bolts did not tighten further when subjected to 470-ft-lb torque.

Six Elastic stop nuts were put on bolts in place of the standard nuts to compare them with the standard nut in a service application. These nuts were tightened to 470-ft-lb torque the same as the standard nuts.

All other hangers in the bridge were inspected and no evidence of loose bolts or distress in the bolts could be found.

Northern Pacific Railroad, Bridge 78.1, Miles City, Mont.

The high-strength bolts installed on the Northern Pacific Railway bridge No. 78.1 at Miles City, Mont., were inspected Sept. 11, 1951.

This bridge is a two-span through truss bridge, carrying a single track. The bolts were placed in floorbeam hangers at the upper chord gusset plates at one end of each span. This bridge was selected as it was desired to test bolts in a location where they were subject to severe cold weather conditions.

During this inspection, one-third of the bolts were checked and one-fourth of the bolts would not tighten when a torque of 470 ft-lb was applied. Of 43 bolts checked, the number of bolts and the torque at which they tightened are as follows: 1 at 270 ft-lb; 3 at 360 ft-lb; 4 at 390 ft-lb; 16 at 420 ft-lb; 9 at 450 ft-lb; 3 at 470 ft-lb. The nuts on the remaining bolts did not turn at the applied torque of 470 ft-lb.

Of interest to note was the fact that the majority of the bolts which had lost tension were on the inside or track side of the hanger.

In this test, two Elastic Stop Nuts were used in place of the standard nut. These were checked with a torque wrench and found to tighten at a torque of 420 ft-lb.

The other hangers were inspected and no evidence of failure or distress in any bolt or connection could be found.

Great Northern Railway, Bridge 10.0, Lurgan, N. D.

The high-strength bolts in the Great Northern Railway bridge 10.0, Lurgan, N. D., were inspected on Sept. 13, 1951.

This bridge is a single-span through truss carrying a single track. The bolts are located in one end floorbeam hanger and one center floorbeam hanger of one truss at the upper chord gusset plate.

These bolts were installed in Nov. 1950, and this location was chosen to give high-strength bolts a service test in locations where they would be subjected to a severe cold climate.

Of the 56 bolts in service in the structure, 33 were checked with a torque wrench to determine whether they had lost tension. The number of bolts and the torque at which these bolts started tightening are as follows: 1 at 270 ft-lb; 1 at 300 ft-lb; 8 at 330 ft-lb; 3 at 360 ft-lb; 6 at 390 ft-lb; 5 at 420 ft-lb; 4 at 450 ft-lb; and 5 which did not turn at 470 ft-lb. The end floorbeam hanger has bolts on both the inside and outside of the member. It is interesting to note that the 5 bolts which did not tighten under a torque of 470 ft-lb are all on the outside of this member. The other 2 bolts which were checked at this point turned at 450 ft-lb. The inside of the same member did not have a bolt that did not tighten at less than the 470 ft-lb, the range being from 300 to 420 ft-lb.

The outside only of the center floorbeam was bolted, and at this point the results were similar to the inside of the end floorbeam, the torques at which the bolts started tightening varying from 270 to 450 ft-lb.

It is assumed that the bolts which were not tightened at this inspection will fall into the same pattern as those that were checked; therefore, they were left undisturbed to see if there is any progressive loss of tension. Part of the undisturbed bolts will be checked at a later inspection.

All bolts that were checked with the torque wrench were tightened to the 470-ft-lb torque.

Great Northern Railway, Bridge 23.3, Rogers, Minn.

The high-strength bolts in the Great Northern Railway bridge 23.3, Rogers, Minn., were inspected on Sept. 14, 1951.

This bridge is a single span through truss span. The high-strength bolts were placed in an end floorbeam hanger and center floorbeam hangers on one truss and the end floorbeam hanger on the other truss. The bolts were used to frame the floorbeam hangers into the gusset plates at the top chord. This bridge was selected as a test structure for the bolts because it was desired to have service applications of high-strength bolts in structures subjected to severe cold climates.

Of 90 bolts in service in this bridge 46 were checked with a torque wrench to determine if they had lost any of their tension. All of the bolts at one end floorbeam hanger were checked, and half of the bolts at the center floorbeam hanger. Of the bolts checked, one bolt started tightening at 360-ft-lb torque, 4 at 420 ft-lb, 2 at 450 ft-lb, and 7 at 470 ft-lb. The remaining 32 bolts checked did not tighten further when the 470-ft-lb torque was applied.

No appreciable difference could be seen in the bolts on the inside of the hanger and those on the outside.

It is interesting to compare the bolts in this structure with those in bridge 10.0 at Lurgan, N. D. The two bridges are identical in all details, were erected in the same year, subject to similar climatic conditions, and carry the same rail traffic. The bolts in the structures were put in under the same conditions by the same workmen, and yet in bridge 10.0 approximately 75 percent of the bolts have lost an average of 30 percent of their tension, while in this bridge 15 percent of the bolts have lost only about 10 percent of their tension.

As a result of the superior behavior of the high-strength bolts over that of rivets during a period of over four years, it is recommended that the Specifications for Assembly of Structural Joints Using High-Tensile Steel Bolts in Steel Railway Bridges, which were presented as information in AREA Proceedings, Vol. 53, 1952, page 607, be published in the Manual with the following revisions:

In Sec. B. Art. 2, Par. (a), delete the words "except the radius of fillet under the bolt head shall not be less than $\frac{1}{64}$ in for size $\frac{5}{8}$ in and under, $\frac{1}{32}$ in for size over $\frac{5}{8}$ to 1 in, incl., and 3/64 in for size over 1 in.

Change Sec. C. Art. 3, to read as follows:

a. The faying surfaces, when assembled, shall be bare, either descaled or carrying the normal mill scale. Faying surfaces shall be free of paint, lacquer, dirt, oil, scale, burrs, pits and other defects that would prevent solid seating of the parts or would interfere with the development of friction between the parts.

Change Sec. D, Art. 1, (b) to read as follows:

b. All nuts shall be tightened to give not less than the bolt tension values given in Table 3.

Report of Committee 7—Wood Bridges and Trestles

C. H. Newlin, *Chairman,*
W. L. Anderson
J. C. Boston
W. W. Boyer
T. J. Boyle
T. P. Burgess
F. H. Cramer
E. F. Croxson
E. M. Cummings
B. E. Daniels
J. P. Dunnagan
P. R. Eastes
S. L. Goldberg
E. L. Haberle
Nelson Handsaker
F. J. Hanrahan
R. P. Hart
M. W. Jackson
J. C. Jacobs
R. E. Jacobus
Milton Jarrell
C. S. Johnson
C. S. Johnson, Jr.
R. P. A. Johnson
J. V. Johnston
W. D. Keeney
J. R. Kelly
H. J. Kerstetter
J. C. Korte
A. L. Leach
C. V. Lund
W. B. Mackenzie
F. W. Madison
L. J. Markwardt
T. K. May
P. L. Montgomery
J. M. Montz
W. C. Howe, *Vice Chairman,*
W. H. O'Brien
W. A. Oliver
C. A. Peebles, Jr.
W. L. Peoples*
H. S. Rimmington
W. C. Schakel
A. H. Schmidt
F. E. Schneider
B. J. Shadrake
J. R. Showalter
Josef Sorkin
R. L. Stevens
F. L. Thompson
L. W. Watson
A. M. Westenhoff
W. C. Wilder
Committee

* Died November 7, 1952.

To the American Railway Engineering Association:

Your committee reports on the following subjects:

1. Revision of Manual.

   Progress report, including recommended revisions .... page 942

2. Grading rules and classification of lumber for railway uses; specifications for structural timber, collaborating with other organizations interested.

   Progress report, including recommended Manual revisions .... page 960

3. Specifications for design of wood bridges and trestles.

   No report.

4. Methods of fireproofing wood bridges and trestles, including fire-retardant paints, collaborating with Committee 17.

   Progress report, including recommended Manual revisions .... page 962

5. Specifications for structural glued laminated lumber, collaborating with Committee 6.

   No report.

6. Design of timber pile dolphins.

   Final Report. The committee requests that the report published in the Proceedings, Vol. 53, 1952, pages 635 to 645, incl., be received as the final report on this assignment .... page 963

A

7. Means of conserving labor and materials, including the adaptation of substitute noncritical materials, and specifications for the reclamation of released materials, tools and equipment, collaborating with Committee 3–A, General Reclamation, Purchases and Stores Division, AAR.

   Progress report, submitted as information .... page 963

THE COMMITTEE ON WOOD BRIDGES AND TRESTLES,
C. H. NEWLIN, *Chairman*.

AREA Bulletin 506, January 1953.

Report on Assignment 1

Revision of Manual

C. V. Lund (chairman, subcommittee), W. W. Boyer, F. H. Cramer, B. E. Daniels, P. R. Eastes, Nelson Handsaker, R. P. Hart, J. C. Jacobs, J. V. Johnston, H. J. Kerstetter, F. W. Madison, W. B. Mackenzie, W. A. Oliver, W. L. Peoples, W. C. Schakel, B. J. Shadrake, J. R. Showalter, L. W. Watson, A. M. Westenhoff.

Your committee offers the following recommendations with respect to the Manual for adoption:

Pages 7–1 to 7–4, incl.

SPECIFICATIONS FOR WOOD PILES

Delete the entire present text under this title and substitute the specification presented with this report as Appendix A.

Pages 7–5 and 7–6

SPECIFICATIONS AND DESIGN OF FASTENINGS FOR TIMBER TRESTLES MATERIAL

Reapprove with the following revision:

Delete the word "Material" from the title, as now printed. Insert section heading A. Material, directly above Arts. 1 to 5, incl.

Revise Art. 5. Cast Steel, to read:

Cast steel shall conform to current ASTM Specifications, designation A 27, Grade 65–35, full annealed with minimum yield point of 33,000 psi.

Revise Art. 6. Nails, Spikes and Drift Pins, as follows:

Change the term "drift pins" in the heading and in the first sentence to read "drift bolts".

Pages 7–7 to 7–9, incl.

SPECIFICATIONS FOR WORKMANSHIP FOR PILE AND FRAMED TRESTLES OF UNTREATED MATERIAL TO BE BUILT UNDER CONTRACT

Delete the entire present text under this title and substitute the specification presented with this report as Appendix B, including revision to the title.

Pages 7–51 to 7–52.3, incl.

SPECIFICATIONS FOR DRIVING WOOD PILES

Reapprove with the following revisions:

(7–51) Revise Art. 1. Scope, to read:

This specification covers the driving of wood piles in trestles, foundations, and for protection work. (See Note 1).

(7–51) Revise Art. 2. Tests, to read:

In the absence of other reliable information to determine pile lengths, a thorough exploration shall be made at the site by borings, driving test piles, or by pile loading tests, prior to the selection of the length of piles for the work, and to determine characteristics incident to pile resistance and penetration.

(7–51) Revise Art. 3. Materials, as follows:

Add the following to the present sentence:

under the subject title Specifications for Wood Piles.

(7–51 and 7–52) Revise Art. 5. Selection and Preparation of Piles, as follows:

(a) Size

Add the following paragraph:

It is presumed that piles will be furnished in approximately the lengths required to secure the desired penetration and bearing. In the event piles are found to be much in excess of the required lengths, they shall be shortened at the small end before driving, as may be directed by the engineer, in order to preserve the desired diameter of pile at the cut-off.

(b) Pointing

Revise to read:

Under ordinary conditions points of piles shall be cut perpendicular to the axis of the pile; where necessary or desirable, points may be trimmed to form a truncated pyramid 4 to 6 in square at the end and with length of trimming not to exceed twice the tip diameter of the pile.

(c) Pile Shoes

Add the following sentence:

Each pile point shall be carefully trimmed to fit the shoe and obtain full and uniform bearing, and to avoid displacement of the shoe or damage to the pile or shoe.

(d) Collars

Revise to read:

Where the heads of piles tend to split when being driven, the heads shall be tightly wrapped with a band of No. 12 gage annealed iron wire not less than 2 in. in width, held in place with staples, or shall be protected with strap-iron bands applied with a banding tool, or other effective means shall be used to prevent splitting.

(e) Driving Cap

Revise to read:

The heads of piles shall be protected while being driven with a driving cap (bonnet) of approved design. The cap shall be shaped to fit over the head of the pile to provide lateral support, and to uniformly distribute the hammer blow. Pile heads shall be trimmed to fit snugly into the cap.

(7–52) Revise Art. 6. Types of Hammers, as follows:

Add the following to the second paragraph:

(See Note 2)

(7–52 and 7–52.1) Revise Art. 7. Driving, as follows:

(a) Leads

Add the following sentence:

Inclined leads shall be used to drive batter piles.

(h) Bearing Capacity

Revise the wording of the first paragraph to read:

Where possible, test piles shall be driven and loading tests made before construction is started, as referred to under Art. 2. In the absence of such data, the following "Engineering News" formulas may be used to estimate the approximate safe bearing capacity of piles in most soils:

Add the following sentence to the second paragraph:

The formulas should not be applied to friction piles driven into such soils as silt, muck, peat, or plastic clays, nor to piles which act as end-bearing piles.

(7–52.2) Revise Art. 8. Framing, as follows:

(b) Treatment

Delete the last sentence.

(7–52.3) Add the following items to the present text:

11. Pile Record

An accurate record shall be kept of all piles, as each is driven, to show the location in the structure, size of pile, penetration, resistance to driving, and other essential data. A suggested form for reporting this information is appended to this specification.

Note 1—For the driving of concrete piles and steel piles, and for information on loading tests, see Pile Foundations, Chapter 8, Masonry.

Note 2—For a discussion of the proper relationship of weight of ram to weight of pile, and net effective energy of blow, in selecting pile driving hammers, reference is made to Vol. 37, 1936, AREA Proceedings.

Pages 7–55 to 7–59, incl.

ECONOMICS

Pages EBT–1 to EBT–4, incl.

ECONOMICS OF BRIDGES AND TRESTLES

In connection with its review of the material on Economics, pages 7–55 to 7–59, incl., in Chapter 7, including Figs. 712 and 713, and the tables, Committee 7 was instructed by the Board of Direction to review at the same time the material on Economics of Filling Bridge Openings on pages 1–36.1 to 1–40, incl., in Chapter 1, and all of the material in the Chapter on Economics of Bridges and Trestles, collaborating with Committees 1, 8 and 15, looking to the consolidation, in Chapter 7, of all of the Manual material relating to economics as applied to bridges and trestles.

The committee has made such review and now recommends the deletion of the material on "Economics", pages 7–55 to 7–59, incl., of Chapter 7, including Figs. 712 and 713, and accompanying tables, and the entire chapter on Economics of Bridges and Trestles. Committee 1—Roadway and Ballast, is recommending in its current report the withdrawal of the material on Economics of Filling Bridge Openings, pages 1–36.1 to 1–40, incl., Chapter 1.

In substitution for all of this material to be withdrawn, your committee recommends the adoption of the material entitled "Economic Comparisons—Methods of Analysis," presented in Appendix C.

Pages 7–61 and 7–62

ECONOMY CURVES

Delete this material, including Fig. 714.

Page 7–64

COMPARATIVE MERITS OF CREOSOTED WOOD BALLASTED DECK AND REINFORCED CONCRETE BALLASTED DECK TRESTLES

Delete this material.

For further recommendations respecting Manual material, see reports on Assignments 2 and 4.

Appendix A

SPECIFICATION FOR WOOD PILES

1953

A. GENERAL PROVISIONS

1. Scope

This specification covers wood piles to be used either untreated or treated by an approved preservative process.

2. Species of Wood

Piles may be of any species which will satisfactorily withstand driving and support the superimposed loads. Species in common use include cedars, cypress, Douglas fir, hemlock, western larch, oaks, pines, spruces, and tamarack.

(Note—For botanical names of wood species see Nomenclature of Domestic Hardwoods and Softwoods).

B. CLASSIFICATION OF PILES

1. Classes

Piles are classified in this specification under two general classes according to quality, First-Class Piles and Second-Class Piles. First-Class Piles are divided into two size groups according to intended use, as follows:

First-Class Piles

Group 1. Piles suitable for use in railway bridges or other heavy construction. The minimum approximate diameter of butt permits the use of load-bearing timber caps 14 in. in width.

Group 2. Piles suitable for use in highway bridges, docks, wharves, important foundations, buildings, and general construction. The minimum approximate diameter of butt permits the use of load-bearing timber caps 12 in. in width.

(Note—Group 2 piles may be specified for railway bridges using steel or concrete caps.)

Second Class Piles

Piles suitable for use in cofferdams, falsework, temporary work, and light foundations or other light construction.

C. GENERAL REQUIREMENTS FOR ALL PIPES

(Note—For definitions of terms used in describing characteristics and defects see Definitions of Terms Used in Describing Standard Grades for Lumber.)

1. General Quality

Except as hereinafter provided, all piles shall be of sound wood, free from defects which may impair their strength or durability as piles, such as decay, red heart, or insect attack. Cedar and cypress piles may have a pipe or stump rot hole not more than 1½ in. in diameter. Cypress piles may have peck aggregating not more than the limitation for holes. Piles having sound turpentine scars not damaged by insects may be accepted.

Knots in clusters shall not be permitted. The sum of sizes of all knots in any foot of length of the pile shall not exceed twice the size of the largest single knot permitted. The size of a knot shall be its diameter measured at right angles to the length of the pile. Sizes of knots shall be limited as specified for each class.

Piles shall be cut above the ground swell and shall have a continuous and reasonably uniform taper from point or butt measurement to tip.

2. Heartwood

Piles specified to have high heartwood content, for use without preservative treatment, shall exhibit a heartwood diameter at the butt not less than eight-tenths the diameter of the pile.

3. Sapwood

Piles for use with preservative treatment shall have not less than 1 in of sapwood at the butt end.

4. Close Grain

If close grain is specified for softwood piles, the pile shall show on the butt end not less than 6 annual rings per inch, measured radially over the outer 3 in of the cross section. Douglas fir and pine averaging from 5 to 6 annual rings per inch shall be accepted as the equivalent of close grain if having one-third or more summerwood.

5. Trimming

All knots and limbs shall be trimmed or smoothly cut flush with the surface of the pile. Ends of the piles shall be sawed square with the axis of the pile.

6. Peeling

Piles are classified herein according to extent of bark removal as clean-peeled, rough-peeled or unpeeled. Clean-peeled piles require the removal of all outer and not less than 80 percent of all inner bark; any remaining strips of inner bark shall be not more than ½ in wide nor more than 8 in long, and there shall be at least 1 in of clean wood between any two such strips. Rough-peeled piles require the complete removal of all outer bark. Unpeeled piles require no removal of bark.

The sapwood of piles shall not be unnecessarily scarred or injured in the process of peeling.

Piles for preservative treatment shall be clean-peeled.

7. Lengths

Piles shall be furnished cut to any of the following lengths as specified: 16 ft to 40 ft, incl., in multiples of 2 ft; over 40 ft, in multiples of 5 ft. Individual piles may vary from the length specified as much as 1 ft plus or minus in piles 40 ft or less, and

2 ft plus or minus in piles over 40 ft in length. The average length of all piles in each shipment shall be not less than the length specified.

8. Twist of Grain

Twist of spiral grain shall not exceed one-half the circumference in any 20 ft of length at the mid-point of the length measured.

9. Diameters

Piles in each class shall have the limiting diameters, measured under the bark, given in Table 1, except that a tolerance of ½ in less in a given minimum diameter will be permitted in not to exceed 25 percent of the pieces of that diameter in any shipment.

The diameter of a pile at the point of measurement shall be taken as its circumference at that point divided by 3.14.

Piles that are materially out-of-round may be rejected.

D. SPECIAL REQUIREMENTS FOR FIRST-CLASS PILES

1. Straightness

A straight line from the center of the butt to the center of the tip of First-Class piles shall lie entirely within the body of the pile. First-Class piles shall be free from short or reversed bends and crooks in which the distance from the center of the pile at any point to lines extending the axis of the pile above or below the section exceeds 4 percent of the length of the bend or crook. A short bend or crook coming under this provision is defined as one not exceeding 5 ft in length; longer bends or crooks shall meet the preceding requirements for straightness.

2. Knots

Knots in First-Class piles shall conform to the requirements specified under General Requirements for All Piles, Sec. C, and in addition the maximum diameter of any knot shall not exceed 4 in or one-third the diameter of the pile where it occurs, whichever is the smaller.

3. Holes

Holes less than ½ in. in average diameter shall be permitted in First-Class piles provided the sum of diameters of all holes in any square foot of pile surface does not exceed 1½ in.

4. Splits and Shakes

Splits in First-Class Piles shall not be longer than the butt diameter.

The length of any shake or combination of shakes, measured along the curve of the annual ring, shall not exceed one-third the circumference of the butt of the pile.

E. SPECIAL REQUIREMENTS FOR SECOND-CLASS PILES

1. Straightness

A straight line from the center of the butt to the center of the tip of Second-Class piles may lie partly outside the body of the pile but the maximum distance between the line and the pile shall not exceed ½ percent of the length of the pile or 3 in, whichever is the smaller. Second-Class piles shall be free from short or reversed bends and crooks in which the distance from the center of the pile at any point to lines extending the axis of the pile above or below the section exceeds 4 percent of the length of the bend

Table 1—Diameters of Wood Piles—Limiting Dimensions

(Lengths in feet, diameters in inches)

Length	First-Class Piles, Group 1: Diam. 3 Ft from Butt, Min	First-Class Piles, Group 1: Diam. 3 Ft from Butt, Max	First-Class Piles, Group 1: Diam. of Tip, Min	First-Class Piles, Group 2: Diam. 3 Ft from Butt, Min	First-Class Piles, Group 2: Diam. 3 Ft from Butt, Max	First-Class Piles, Group 2: Diam. of Tip, Min	Second-Class Piles: Diam. 3 Ft from Butt, Min	Second-Class Piles: Diam. 3 Ft from Butt, Max	Second-Class Piles: Diam. of Tip, Min
Douglas Fir, Hemlock, Larch, Pine, Spruce, Tamarack									
Under 40	14	18	9	12	20	8	12	20	8
40 to 50, incl.	14	18	9	12	20	7	12	20	6
51 to 70, incl.	14	18	8	13	20	7	12	20	6
71 to 90, incl.	14	20	7	13	20	6	12	20	6
Over 90	11	20	6	13	20	5	12	20	5
Oak and Other Hardwoods, Cypress									
Under 30	14	18	9	12	18	8	12	20	8
30 to 40, incl.	14	18	9	13	20	7	12	20	7
Over 40	11	18	8	13	20	6	12	20	6
Cedar									
Under 30	14	22	9	12	22	8	12	22	8
30 to 40, incl.	14	22	9	13	22	8	12	22	8
Over 40	11	22	8	13	22	7	12	22	7

or crook. A short bend or crook coming under this provision is defined as one not exceeding 5 ft in length; longer bends or crooks shall meet the preceding requirements for straightness.

2. Knots

Knots in Second-Class piles shall conform to the requirements specified under General Requirements for All Piles, Sec. C, and in addition the maximum diameter of any knot shall not exceed 5 in or one-half the diameter of the pile where it occurs, whichever is the smaller.

3. Holes

Holes less than ½ in. in average diameter shall be permitted in Second-Class piles provided the sum of the diameters of all holes in any square foot of pile surface does not exceed 3 in.

4. Splits and Shakes

Splits in Second-Class piles shall not be longer than 1½ times the butt diameter.

The length of any shake or combination of shakes measured along the curve of the annual ring, shall not exceed one-half the circumference of the butt of the pile.

F. INQUIRIES AND PURCHASE ORDERS

Each inquiry or purchase order for piles purchased under this specification should clearly state:

1. The number of pieces of each length.
2. The species of wood.
3. Whether the piles shall conform to the requirements for First-Class Piles, Group 1, or Group 2, or the requirements for Second-Class Piles.
4. Whether piles shall be clean-peeled, rough-peeled, or unpeeled.
5. If close grain is wanted (in softwood piles).
6. If high heartwood content is wanted.
7. Whether piles shall be treated or untreated, and, if treated, the type of preservative treatment and pounds retention of preservative and minimum penetration.
8. Any exceptions to this specification, such as:
   a. The entire removal of all inner bark for clean-peeled piles.
9. Instructions for inspection, marking, acceptance and shipment.

Appendix B

SPECIFICATIONS FOR WORKMANSHIP FOR CONSTRUCTION OF PILE AND FRAMED TRESTLES CARRYING RAILWAY TRAFFIC

1953

1. Scope

This specification covers workmanship for the construction of pile or framed trestles carrying railway traffic.

2. General Provisions

a. Trestles constructed under this specification shall be built complete, ready for the laying of track rails, in a workmanlike manner, in strict accordance with the plans and the intent of this specification.

b. It is presumed that the design of structures to which this specification attaches is in accordance with prevailing practice, and, more specifically, in general accordance with the Specification for Design of Wood Bridges and Trestles of the AREA.

c. Nothing contained herein shall be construed as superseding details or notations shown on design drawings. Where this specification conflicts with the drawings, the drawings will govern.

d. Workmanship shall be of the best quality in each class of work. Competent bridge carpenters shall be employed and all framing shall be true and exact. No blocking or shimming will be permitted, except as otherwise provided herein.

e. On completion of the work, all surplus material or material salvaged from an existing structure shall be removed from the premises as directed. Material not salvageable and other refuse shall be destroyed or otherwise disposed of. Premises shall be left in a clean, neat and orderly condition.

3. Handling and Storage of Material

a. All material shall be handled to avoid structural damage or unnecessary disfiguring.

b. Piling or timber that has been treated with preservatives shall be handled with extreme care in unloading and assembling to avoid damage to the timber which would expose untreated wood. These materials shall be preferably handled with rope slings. Sharp-pointed bars, peavies, hooks, tongs or similar tools shall not be used, except as approved by the chief engineer.

c. Materials shall be stored at the site in a neat manner at proper clearance to operated tracks.

d. Care shall be exercised to prevent fires in material held in storage. The ground underneath and in the vicinity of piling and lumber shall be scalped and cleared of all weeds, rubbish and combustible material.

e. Treated lumber shall be close-stacked in a manner that will prevent long timbers or preframed material from sagging or becoming crooked.

Untreated lumber shall be open-stacked on suitable skids at least 1 ft above the ground and above possible high water; it shall be piled in a manner to shed water and to prevent warping. When required, it shall be protected from the weather by suitable covering.

Piling shall be stacked in a manner to prevent excessive bending.

f. Hardware received at the job site shall be protected from corrosion by storing under cover or by a protective coating.

4. Pile Driving

Piles shall be driven, cut off and framed in accordance with the current AREA Specifications for Driving Wood Piles, Part 3, this Chapter.

5. Framing of Timber

a. All cutting, framing, and boring of timbers to be treated, shall be done before treatment unless otherwise shown on the plans or specifically permitted by the chief engineer.

b. All cuts or abrasions made in or suffered by treated lumber shall be carefully trimmed and then field treated by the application of two saturating coats of hot creosote oil. All holes bored in treated material shall be field treated with hot creosote oil under pressure, using an approved type of bolt hole treater, in such a manner that the entire surface of the hole receives thorough penetration. All countersunk recesses for bolts which would form pockets to retain water shall be treated as for cuts and then filled with a suitable mastic after the bolt is placed.

c. Sills shall have a true and even bearing on foundation piles, timber grillages, mats or pedestals. All earth shall be removed from around sills so that there will be free air circulation around them.

d. Posts in framed bents shall be sawed to proper length (vertical or batter) and shall have an even bearing on caps and sills.

e. Caps shall be sized to a uniform depth and placed to a uniform and even bearing on piles or posts.

f. Sash and sway bracing, tower bracing and girts shall bear firmly against the piles or timber to which secured. When necessary, fillers shall be placed to avoid bending the bracing more than 1 in out of line when the bracing bolts or other fastenings are drawn up tight. Built-up fillers will not be permitted and each filler shall be a single piece of creosoted lumber of like kind to that in the brace with a width of not less than 6 in and a length of not less than 12 in.

g. Stringers shall be sized to provide a uniform depth and even bearing at supports. They shall be assembled in the structure according to plans.

h. Ties shall be sized and spaced in accordance with the plans.

i. Guard timbers shall be framed in accordance with the plans and laid to line and uniform top surface.

j. Deck plank and ballast retainers on ballasted deck trestles shall be placed in accordance with the plans. Drainage shall be provided for in the manner specified.

k. Bulkheads at the ends of trestles shall be of sufficient height and width to retain properly the shoulders of embankments and to provide a berm sufficient to prevent loss of embankment from beneath the bulkhead. When necessary, special anchorage, such as bulkhead piles or dead-men buried in the embankment, shall be provided to support the bulkhead.

l. Refuge platforms, water barrel platforms, footwalks, motor car set-off or other special platforms shall be in accordance with the plans.

m. All fastenings, including bolts, dowels, lag screws, timber connectors and other type fastenings shall be placed in accordance with the plans, drawn up securely, and on completion of the structure shall be retightened. Unless otherwise shown on the plans, holes for dowels and drift bolts shall be bored $\frac{1}{16}$ in smaller than the nominal diameter of the dowel or bolt used; holes shall not be bored deeper than the length of the dowel or bolt. Holes for machine bolts and rods other than dowels and drift bolts shall be bored the same size as the nominal diameter of the bolt or rod used. Holes for lag screws shall be bored with a bit not larger than the body of the screw at the base of the thread.

Screw-type fastenings shall be screwed into place for the entire length of the fastening. Driving with a maul or other tool will not be permitted.

n. Timber connectors shall be of the types specified on the plans. Split-ring and shear-plate connectors shall be installed in pre-cut grooves of the dimensions shown on the plans or as recommended by the manufacturer. Toothed-ring and spike-grid connectors, and clamping plates, shall be forced into the contact surfaces of the timbers joined by means of proper pressure tools; all connectors of these types at any joint shall be embedded simultaneously and uniformly.

Appendix C

ECONOMIC COMPARISONS: METHODS OF ANALYSIS

A. INTRODUCTION

When it becomes necessary to consider the replacement of an existing structure, by reason of deterioration, damage, obsolescence or other causes, it is ordinarily desirable that an economic comparison be made of various plans for replacement. This problem resolves itself into a mathematical analysis to determine the most advantageous expenditure. The investigation should take into account also the economy of repairing the existing structure to maintain it in service for one or more years.

Whereas this discussion relates principally to replacement of bridges, the principles and methods are applicable to any construction or replacement of a fixed property.

B. GENERAL CONSIDERATIONS

Obviously, when a structure can be replaced with a more permanent one at little or no greater first cost than for renewal in kind, there can be no doubt of the economy of the improvement. If such economy is not self-evident, however, a careful analysis of all the elements of cost should be made. This analysis will be based on first cost, including the expense for maintaining traffic during construction, future replacements, interest value of the investment, annual maintenance and operation, fire risk, effect of the expenditure on taxation, etc. Fire risk and taxation are ordinarily treated only as matters of policy, but may dictate the type of construction selected. Future replacements as well as future salvage are considered on the basis of their present worth.

Economic comparisons of the type treated herein should not include any charges for past expenditures or existing investment value, since nothing which is proposed can alter the economic charges for money already spent, with the possible exception of effect on taxation. It is correct to include the present worth of probable future work to an existing structure which will be necessary to carry it to the end of the service life of the alternate structure under consideration.

It should be borne in mind that cost estimates are seldom exact enough to warrant undue nicety in calculations. The method and interval of compounding interest, the use of different rates for interest and for computation of sinking fund, and even the rate of interest itself, are likely to be of less relative importance than the use of good judgment in estimating the service life of structures. Economic comparisons are reliable only in proportion to the sound judgment used in setting them up and interpreting them.

C. DISCUSSION OF SERVICE LIFE

The accuracy with which the service life of structures is estimated will usually determine the validity of the comparison to a greater extent than any of the other assumptions. Reference to actual experience under similar conditions is most important. In selecting a service life and allowance for maintenance, the probable manner of renewal must be considered. A timber trestle, if maintained by partial replacements, may be assigned a service life equal to that of the railroad line, although no part of the trestle may last more than a fraction of that time; if it is to be renewed as a whole, however, its service life will closely agree with that of the timber in it. In the first instance, the annual maintenance allowance must be sufficient to cover all partial replacements, while if periodic complete renewals are assumed, maintenance will be limited to surfacing, replacement of defective timbers, etc.

Consideration should be given to the possibility of future line revision or abandonment in forecasting the service life of the proposed work. When there is any occasion for doubt, a low estimate of service life should be made; when the comparison favors the more permanent improvement by only a relatively small amount, preference should usually be given to the less permanent construction.

In any comparison involving differing fire hazards it is proper to include this element of expense, if it can be evaluated. In many cases, damage or loss of a structure itself will not be as important a factor as the assumed accident, delay and detour costs incident to traffic.

D. METHODS OF ANALYSIS

The two methods of analysis most favored by statisticians are (1) computation of the annual sum which, like a rental, will cover all present and future investment and maintenance charges on the proposed structure, and (2) computation of the total capital which, if invested, will furnish funds to build and perpetually maintain the structure. The first method will herein be called the Annual Cost Method; the second, the Capitalization Method. A little study will show that the two methods are based on the same principle, and the computed total annual cost of a project will equal the interest, at the assumed rate, on the total computed capitalization; therefore, both methods indicate the same order of relative economy.

Both methods require assumptions as to interest rates and manner of compounding interest, and service life. They require the use of formulas, or tables, such as those appended hereto. A third method, based on straight-line depreciation, is also widely used, and is illustrated in the examples.

In projects of such magnitude that special loans must be obtained, the probable terms of such loans will govern the interest. In ordinary projects, the money may be taken from current earnings or working capital; the interest rate should be based on the value of the railroad's money, which is at least equal to the highest interest rate which could be saved by retiring outstanding bonds.

The three methods are explained in greater detail as follows:

1. *Annual Cost Method.* The annual cost is the sum of (a) simple interest on the first cost; (b) an annual sum which, with compound interest added, will accumulate a sinking fund equal to the first cost or the replacement cost at the end of the service life; and (c) the estimated average annual maintenance expense. Amount (b) can be computed from the appended tables, Col. C.

2. *Capitalization Method.* A fund is computed which is the sum of (a) the first cost of the project; (b) an amount on which the accumulated compound interest, exclusive of the principal, will equal the first (or replacement) cost of the project at the end of its service life; and (c) an amount on which the simple interest equals the average amount required yearly for maintenance. Amount (b) can be computed from the appended tables, Col. B. Amount (c) is the estimated annual maintenance divided by the (decimal) rate of interest. Theoretically, with unchanging costs and interest rates, the total fund so accumulated will build the structure and provide for its perpetual maintenance and periodic replacement in kind.

(In investment accounting, a sinking fund usually amortizes the original investment, so that accounts will be cleared of any overlapping charges when a replacement is to be financed. Usually, in methods (1) and (2) assumption of a different cost level for future replacement is considered too speculative for conservative accounting. However, in comparing a structure of short service life with one which may extend through two or more renewals of the first, the future cost of such renewals during the life of the more permanent alternative is of concern in the comparison. If changing cost levels are considered to be definitely indicated, items (b) in the foregoing methods should be based on future replacement cost rather than on present cost. This may be important in affecting the validity of the comparison.)

3. *Straight-Line Method.* The straight-line depreciation method of comparative analysis, while only mathematically approximate, is frequently used on account of its simplicity. It involves the division of first cost by the estimated service life. To this annual charge, interest and maintenance are added. In keeping with the simplicity of the method, the reduced interest on the diminishing principal may be approximated by figuring straight interest on one-half the total cost. Maintenance cost is added as under the annual cost method.

While computations by the straight-line method can be made without involved calculations, or reference to tables, this method is not ordinarily recommended. It is more approximate than methods (1) and (2) and does not permit present and future work to be considered in correct relationship. This can be done under the first two methods by computing the present worth of future expenditures. Thus, work at various future dates may be brought to a common basis for comparison.

E. ECONOMIC FORMULAS

The appended tables, for several commonly used rates of interest, give factors which, when multiplied by the estimated cost of the project, will give the amounts required in making comparisons by the annual cost and capitalization methods. They are based on interest paid at the end of each year.

Col. A gives the total of principal plus interest for terms from 1 to 100 years. It is included here because its formula, $(1 + r)^n$ is the basis of all other compound interest values.

Col. B is used to determine, in the capitalization method, the capital needed to rebuild the structure at periodic intervals.

Col. C is used in the annual cost method to compute the annual payment which will create a sinking fund to liquidate the investment, or rebuild the structure.

Col. D, the present worth of one dollar to be spent at the end of n years, may be used in either method (1) or (2) to reduce future expenditures to the current date.

The formulas for these values, in which n equals the term of years, r equals the interest rate expressed as a decimal, and v equals $(1 + r)^n$ are as follows:

Column A. Values given equal $(1 + r)^n$, or v

Column B. Values given equal $\dfrac{1}{v - 1}$

Column C. Values given equal $\dfrac{r}{v - 1}$

Column D. Values given equal $\dfrac{1}{v}$

These formulas may be used to prepare tables for other rates of interest.

Examples in Use of Methods of Analysis

Example 1—A pile trestle is near the end of its service life. It can be maintained for 2 years at a cost of $4000, or replaced with a creosoted open-deck trestle having an estimated life of 35 years, at a cost of $36,000, or replaced with earth fill and a concrete culvert, having an assumed life of 80 years, at a cost of $54,000. What is the economical thing to do?

SOLUTION OF PROBLEM (ASSUMED INTEREST RATE, 4 PERCENT)

	Repairs	*Treated Pile Trestle*	*Fill and Concrete Culvert*
Given:			
Estimated life	2 years	35 years	80 years
Estimated cost	$4,000	$36,000	$54,000
Annual maintenance (average)	------	$ 350	$ 200
1. Annual Cost Method:			
Interest	$ 160	$ 1,440	$ 2,160
Sinking Fund	1,961	489	94
Maintenance	------	350	200
Total annual cost	$2,121	$ 2,279	$ 2,454
2. Capitalization Method:			
First Cost	not	$36,000	$54,000
Capitalized replacement	applicable	12,219	2,449
Capitalized maintenance	------	8,750	5,000
Total capital	------	$56,969	$61,449
3. Straight-Line Method:			
Annual proportion of cost	$2,000	$ 1,029	$ 675
Interest	80	720	1,080
Maintenance	------	350	200
Total annual cost	$2,080	$ 2,099	$ 1,955

The computations are as follows, using the appended (4 percent) tables:

1. ANNUAL COST METHOD: *Repairs.* Interest, 0.04 × $4000 = $160. Sinking fund for 2 years, 0.49020 × $4000 = $1961. Maintenance, none; included in the $4000. Total annual cost, $2121. *Treated Trestle.* Interest, 0.04 × $36,000 = $1440. Sinking fund for 35 years, 0.01358 × $36,000 = $489. Maintenance, $350. Total annual cost, $2279. ***Fill and Culvert.*** Interest, 0.04 × $54,000 = $2160. Sinking fund for 80 years, 0.00174 × $54,000 = $94. Maintenance, $200. Total, $2454.

2. CAPITALIZATION METHOD: *Treated Trestle.* First cost, $36,000; capital to produce $36,000 every 35 years, 0.33943 × $36,000 = $12,219; capital to produce estimated maintenance of $350 per year, $350 ÷ 0.04 = $8750; total, $56,969. *Fill and Culvert.* First cost, $54,000; capital to produce $54,000 every 80 years, 0.04535 × $54,000 = $2449; capital to produce $200 per year for maintenance, $200 ÷ 0.04 = $5000; total $61,449. (It is not considered that a capitalization of the repair alternate, made in a way to show its correct relative economy, would find general acceptance.)

3. STRAIGHT-LINE METHOD: *Repairs.* Annual proportion of total cost $4000 ÷ 2 = $2000; interest, 0.04 × $4000 ÷ 2 = $80; maintenance (included in the $4000). Total, $2080. *Treated Trestle.* Annual proportion $36,000 ÷ 35 = $1029; interest 0.04 × $36,000 ÷ 2 = $720; maintenance, $350. Total, $2099. *Fill and Culvert.* Annual proportion, $54,000 ÷ 80 = $675; Interest, 0.04 × $54,000 ÷ 2 = $1080; Maintenance, $200. Total, $1955.

By method (1) the comparison indicates that the present structure can be economically carried 2 years longer by repairs, and methods (1) and (2) indicate that there will then be some economical advantage in rebuilding it as a treated pile trestle rather than filling it. However, the elimination of fire risk by filling, though not set up in the comparison, might well be adjudged of value enough to make filling preferable. But if the structure in this location might be affected by line change or abandonment, the shortened service life of the fill and culvert would give the trestle a more decided economic advantage. By method (3) the filling appears to be more economical than the trestle or the repairs, and if this analysis were accepted, the trestle should be filled now.

Example 2. On a projected new route, estimates have been made for a steel bridge on concrete substructure, and for an alternate treated timber ballasted-deck bridge, as follows: Steel bridge, cost $117,000, life 75 years; timber deck, $4000, life 35 years; estimated annual maintenance, $300, including painting. Timber bridge, cost $90,000, life 45 years; estimated maintenance $400 per year.

Solution of Problem. (Assumed Interest Rate 3½ Percent)

	Steel Bridge		*Timber Bridge*	
1. Annual Cost Method:				
Interest	0.035 × 121,000	$ 4,235	0.035 × 90,000	3,150
Sinking Fund	0.00287 × 117,000	336	0.00945 × 90,000	850
	0.01500 × 4,000	60		
Maintenance		300		400
Total		$ 4,931		$ 4,400
2. Capitalization Method:				
First cost		$121,000		90,000
Capitalized replacement	0.08198 × 117,000	9,592	0.27010 × 90,000	24,309
	0.42852 × 4,000	1,714		
Capitalized maintenance	$300 ÷ 0.035	8,571	$400 ÷ 0.035	11,428
Total		$140,877		$125,737
3. Straight-Line Method:				
Annual proportion	117,000 ÷ 75	$ 1,560	90,000 ÷ 45	$ 2,000
	4,000 ÷ 35	114		
Interest	0.035 × 121,000 ÷ 2	2,118	0.035 × 90,000 ÷ 2	1,575
Maintenance		300		400
Total		$ 4,092		$ 3,975

The comparison shows by all three methods that the treated timber ballasted deck bridge is not only lower in first cost, but also more economical in the long run. Therefore, in this instance the timber bridge should be constructed unless the relative fire immunity of the steel bridge is considered to have an annual value of over $500.

Example 3. A large steel bridge will require heavy repairs and renewals which could be programmed approximately as follows:

This year $100,000
Next 4 years .... $30,000 per year
Tenth year .... $70,000 (this is an average date for a probable series of further repairs more extensive than ordinary maintenance.)

It is anticipated that the railway line has a foreseeable useful life of 50 years, and that no other renewals will be needed during this time, other than an average maintenance cost of $3000 annually, which includes painting, pier protection, track upkeep, etc. If the bridge is abandoned in favor of an available alternate route, the cost of demolishing it will be $50,000 in excess of salvage. New connections will cost $5000. The problem is, how much can we afford to pay in annual charges for the use of the alternate route? (It is assumed that there is no difference in mileage, or train operation and other costs, and no operating objection.)

EXPENDITURES FOR CONTINUED USE OF EXISTING BRIDGE

	Expenditure	Present Worth Factor	Amount (4% interest)
This year	$100,000	1.00000	$100,000
One year hence	30,000	0.96154	28,846
Two years hence	30,000	0.92456	27,737
Three years hence	30,000	0.88900	26,670
Four years hence	30,000	0.85481	25,644
Tenth year hence	70,000	0.67556	47,289
Present worth of programmed renewals			$256,186
Less alternate cost of demolition and connections			55,000
Net present worth of amount to be saved by abandonment			$201,186
Annual costs to be saved by abandonment:			
Interest	0.04 × $201,186		$ 8,047
Fifty-year sinking fund	0.00655 × $201,186		1,318
Annual maintenance			3,000
Total			$ 12,365

Hence, if it appears possible to obtain the use of an acceptable alternate route for an annual charge, for rental and maintenance, of $12,365 or less, this possibility should be thoroughly investigated before undertaking heavy work on the existing bridge. (In some instances, removal of the structure would result in a reduction of taxes, which could be added to the saving.)

The foregoing problems have been prepared for illustration only, and are not intended to imply any intrinsic economy in one kind of construction over another. Each case must be analyzed independently, except where acquired judgment, or management policy, may make certain of the comparisons unnecessary.

FINANCIAL TABLES

3% Interest Rate

3% Years	A $1 will then amount to:	B Amount on which interest will total $1:	C Sinking fund payments to equal $1:	D Present worth of $1:
1	1.03000	33.3333	1.00000	0.97087
2	1.06090	16.4204	0.49261	.94260
3	1.09273	10.7843	.32353	.91514
4	1.12551	7.9676	.23903	.88849
5	1.15927	6.2785	.18835	86261
6	1.19405	5.15325	0.15460	0.83748
7	1 22987	4 35021	.13051	.81309
8	1 26677	3.74855	.11246	.78941
9	1.30477	3.28113	.09843	.76642
10	1.34392	2.90768	08723	.74409
11	1.38423	2 60258	0.07808	0.72242
12	1.42576	2.34874	.07046	.70138
13	1 46853	2 13432	.06403	68095
14	1.51259	1.95088	05853	66112
15	1.55796	1.79222	.05377	64186
16	1 60470	1.65370	0.04961	0.62317
17	1 65285	1.53175	.04595	.60502
18	1.70243	1.42362	.04271	.58740
19	1.75350	1.32713	.03981	.57029
20	1.80611	1 24052	.03722	.55368
21	1.86029	1.16239	0.03488	0 53755
22	1 91610	1.09158	.03275	.52189
23	1 97358	1.02713	03081	.50669
24	2.03279	0 96825	.02905	.49193
25	2 09378	0.91426	.02743	.47761
26	2.15659	0.86461	0.02594	0.46370
27	2 22129	.81881	.02456	.45019
28	2.28793	.77644	.02329	.43708
29	2 35658	.73716	.02211	.42435
30	2 42726	.70064	.02102	.41199
31	2 50008	0.66663	0.02000	0 39999
32	2 57508	.63489	.01905	.38834
33	2 65234	60520	.01816	.37703
34	2.73190	57740	.01732	.36605
35	2.81386	.55131	.01654	.35538
36	2 89827	0 52679	0.01580	0.34503
37	2.98522	.50372	.01511	.33498
38	3 07478	.48198	.01446	.32523
39	3.16702	46146	.01384	.31575
40	3 26204	.44208	01326	.30656
41	3.35990	0.42375	0 01271	0.29763
42	3 46070	.40639	.01219	.28896
43	3 56452	.38994	.01170	.28054
44	3 67146	.37433	.01123	.27237
45	3.78160	.35951	.01078	.26444
46	3 89504	0.34542	01036	0.25674
47	4 01189	.33202	.00996	.24926
48	4.13226	.31926	.00958	.24200
49	4 25623	.30710	00921	.23495
50	4.38391	.29552	.008865	.22811
55	5 08215	0.24497	.007349	0.19677
60	5 89160	.20443	.006133	.16973
65	6.82998	.17153	.005146	.14641
70	7 91782	.14455	.004337	.12630
75	9.17893	.12226	.003668	.10895
80	10 6409	0.10372	.003112	0.09398
85	12.3357	.08822	.002647	.08107
90	14.3005	07518	.002256	.06993
95	16 5782	.06419	.001926	.06032
100	19 2186	.05489	.001647	.05203

3½% Interest Rate

3½% Years	A $1 will then amount to:	B Amount on which interest will total $1:	C Sinking fund payments to equal $1:	D Present worth of $1:
1	1.03500	28.5714	1.00000	0.96618
2	1.07122	14.0400	0.49140	.93351
3	1.10872	9.1981	.32193	.90194
4	1.14752	6.7786	.23725	.87144
5	1.18769	5.3280	.18648	.84197
6	1.22926	4.36195	0.15267	0.81350
7	1.27228	3.67270	.12854	.78599
8	1.31681	3.15648	.11048	.75941
9	1.36290	2.75560	.09645	.73373
10	1.41060	2.43547	.08524	.70892
11	1.45997	2.17406	0.07609	0.68495
12	1.51107	1.95668	06848	.66178
13	1.56396	1.77319	.06206	.63940
14	1.61869	1.61631	.05657	.61778
15	1.67535	1.48072	.05183	.59689
16	1.73399	1.36242	0.04768	0.57671
17	1.79468	1.25838	.04404	.55720
18	1.85749	1.16620	.04082	.53836
19	1.92250	1.08401	.03794	.52016
20	1.98979	1.01032	.03536	.50257
21	2.05943	0 94390	0.03304	0.48557
22	2.13151	.88377	.03093	.46915
23	2.20611	.82911	.02902	.45329
24	2.28333	.77922	.02727	.43796
25	2.36324	.73354	.02567	.42315
26	2.44596	0.69158	0.02421	0.40884
27	2.53157	.65293	.02285	.39501
28	2 62017	.61722	.02160	.38165
29	2.71188	.58415	.02045	.36875
30	2 80679	.55347	.01937	.35628
31	2 90503	0.52493	0.01837	0.34423
32	3.00671	.49833	.01744	.33259
33	3.11194	.47350	.01657	.32134
34	3.22086	.45028	.01576	.31048
35	3.33359	.42852	.01500	.29998
36	3.45027	0.40812	0.01428	0.28983
37	3.57103	.38895	.01361	.28003
38	3.69601	.37092	.01298	.27056
39	3.82537	.35394	.01239	26141
40	3.95926	.33792	.01183	.25257
41	4.09783	0.32281	0.01130	0.24403
42	4.24126	.30852	01080	.23578
43	4.38970	.29501	.01033	.22781
44	4 54334	.28222	.00988	.22010
45	4.70236	.27010	.00945	.21266
46	4 86694	0.25860	0.00905	0.20547
47	5.03728	.24769	.00867	.19852
48	5 21359	.23733	.00831	.19181
49	5.39606	.22748	.00796	.18532
50	5 58493	.21811	.00763	.17905
55	6.63314	0.17752	0.00621	0.15076
60	7.87809	.14539	.00509	.12693
65	9 35670	.11966	.00419	.10688
70	11.11283	.09888	.00346	08999
75	13.19855	.08198	.00287	.07577
80	15.67574	0.06814	0.00238	0.06379
85	18.61786	.05676	.00199	.05371
90	22.11218	.04737	.00166	.04522
95	26.26233	.03958	.00139	.03808
100	31.19141	.03312	.00116	.03206

FINANCIAL TABLES

4% Interest Rate

4% Years	A $1 will then amount to:	B Amount on which interest will total $1:	C Sinking fund payments to equal $1:	D Present worth of $1:
1	1.04000	25.0000	1.00000	0.96154
2	1.08160	12.2549	0.49020	.92456
3	1.12486	8.0087	.32035	.88900
4	1.16986	5.8872	.23549	.85481
5	1.21665	4.6157	.18463	.82193
6	1.26532	3.76905	0.15076	0.79031
7	1.31593	3.16524	.12661	.75992
8	1.36857	2.71320	.10853	.73069
9	1.42331	2.36232	.09449	.70259
10	1.48024	2.08227	.08329	.67556
11	1.53945	1.85372	0.07415	0.64958
12	1.60103	1.66380	.06655	.62460
13	1.66507	1.50359	.06014	.60057
14	1.73168	1.36672	.05467	.57748
15	1.80094	1.24853	.04994	.55526
16	1.87298	1.14550	0.04582	0.53391
17	1.94790	1.05496	.04220	.51337
18	2.02582	0.97483	.03899	.49363
19	2.10685	0.90346	.03614	.47464
20	2.19112	0.83954	.03358	.45639
21	2.27877	0.78200	0.03128	0.43883
22	2.36992	.72997	.02920	.42196
23	2.46472	.68273	.02731	.40573
24	2.56330	.63967	.02559	.39012
25	2.66584	.60030	.02401	.37512
26	2.77247	0.56418	0.02257	0.36069
27	2.88337	.53096	.02124	.34682
28	2.99870	.50032	.02001	.33348
29	3.11865	.47200	.01888	.32065
30	3.24340	.44575	.01783	.30832
31	3.37313	0.42138	0.01686	0.29646
32	3.50806	.39872	.01595	.28506
33	3.64838	.37759	.01510	.27409
34	3.79432	.35787	.01431	.26355
35	3.94609	.33943	.01358	.25342
36	4.10393	0.32217	0.01289	0.24367
37	4.26809	.30599	.01224	.23430
38	4.43881	.29080	.01163	.22529
39	4.61637	.27652	.01106	.21662
40	4.80102	.26309	.01052	.20829
41	4.99306	0.25043	0.01002	0.20028
42	5.19278	.23850	.00954	.19257
43	5.40050	.22725	.00909	.18517
44	5.61652	.21661	.00866	.17805
45	5.84118	.20656	.00826	.17120
46	6.07482	0.19705	0.00788	0.16461
47	6.31782	.18805	.00752	.15828
48	6.57053	.17952	.00718	.15219
49	6.83335	.17143	.00686	.14634
50	7.10668	.16376	.00655	.14071
55	8.64637	0.13078	0.00523	0.11566
60	10.51963	.10505	.00420	.09506
65	12.79874	.08475	.00339	.07813
70	15.57162	.06863	.00275	.06422
75	18.94526	.05572	.00223	.05278
80	23.04980	0.04535	0.00174	0.04338
85	28.04361	.03698	.00148	.03566
90	34.11934	.03019	.00121	.02931
95	41.51139	.02468	.00099	.02409
100	50.50495	.02020	.00081	.01980

5% Interest Rate

5% Years	A $1 will then amount to:	B Amount on which interest will total $1:	C Sinking fund payments to equal $1:	D Present worth of $1:
1	1.05000	20.0000	1.00000	0.95238
2	1.10250	9.7561	0.48780	.90703
3	1.15762	6.3442	.31721	.86384
4	1.21551	4.6402	.23201	.82270
5	1.27628	3.6195	.18097	.78353
6	1.34010	2.94035	0.14702	0.74622
7	1.40710	2.45640	.12282	.71068
8	1.47746	2.09444	.10472	.67684
9	1.55133	1.81380	.09069	.64461
10	1.62889	1.59009	.07950	.61391
11	1.71034	1.40778	0.07039	0.58468
12	1.79586	1.25651	.06283	.55684
13	1.88565	1.12912	.05646	.53032
14	1.97993	1.02048	.05102	.50507
15	2.07893	0.92685	.04634	.48102
16	2.18288	0.84540	0.04227	0.45811
17	2.29202	.77398	.03870	.43630
18	2.40662	.71092	.03555	.41552
19	2.52695	.65490	.03274	.39573
20	2.65330	.60485	.03024	.37689
21	2.78596	0.55992	0.02800	0.35894
22	2.92526	.51941	.02597	.34185
23	3.07152	.48274	.02414	.32557
24	3.22510	.44942	.02247	.31007
25	3.38635	.41905	.02095	.29530
26	3.55567	0.39129	0.01956	0.28124
27	3.73346	.36584	.01829	.26785
28	3.92013	.34245	.01712	.25509
29	4.11614	.32091	.01605	.24295
30	4.32194	.30103	.01505	.23138
31	4.53804	0.28264	0.01413	0.22036
32	4.76494	.26561	.01328	.20987
33	5.00319	.24980	.01249	.19987
34	5.25335	.23511	.01176	.19035
35	5.51602	.22143	.01107	.18129
36	5.79182	0.20869	0.01043	0.17266
37	6.08141	.19680	.00984	.16444
38	6.38548	.18568	.00928	.15661
39	6.70475	.17529	.00876	.14915
40	7.03999	.16556	.00828	.14205
41	7.39199	0.15645	0.00782	0.13528
42	7.76159	.14789	.00739	.12884
43	8.14967	.13987	.00699	.12270
44	8.55715	.13232	.00662	.11686
45	8.98501	.12524	.00626	.11130
46	9.43426	0.11856	0.00593	0.10600
47	9.90597	.11228	.00561	.10095
48	10.40127	.10637	.00532	.09614
49	10.92133	.10079	.00504	.09156
50	11.46740	.09554	.00478	.08720
55	14.63563	0.07334	0.00367	0.06833
60	18.67919	.05656	.00283	.05354
65	23.83990	.04378	.00219	.04195
70	30.42642	.03398	.00170	.03287
75	38.83269	.02643	.00132	.02575
80	49.56144	0.02059	0.00103	0.02018
85	63.25435	.01606	.00080	.01581
90	80.73036	.01254	.00063	.01239
95	103.03467	.00980	.00049	.00971
100	131.50126	.00766	.00038	.00760

Report on Assignment 2

Grading Rules and Classification of Lumber for Railway Uses; Specifications for Structural Lumber Collaborating with Other Organizations Interested

W. C. Howe (chairman, subcommittee), W. L. Anderson, T. J. Boyle, F. H. Cramer, F. J. Hanrahan, R. P. Hart, R. E. Jacobus, R. P. A. Johnson, A. L. Leach, C. V. Lund, F. W. Madison, L. J. Markwardt, T. K. May, W. H. O'Brien, A. M. Westenhoff, R. R. Cahal (collab.—Com. 6).

Your committee offers the following recommendations with respect to the Manual, for adoption.

Pages 7–71 to 7–75, incl.

NOMENCLATURE OF COMMERCIAL DOMESTIC SOFTWOODS AND HARDWOODS

Change title to read, "Nomenclature of Domestic Hardwoods and Softwoods", to agree with the ASTM title.

Delete the entire present text and substitute therefor the following:

The same as ASTM current nomenclature, D 1165. This nomenclature is to be used for standard commercial names for lumber cut from species of domestic hardwoods and softwoods. The names as listed under this nomenclature shall be used in the construction of contracts and other documents arising in transactions of purchase and sale of American Standard Lumber.

Pages 7–75 to 7–84, incl.

DEFINITIONS OF TERMS USED IN DESCRIBING STANDARD GRADES FOR LUMBER

Reapprove with the following changes:

Page 7–76. Change definition for "small surface check" to read as follows: "Perceptible opening not over 4 in long and $\frac{1}{32}$ in wide".

Change definition for "large surface check" to read as follows: "Over $\frac{1}{32}$ in wide or over 10 in long".

After "close grain" substitute the following: Lumber having a relatively large number of annual rings per inch. See U. S. Department of Agriculture Miscellaneous Publication 185 or Industry Grading Rules for qualifications for various species.

Add new definition, as follows:

compression wood. Abnormal wood that forms on the underside of leaning and crooked coniferous trees. It is characterized aside from its distinguishing color by being hard and brittle and by its relatively lifeless appearance. Distinction of color between the bands of summerwood and springwood is usually lost.

Page 7–77. Add, under *cross grain* (slope of grain), the following;

straight grain. Slope of grain not exceeding 1 in. in each 20 in of length.

After *"medium cross grain"*, change to read, slope of grain over 1 in. in a length of 15 in, but not over 1 in. in a length of 8 in.

After *"steep cross grain"*, change to read, slope of grain more than 1 in. in a length of 8 in.

After *"density rules"*, change to "See U. S. Department of Agriculture Miscellaneous Publication 185 or ASTM Specification, designation D 245.

After "edge", change to "The narrow face of rectangular shaped lumber".

After *"face"*, change to "The longitudinal surface of a piece of lumber, sometimes further designated as "wide" face or "narrow" face".

Page 7–78. Add:

free of heart centers. When the pith is not enclosed within the four sides of the piece.

honeycomb (decay). Honeycomb is a form of decay in which large or small pits occur in the wood.

Page 7–79. Change second sentence after *"sound knot"* to read: "May vary in color from the natural color of the wood to reddish brown or black".

After *"corner knot"*, change to "Located at the intersection of adjacent faces".

Add:

spike knot. A knot sawed in a lengthwise direction.

Page 7–81. Add:

saw butted. Trimmed by a saw on both ends.

Add:

ring shake. Partially or completely encircles the pith.

After *"side cut"*, change to "When the pith is not enclosed within the four sides of the piece".

Page 7–82. After *"straight grain"*, delete present sentence. Revise to read: "See cross grain".

All references to Par. 801 to 875 on pages 7–76 to 7–83, incl., should be changed to read: See "American Lumber Standards".

Pages 7–84 to 7–87, incl.

STANDARD LUMBER ABBREVIATIONS

Delete this entire document and substitute the following:

The same as American Lumber Standards Abbreviations, as approved by the American Lumber Standards Committee.

These standard lumber abbreviations are commonly used for softwood lumber. When used in the construction of contracts and other documents arising in transactions of purchase and sale of American Standard Lumber, these abbreviations shall be construed as provided therein.

There are additional abbreviations applicable to a particular region or species which may be included in approved grading rules.

Abbreviations are commonly used in the forms indicated, but variations, such as the use of upper and lower-case type, and in the use or omission of periods and other forms of punctuation, are optional.

Pages 7–89 to 7–99, incl.

AMERICAN LUMBER STANDARDS FOR SOFTWOOD LUMBER

Delete this material and substitute therefor the following:

The same as current American Lumber Standards for Softwood Lumber, U. S. Department of Commerce.

Report on Assignment 4

Methods of Fireproofing Wood Bridges and Trestles Including Fire-Retardant Paints

Collaborating with Committee 17

J. V. Johnston (chairman, subcommittee), J. C. Boston, W. W. Boyer, B. E. Daniels, J. P. Dunnagan, E. L. Haberle, J. C. Jacobs, W. D. Keeney, J. R. Kelly, H. J. Kerstetter, A. L. Leach, L. J. Markwardt, T. K. May, W. B. Mackenzie, P. L. Montgomery, C. A. Peebles, Jr., H. S. Rimmington, W. C. Schakel, F. E. Schneider, F. L. Thompson.

Your committee offers the following recommendation with respect to the Manual, for adoption:

Pages 7–66 to 7–68, incl.

BEST METHOD OF FIREPROOFING WOOD BRIDGES AND TRESTLES

Delete the entire material under this title, except Figs. 715, 716, 717 and 718, and substitute the following:

METHODS OF FIREPROOFING WOOD BRIDGES AND TRESTLES

1953

The following methods are used in providing fire protection for open-deck bridges and trestles:

1. *Metal Protection*—This method consists of covering the deck partially or completely with sheets of No. 24 gage galvanized iron fastened with 12d heavy galvanized barbed car nails with flat heads and diamond points.

2. *Coatings*—Coatings of bituminous and non-bituminous materials with clean gravel embedded in them are showing promise of being fire resistant when applied on horizontal surfaces. Vertical surfaces require special treatment.

3. *Impregnation*—This method includes the use of various salt solutions applied at treating plants. The treated wood, in addition to being made fire resistant, is also given protection against decay and termite attack.

4. *Fire Alarm Systems*—Under this method fusible-link detector systems are so connected with the signal and communication systems that in case of fire the block signals will show warning indications, and the nearest telegraph operator will receive notification so that maintenance of way forces may be assembled to combat the fire.

Special fire-fighting apparatus and watchmen should be employed in unusual cases where conditions warrant.

5. *Housekeeping*—(Applicable to both open and ballasted-deck bridges and trestles.)

   a. All steam locomotives should have adequate and well maintained spark screens in the front end, and ash pans should be maintained with tight fits so that fire and hot coals cannot drop out.

   b. Decks should be kept clear of all combustible material, and decayed spots in exposed ties or timbers should be kept trimmed.

   c. All brush and weeds should be kept down for a distance of at least 25 ft from the bridge, both underneath and on the embankment at the ends of the bridge or trestle. Also, all sod should be removed from under all timber bridges and for a distance of 3 ft outside the timbers. This may be accomplished by scalping or, preferably, by the use of a chemical weed killer or soil sterilant.

d. Water barrels with buckets should be maintained on all timber bridges, installing 1 barrel each for structures up to 50 ft long and 1 additional barrel for each additional 150 ft or fraction thereof. For creosoted structures, sand boxes with water-tight covers for keeping the sand dry are recommended, dry sand being more effective than water in extinguishing small fires on creosoted structures.

6. *Fire Barriers*—(Applicable to both open and ballasted-deck bridges and trestles.)

It is advisable to protect long bridges and trestles by introducing fire barriers at intervals of about 400 ft. This will reduce the hazard by preventing loss of the entire structure in case of fire. Such barriers may be grouped by types of construction, as follows:

a. Earth fill (see Fig. 715).
b. Reinforced concrete piers or concrete pile bents (see Fig. 716).
c. Facing bents with fire-resisting materials (see Fig. 717).
d. Application of mastic materials to open-deck structures (see Fig. 718).

Report on Assignment 6

Design of Timber Pile Dolphins

Milton Jarrell (chairman, subcommittee), J. C. Boston, T. P. Burgess, E. M. Cummings, W. C. Howe, C. S. Johnson, W. D. Keeney, J. C. Korte, W. A. Oliver, W. H. O'Brien, W. L. Peoples, H. S. Rimmington, A. H. Schmidt, B. J. Shadrake, Josef Sorkin, W. C. Wilder.

Last year your committee submitted a progress report (see Proceedings, Vol. 53, 1952, pages 635 to 645, incl.), as information, following a study of the design, plans and specifications for timber pile dolphins as prepared by a number of roads, consulting engineers, and public authorities. The committee has no further information to submit at this time, and requests that the 1952 report be considered as a final report on this assignment.

Report on Assignment 7

Means of Conserving Labor and Materials, Including the Adaptation of Substitute Noncritical Materials, and Specifications for the Reclamation of Released Materials, Tools and Equipment

Collaborating with Committee 3-A, General Reclamation, Purchases and Stores Division, AAR

S. L. Goldberg (chairman, subcommittee), T. P. Burgess, E. M. Cummings, Nelson Handsaker, Milton Jarrell, C. A. Peebles, Jr., J. R. Showalter, W. C. Wilder.

This is a progress report, submitted as information.

The subject of conservation is not new to American railroads. Being one of the largest industries in the country, railroads use vast quantities of materials of all kinds and depend on skilled personnel for their operation. Through the years, various practices have been introduced for economic reasons to conserve both labor and material. Today, conservation is practiced not only for economic reasons but also because it is necessary during times of national emergency.

Your committee has compiled the following practices by means of which labor and material for wood railway bridges and trestles may be conserved:

1. *Good Personnel Relations.*

By far, the most effective means of conserving labor and materials is by having good personnel relations. Happy and satisfied personnel produce the most in the shortest possible time, and because of concentrated effort, there is less waste through carelessness and indifference. Only by employing and promoting supervisory personnel who command the respect of subordinates can the railroads ever hope to use its skilled labor to its maximum efficiency.

2. *Substitution of Sizes of Timber.*

Two cases of this type of conservation with respect to timber trestles may be used as illustrations. One is the use of a double cap (made of two timbers bolted together to make up the necessary width to bear on the piles or posts) in pile or framed bents, which results in cheaper purchase prices, timber sizes that are more readily available, a reduction in decay, and a cap that can be changed out in part. The other case is the development of the proper relation between span length, size of stringers, and number of piles or posts per bent for the greatest economy consistent with suitable channel openings.

3. *Judicious Use of Commercially Graded Timber.*

Considerable saving can be effected by designing with a specific grade in mind for a specific use. An example would be the use of a lower grade of timber for cross caps on a timber pier where the stress is mostly a result of bearing rather than bending. The use of lower grades for bracing material will also aid in conserving the better grades of timber for use where their ability to accommodate larger unit stresses may be utilized to the fullest extent. The use of recommended unit stresses for the various kinds of timber and their grades will help to eliminate the guess work in timber design, resulting in smaller members and, consequently, savings in materials.

4. *Actual Measurement of the Effect of Moving and Static Train Loads on the Various Component Parts of the Structure Together with Careful Analysis and Design.*

It is common knowledge that present methods of structural analysis are based on assumptions that greatly simplify the complexity of nature. There is a possibility that improvement of these present-day methods may be realized by measuring and studying the actual distribution of stress in a structure. By so doing, the most economical design may be brought about and the tendency toward over design, which means larger members and waste of materials, may be held to the minimum.

5. *Use of Glued Laminated Timber to Make Up a Desired Size as a Substitute for Large Size Timber.*

While glued laminated timber is proving satisfactory, it is rather expensive as compared to the full size timber. Should the time ever come when it is impossible to obtain large size timbers, glued laminated timber may come into general use.

6. *Use of Treated Material with Sufficient Details and Planning of the Work to Hold Field Cuts and Holes to the Minimum.*

While the first cost of a treated timber structure is higher than one that is untreated, the treated structure will have a greater life, requiring fewer rebuildings over a given number of years, and, consequently, a conservation of material will result. Holes and cuts made in treated timber during construction greatly reduce the effectiveness of the treatment and lessen the life span. Effective means for prolonging the life of a treated structure are to prebore as many holes as possible and preframe timber before treatment; provide filler blocks between piles and sway and sash braces, rather than notch the pile (when piles of a bent vary in size); use portable pressure treating tools on all field holes; treat all field cuts; use special waterproofing treatment for timber piles at cut-off; and handle all treated timber carefully to avoid injury to the outer fibers.

7. *Salvaging Falsework and Reclaiming Sound Material From Structures That Have Been Replaced.*

While a timber structure as a whole may need replacing, some of its parts may still be sound material. By careful inspection, the best timbers may be salvaged, framed and treated as required, and reused either for repairs or new construction. For example, old stringers may be reclaimed, treated, and used as bulkheads at end bents. Piles may be made into fence or sign posts. The sound portions of large timbers may be resawed to make smaller lumber.

8. *Use of Power Tools and Off-Track Equipment.*

The economy of using off-track equipment and portable power tools to reduce hand labor is now generally recognized. Supervisors of labor should keep informed of new developments in labor-saving appliances which seem to be worth trying from the economy standpoint.

9. *Good Maintenance Program.*

By obtaining the longest possible safe service from a timber structure, material and labor may be conserved. Structures which at first may appear to need replacing may sometimes be economically carried to good advantage for a long time by making repairs after careful inspection and analysis by competent and qualified structural engineers. The following are some of the more common failures in timber structures that may be encountered, together with suggested methods of repair to keep the bridge in service:

a. Splitting of timber caps and piles, Fig. 1(a). All dirt should be removed from the cracks and a bituminous filler applied before bolting.

b. Crushing of stringers at the caps due to insufficient bearing, Fig. 1(b). Bolt scabs on the sides of the caps, using a sufficient number of bolts and split-ring connectors to develop effectively the material, making sure the scab is in direct contact with the stringers. At end bents where both sides of the cap are not accessible, drive spikes may be substituted for bolts. Stringers may be jacked and shims inserted in case of excessive crushing.

c. Cracks in stringers, Figs. 2(a), 2(b), and 2(c). Drive spikes may be used to good advantage in checking this type of failure.

d. Sagging and visibly defective stringers, Fig. 2(d). Often timber scabs may be applied to the bottom of the stringers, utilizing drive spikes and split-ring connectors.

e. Ties that are plate cut may be given added life by turning them over and shimming if necessary.

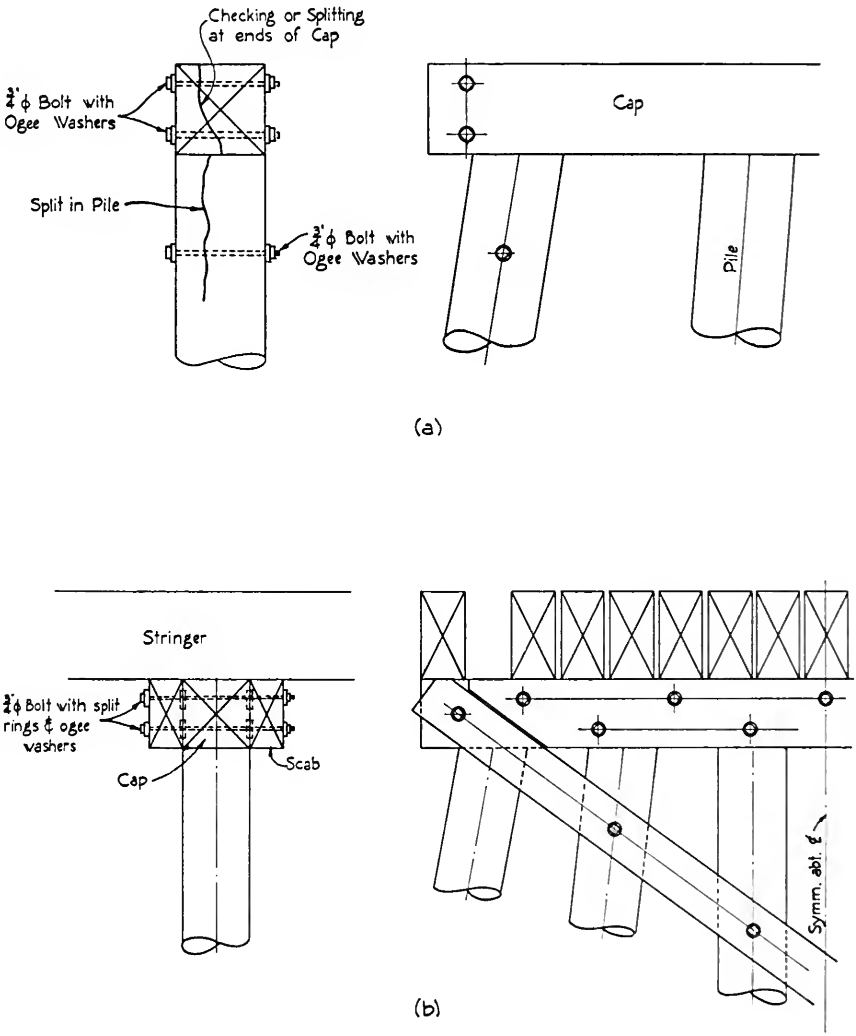


FIG. 1
MAINTENANCE OF TBR. TRESTLES
TO CONSERVE MATERIALS
AREA

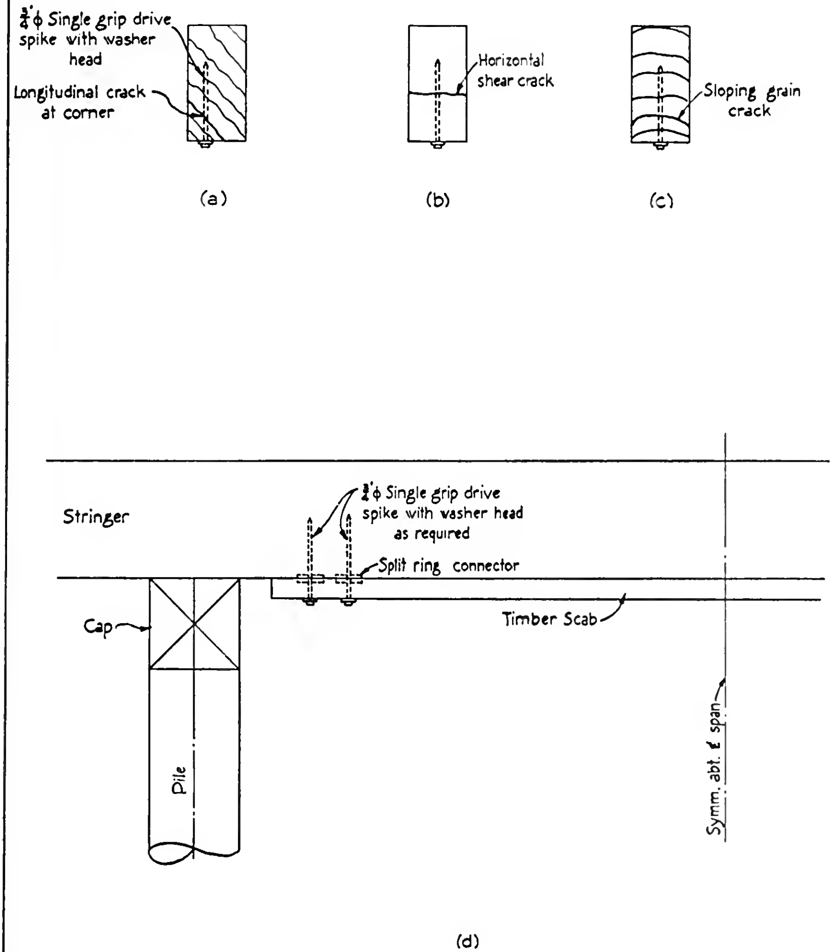


FIG. 2
MAINTENANCE OF TBR TRESTLES
TO CONSERVE MATERIALS
AREA

Report of Committee 5—Track

F. J. Bishop, *Chairman,*
H. S. Ashley
D. B. Barge, Jr.
L. E. Bates
T. H. Beebe
M. C. Bitner
W. R. Bjorklund
J. A. Blalock*
Blair Blowers
T. F. Burris
H. F. Busch
M. D. Carothers
E. W. Caruthers
H. B. Christianson
C. A. Colpitts
W. E. Cornell
E. D. Cowlin
H. W. Cox, Jr.
F. W. Creedle
P. H. Croft

A. F. Huber, *Secretary,*
L. W. Deslauriers
K. E. Dunn
H. F. Fifield
J. W. Fulmer
R. G. Garland
W. E. Griffiths
C. E. R. Haight
A. E. Haywood
A. B. Hillman
J. P. Hiltz
J. W. Hopkins
W. G. Hulbert
C. H. Johnson
H. F. Kimball
T. R. Klingel
Charles Kuchel
E. E. Martin
R. E. Miller
E. R. Murphy

L. L. Adams, *Vice Chairman,*
W. N. Myers
H. B. Orr
M. P. Oviatt
J. S. Parsons
G. A. Peabody
C. E. Peterson
S. H. Poore
J. A. Reed
M. K. Ruppert
R. D. Simpson
R. C. Slocomb
G. R. Sproles
C. R. Strattman
R. E. Tew
R. H. Timmins
C. E. Weller
Troy West
J. B. Wilson
M. J. Zeeman

Committee

* Died August 29, 1952.

To the American Railway Engineering Association:

Your committee reports on the following subjects:

A

4. Prevention of damage resulting from brine drippings on track and structures, collaborating with Committee 15, and Mechanical Division, AAR.
   Progress report, presented as information .... page 1036

5. Design of tie plates, collaborating with Committees 3 and 4.
   Progress report on tie plate service test measurements and recommendation for reapproval of Manual material on tie plates .... page 1037

6. Hold-down fastenings for tie plates, including pads under plates; their effect on tie wear, collaborating with Committee 3.
   Progress report, submitted as information .... page 1047

7. Effect of lubrication in preventing frozen rail joints and retarding corrosion of rail and fastenings.
   Progress report, submitted as information, and reapproval of Manual material on Track Bolt Tension Practice .... page 1066

8. Field measurement of forces resulting from rail anchorage.
   Progress report, recommending reapproval of Manual material .... page 1080

9. Critical review of the subject of speed on curves as affected by present-day equipment.
   Progress report, submitted as information, and recommended revision of Manual material on curves .... page 1081

10. Methods of heat treatment, including flame hardening, of bolted rail frogs and split switches, together with methods of repair by welding.
    Brief progress report, submitted as information .... page 1083

11. Means of conserving labor and materials, including the adaptation of substitute noncritical materials, and specifications for the reclamation of released materials, tools and equipment, collaborating with Committee 3-A, General Reclamation, Purchases and Stores Division, AAR.
    Progress report, submitted as information .... page 1084

THE COMMITTEE ON TRACK.
F. J. BISHOP, *Chairman.*

AREA Bulletin 507, February 1953.

MEMOIR

James Arthur Blalock

James Arthur Blalock, division engineer of the Richmond, Fredericksburg and Potomac Railroad, who was born in Richmond, Va., March 20, 1915, died on August 29, 1952. He attended the public schools of Richmond and was graduated from the Virginia Polytechnic Institute, Blacksburg, Va., in 1937 with a degree in Civil Engineering.

He started his railroad career on the Pennsylvania Railroad, July 1, 1937, and worked at various points on that system until December 1, 1941, when he went with the Richmond, Fredericksburg and Potomac Railroad as assistant supervisor of track.

He was promoted to supervisor, assistant division engineer, and, in December 1950, he became division engineer, which position he held at the time of his death.

Mr. Blalock's death came after a brief illness and he was buried from St. Marks Episcopal Church in Richmond. He is survived by his wife, Mrs. Elizabeth O'Byrne Blalock, and three sons.

Mr. Blalock became a junior member of the American Railway Engineering Association in 1942, and a member in 1945. He was an active member of Committee 5—Track, from 1945 to the time of his death. He was a Certified Civil Engineer in the State of Virginia and a member of the Roadmasters' and Maintenance of Way Association of America, and member of Meridian Lodge No. 284, AF&AM.

In the death of "Jay" Blalock the railway engineering profession lost a young, forward-looking man, much interested in new and more efficient ways of performing railroad maintenance operations.

The American Railway Engineering Association and the Track committee will miss him as a friend and fellow worker.

MEMOIR

Charles W. Breed

Charles W. Breed, retired engineer of standards of the Chicago, Burlington and Quincy Railroad, died on April 25, 1952. He was born December 17, 1878, at Quincy, Ill., and studied engineering subjects at the Armour Institute of Technology, Chicago. He started his railroad career with the CB&Q in September 1897, and served in various engineering capacities until he entered military service in May 1917. He left the armed service in July 1919 as Captain of Engineers and returned to the Burlington as office engineer. In 1943 Mr. Breed was appointed engineer of standards, in which capacity he served until his retirement in 1948.

Mr. Breed became a member of the AREA in 1921 and was appointed to the Track Committee on which he served continuously until his death. He was most interested and helpful in all of the subjects handled by the Track Committee and was generally a chairman of one of the sub-committees handling such subjects as: Gage and Elevation for Curves, Stringlining of Curves, Bolt Tension for Rail Joints, and Lubrication for Rail Joints.

Mr. Breed served as a member of Committee 16—Economics of Railway Location and Operation, from 1938 until 1948 and, as chairman of a subcommittee prepared several interesting reports on the "Effect of Speeds in Excess of 75 Mph on the Economics of Railroad Operation." He was always a valued member of the AREA and his demise is greatly regretted by its members.

Mr. Breed is survived by his wife, Mrs. Elizabeth Breed, two sons, Charles W. Jr., and Homer, and two married daughters, Mrs. R. Shingle and Mrs. A. W. Esping.

He was a faithful and valued member of the First Congregational Church of Western Springs, Ill., where he resided, and he was also the village engineer of that community.

Report on Assignment 1

Revision of Manual

C. R. Strattman (chairman, subcommittee), L. L. Adams, T. H. Beebe, F. J. Bishop, J. A. Blalock, F. W. Creedle, P. H. Croft, H. F. Fifield, C. E. R. Haight, J. W. Hopkins, A. F. Huber, H. F. Kimball, W. N. Myers, G. R. Sproles, M. J. Zeeman.

Your committee offers the following recommendations with respect to the Manual.

Reapprove the following six documents without change, these documents having been either revised or reapproved by action of the 1952 convention:

Pages 5–11 and 5–12

SPECIFICATIONS FOR HIGH-CARBON STEEL TRACK SPIKES

Page 5–46

SPECIFICATION FOR LUBRICATION OF RAILS ON CURVES

Page 5–20.1

SPECIFICATIONS FOR LAYING NEW TRACK

Page 5–20.4

SPECIFICATIONS FOR LAYING RAIL

Page 5–45

SPECIFICATIONS FOR TAMPING

Page 5–46

SPECIFICATIONS FOR GAGE

The following documents now appearing in the Manual have been reviewed by your committee during the past year and are being offered for reapproval without change:

Pages 5–23 to 5–26, incl.

SPIRALS

Page 5–19

WELDING OF MANGANESE CASTINGS IN SPECIAL TRACKWORK

Page 5–19

OILING OF TRACK FIXTURES

Pages 5–15 and 5–16

SPECIFICATIONS FOR SOFT STEEL CUT TRACK SPIKES

Pages 5–16.1 and 5–16.2

DESIGN OF CUT TRACK SPIKES

Pages 5–38 to 5–41, incl.

STRINGLINING OF CURVES BY CHORD METHOD

Page 5–18

TEMPERATURE EXPANSION FOR LAYING NEW RAILS

Pages 5–44 and 5–45

VERTICAL CURVES

In the seventh paragraph, change definition of "L" to read: "L = Length of vertical curve in 100-ft stations.

In the sketch, place the letter "M", which signifies the distance from point "B" to curve, between the arrows rather than adjacent to the curved line.

Glossary

Change the definition of Track Bolt in the Manual to read as follows:

Track Bolt.—A bolt with a button head and oval, or elliptical, neck and a threaded nut designed to fasten together rails and joint bars.

In the definition of Crossover—Double, or Scissors, page 8, delete the word "Scissors".

Delete the definition, Scissors Crossover, appearing on page 24.

In the Portfolio of Trackwork Plans, under definition of Crossover—Double or Scissors, delete the word "Scissors".

Delete definition of Wye, page 33 of the Glossary and substitute the definition shown on page 30.

Delete definition of Compromise Joint shown on page 7 of the Glossary and substitute the following:

Compromise Joint (Bar).—Joint bars designed to connect rails of different fishing height and section or rails of the same section but of different joint drillings.

Other recommendations affecting Manual material are presented in the following subcommittee reports.

Report on Assignment 2

Track Tools

Collaborating with Committees 1 and 22, and with Purchases and Stores Division, AAR

Troy West (chairman, subcommittee), L. L. Adams, H. S. Ashley, L. E. Bates, F. J. Bishop, W. R. Bjorklund, T. F. Burris, E. W. Caruthers, W. E. Cornell, L. W. Deslauriers, T. R. Klingel, Charles Kuchel, E. E. Martin, W. N. Myers, M. P. Oviatt, C. E. Peterson, R. C. Slocomb, J. B. Wilson.

Part 1

Your committee offers the following recommendations with respect to specifications and plans for track tools appearing in the Manual, pages 5–47 to 5–70, incl.

Pages 5–47 to 5–50, incl.

SPECIFICATIONS

Reapprove with the following minor revisions.

Page 5–48, Art. 4. Acceptance

Change to read:

In order to be accepted the tools must fulfill all the requirements of these specifications and plans.

(The phrase "and plans" was added because the plans are a part of the specifications.)

Page 5–48, Art. 5. Shipment or Delivery

Change to read:

Tools shall be properly packed for shipment to avoid damage. All bundles and boxes shall be plainly marked with the name of the purchaser, purchaser's order number, the name of the manufacturer, and the point of shipment.

(The phrase "purchaser's order number" has been added since it is recognized as necessary shipping information.)

Page 5–48, Art. 9. Spike Mauls—Plan No. 3

In third line, change words "open-hearth" to "carbon" since open hearth refers to a process of making carbon or alloy steel.

Page 5–49, Art. 20. Sledge—Plan No. 13

In third line, change words "open-hearth" to "carbon" since open hearth refers to a process of making carbon or alloy steel.

Page 5–49, Art. 25. Track Shovel—Plan No. 21

Change 2. Materials, first paragraph, to read:

Blades shall be of carbon or alloy steel with a Rockwell hardness for carbon steel of 45 to 50.

(The word "carbon" has been substituted for "open hearth, crucible, electric furnace" since the latter terms refer to processes.)

Page 5–50, Art. 26. Ballast Fork—Plan No. 22

Change to read:

1. Scope and Design

The dimensions shall conform to the plans, which are made a part of this specification. The total variation in the overall length of the forks shall not exceed ½ in more or less of the dimensions shown on plan.

2. Material

Forks shall be made of high-grade carbon steel.

Tines of forks shall show Rockwell hardness of 35–45.

Straps shall be 0.04 U.S. standard gage steel.

3. Handles

This specification covers either wood, malleable iron or combination wood-metal handle tops. Handles shall be made of ash and shall conform to Grade AA and be in accordance with the general Specifications for Handles for Track Tools.

(Related subject matter was regrouped under proper heading. The word "carbon" was substituted for open hearth in subarticle 2.)

Page 5–50, Art. 27. Rail Tongs for Use With Crane—Plan No. 23

Withdraw from the Manual, since this tool is considered unsafe for use.

Pages 5–51 to 5–53, incl.

SPECIFICATIONS FOR ASH AND HICKORY HANDLES FOR TRACK TOOLS

Reapprove without change.

Pages 5–54.1 to 5–70, incl.

PLANS FOR TRACK TOOLS

Reapprove the index and all of the plans shown on these pages, with the following revisions:

Page 5–54.1

Revise index sheet as follows:

Under column headed, Plan Number, show plan number as it appears in title of each individual drawing, such as 1–53.

Under column, Grade of Steel, show subheading, "All steels shall be manufactured by open-hearth process".

Change the symbols "O.H." and the word "Electric" under column, Grade of Steel, to "Carbon".

Change the word "Cast" under column, Grade of Steel, for Plan No. 20, to "See Plan".

(The changes in the index correspond to the revisions recommended on the individual track tool plans and show accurate data for grade of steel that use has established.)

Page 5–54.1

RECOMMENDED LIMITS OF WEAR FOR TOOLS TO BE RECLAIMED

Reapprove with the following change.

Delete reference to Plan 16 in third sentence of the first paragraph since it is considered unnecessary to show limit of wear on such a tool.

Pages 5–54.2 to 5–70, incl.

PLANS

Page 5–54.2. Clay Pick—Plan No. 1–42

Revise as follows:

Change the note, "Double pointed pick shall be furnished when specified. Either type shall be furnished in open-hearth or alloy steel as specified," to read: "Double pointed pick shall be furnished when specified. Either type shall be furnished in carbon or alloy steel as specified."

Change the note, "Brinell 425–500 for O.H. steel only," to read: "Brinell 425–500 for carbon steel only."

Page 5–54.2. Tamping Pick—Plan No. 2–42

Revise as follows:

Change the note, "Furnished in open hearth or alloy steel as specified," to read: "Furnished in carbon or alloy steel as specified."

Change the note, "Brinell 425–500 for O.H. steel only," to read: "Brinell 425–500 for carbon steel only."

Page 5–55. Spike Mauls—Plan No. 3–42

Revise as follows:

Delete type 1 spike maul and show only type 2 maul. This change is recommended because a very large percentage of the railroads now use only type 2 maul.

Change the note, "Furnished in open hearth or alloy steel as specified," to read: "Furnished in carbon or alloy steel as specified."

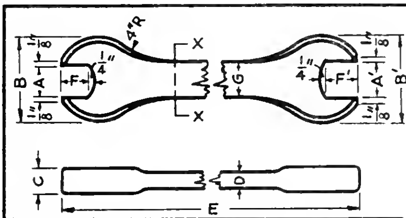
Show that Brinell 425–500 is for carbon steel only.

Page 5–55. Track Wrenches for ASA—Heavy Nuts—Plan No. 4

Page 5–56. Track Wrenches for ASA—Regular Nuts—Plan No. 4–A.

Revise as follows:

Delete Plans No. 4 and No. 4–A and substitute Plan No. 4–53 to conform to recent convention approval of track bolt and nut sizes submitted by the Rail committee.

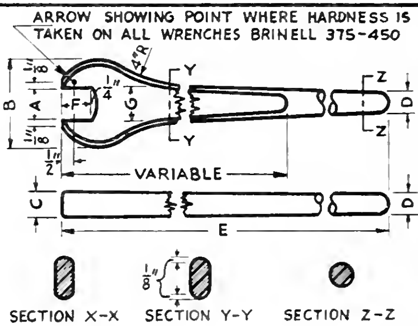


SINGLE END — DIMENSIONS IN INCHES									
BOLT SIZES	WIDTH OF NUT	A MIN	A MAX	B	C	D	E	F	G
3/4	1 1/4	1.257	1.330	3 1/2	15/16	3/4	30	1 1/4	1 1/2
7/8	1 7/16	1.445	1.519	4	15/16	3/4	36	1 1/4	1 1/2
** 1	1 1/2	1.508	1.583	4	15/16	7/8	42	1 3/8	1 1/2
1	1 5/8	1.634	1.709	4	15/16	7/8	42	1 3/8	1 1/2
** 1 1/8	1 11/16	1.696	1.771	4 1/8	15/16	7/8	48	1 9/16	1 1/2
1 1/8	1 13/16	1.822	1.898	4 1/8	15/16	7/8	48	1 9/16	1 1/2
1 1/4	2	2.011	2.088	4 1/2	1	7/8	48	1 3/4	1 1/2
1 3/8	2 3/16	2.199	2.277	5	1	7/8	54	1 15/16	1 1/2

DOUBLE END DIMENSIONS IN INCHES														
BOLT SIZES	WIDTH OF NUT	A MIN	A MAX	A' MIN	A' MAX	B	B'	C	D	E	F	F'	G
3/4 & 7/8	1 1/4 & 1 7/16	1.257	1.330	1.445	1.519	3 1/2	4	15/16	1/2	36	1 1/4	1 1/4	1 1/2
7/8 & 1	1 7/16 & 1 5/8	1.445	1.519	1.634	1.709	4	4	15/16	1/2	42	1 1/4	1 3/8	1 1/2
** 1 & 1 1/8	1 1/2 & 1 11/16	1.508	1.583	1.696	1.771	4	4 1/8	15/16	9/16	48	1 3/8	1 9/16	1 1/2
1 & 1 1/8	1 5/8 & 1 13/16	1.634	1.709	1.822	1.898	4	4 1/8	15/16	9/16	48	1 3/8	1 9/16	1 1/2
1 1/8 & 1 1/4	1 13/16 & 2	1.822	1.898	2.011	2.088	4 1/8	4 1/2	*	9/16	48	1 9/16	1 3/4	1 1/2
1 1/4 & 1 3/8	2 & 2 3/16	2.011	2.088	2.199	2.277	4 1/2	5	1	9/16	48	1 3/4	1 15/16	1 1/2

** SIZES NOT RECOMMENDED FOR NEW DESIGN

* C = 15/16 ON 1 1/8 END, 1 ON 1 1/4 END



NOTE:

1. WIDTH OF NUT SHALL BE STAMPED PLAINLY IN 3/4" CHARACTERS ON ONE SIDE OF HEAD NEAR EACH JAW
2. TOLERANCE –
   2% ON LENGTH
   5% ON CROSS SECTION
3. SINGLE END WRENCH WILL BE FURNISHED WITH END TAPERED FOR LAST 6" TO 1/2" DIAM AT END WHEN SPECIFIED
4. ALL WRENCH JAWS SHALL BE MILLED TO DIMENSIONS SHOWN

Plan No. 4–53—Track wrenches for AREA recommended track bolt nuts.

Page 5–57. Tie Tongs—Plan No. 7–46.

Revise as follows:

Redraw the plan to show round handles. Add note, "Handles can be made from ½-in by 1-in bars, if preferred, instead of rounds as shown.

(This is recommended because the round handles are safer and are used by almost all of the railroads.)

Add insert to show enlargement of peavy point for clarity.

Change the note, "Furnished in open-hearth or alloy steel," to read: "Furnished in carbon or alloy steel."

Page 5–58. Timber Tongs—Plan No. 8–40

Revise as follows:

Change the note, "Furnished in open hearth or alloy steel," to read: "Furnished in carbon or alloy steel."

Add insert to show enlarged view of peavy point for clarity.

Page 5–60. Track Adze—Plan No. 12–44

Revise as follows:

Change note, "Furnished in open hearth or alloy steel as specified," to read: "Furnished in carbon or alloy steel as specified."

Show that Brinell 375–450 applies to carbon steel only.

Page 5–61. Carpenters Adze—Plan No. 12-A-42

Revise as follows:

Change the note, "Furnished in open hearth or alloy steel as specified," to read: "Furnished in carbon or alloy steel as specified."

Page 5–61. Double Faced Sledge—Plan No. 13–45

Revise as follows:

Change the note, "Furnished in open hearth or alloy steel as specified," to read: "Furnished in carbon or alloy steel as specified."

Show that Brinell 425–500 applies to carbon steel only.

Page 5–63. Track Chisel—Plan No. 17–44

Revise as follows:

Change angle of cutting edge from 55 deg to 65 deg and change radius of cutting edge from 1 in to 1½ in. This change is recommended because use has proved that the blunt and flatter edge is safer and more durable.

Change the note, "This design furnished in open hearth or alloy steel," to read: "This design furnished in carbon or alloy steel as specified".

Page 5–64. Tie Plug Punch—Plan No. 18–42

Revise as follows:

Add note, "Furnished in carbon or alloy steel as specified."

Show Brinell hardness applies to carbon steel only.

Page 5–64. Round Track Punch—Plan No. 19–42.

Revise as follows:

Add note, "Furnished in carbon or alloy steel as specified."

Show that Brinell hardness as shown applies to carbon steel only.

Page 5–67. Rail Tongs for Use with Crane—Plan No. 23–47.

Withdraw from Manual since it is considered unsafe for use.

Page 5–69. 26-In Scythe—Plan No. 28–40

Revise as follows:

Delete note, "Furnished in crucible, cast, or tool steel as specified. To be properly forged and tempered, cutting edge to be ground and polished."

(This is recommended because it is considered too restrictive.)

TRACK SPIKE STARTER

Work is being continued in the development of a track spike starter by trying out in field tests three varying designs of starters on five different railroads.

Part 2

Use of Aluminum Alloy In Making Track Tools

The following is a progress report, submitted as information.

Information has been developed on this subject by a letter questionnaire to principal railroads on the desirability of lighter tools and by a laboratory investigation about the utility of aluminum alloy in making track tools.

In a letter canvas last May to the engineering departments of principal railroads, they were asked whether or not they use any track tools made of aluminum alloy, and if so, to let the committee know if their use has been satisfactory. Also, they were asked for their opinion about the necessity of further developing their use.

The committee received 78 replies, and a summary of the information received is as follows:

74 percent of those who replied have used aluminum alloy tools.
95 percent of those who have used aluminum tools say that their use has been satisfactory.
56 percent replied that they were interested in further development.
33 percent replied that they were not interested in further development.
11 percent made no comment.

The experience of those who reported on having used aluminum tools was based in almost all cases on the use of aluminum track jacks.

The main reason indicated in the replies to wanting further development was hope for added productivity by the track men who are required to use them.

Those who reported that they were not interested in further development said they thought the cost would be too much higher in comparison with tools made of ferrous metal.

The following is a report of a laboratory test of three aluminum specimens made by the research staff, Engineering Division, AAR.

BEND TESTS OF LINING BARS

Foreword

These laboratory tests were made as a part of the investigation of the use of aluminum alloys for the purpose of reducing the weight of track tools. Comparative bend tests were made with four 5-ft 6-in lining bars including one of C–1060 steel made in accordance with AREA Plan 5–44, and three forged from an aluminum alloy designated 14S–T6. This is a high-strength alloy having an ultimate tensile strength of 70,000 psi and a yield strength of 60,000 psi. Unlike carbon steel, the above mentioned aluminum alloy does not become brittle at sub-zero temperatures. The physical properties remain about the same to — 50 deg F, and gradually improve for lower temperatures.

Test Specimens

Three aluminum specimens were furnished for a comparative test with one AREA carbon steel specimen, 5-ft 6-in. in length by 1½ in square. Two of the aluminum alloy specimens were made 2-in square for the purpose of providing a stiffness equal to that of the 1½-in square carbon steel specimen. One aluminum specimen was furnished with approximately the same dimensions as those for the carbon steel lining bar.

Dimensions for the four bars are given in the table included in Fig. 1. The aluminum bars were forged cold, and the finished bars had many deviations in the surface and shape of the cross section.

Test Procedure

In the AREA Specifications and Plans for Track Tools, the following physical test for lining bars is specified (Manual, page 5–48):

> "One bar to be tested from each lot of 10 dozen or less by applying a load of 350 pounds 12 inches from the end of the handle, with the point suitably secured 3 inches from the end, without leaving a permanent set in excess of ¼ inch."

The bend tests on the four specimens were not conducted exactly in the above manner because of the difficulty in rigidly securing the bars along the 3-in length of the wedge point for the loads contemplated in making the bend test. Accordingly, the bars were held in the testing machine by clamping a 6-in length of the uniform section of the bar, as shown in the top portion of Fig. 1. This method reduced the moment arm for testing the 5-ft 6-in lining bars from 51 in (AREA) to 45 in for all of the specimens. The load at position P (Fig. 1) was applied by increments of 50 lb with a calibrated chain hoist scale.

Test Results

The graph in the lower portion of Fig. 1 shows load-permanent set curves for each of the four specimens. The two aluminum bars, with the 2-in square section (Nos. 9 and 10), developed a smaller permanent set than the other two bars having the 1½-in square section. None of the bars had any noticeable set below 350 lb. On the basis of having maximum bending stresses in the 5-ft 6-in AREA bars equal to that resulting from the 350-lb load with a 51-in moment arm, the load should be increased to 400 lb for the 45-in arm. All four specimens exceeded the requirement of the AREA bend test of ¼-in maximum permanent set with a 350-lb load, and a 51-in moment arm, or the equivalent 400-lb load with a 45-in arm.

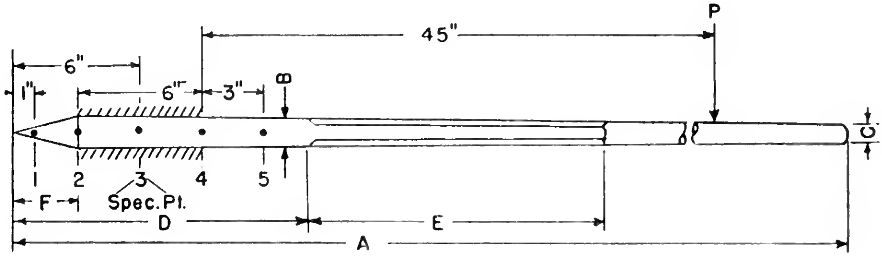
Using the carbon steel bar as the basis of comparison, it was determined that for a given amount of permanent set in inches, specimen 8 (1½-in square aluminum) required a load 28 percent less than the corresponding load on the carbon steel bar. The corresponding figure for the 2-in square aluminum bars (Nos. 9 and 10) exceeded the loads for the steel bar by 40 percent.

It will be observed in the table of Fig. 1 that the Brinell readings for the aluminum bars reached a maximum of 143 for 500-kg load. This figure for the 3000-kg load is equivalent to a Brinell hardness of 166. The 2-in square aluminum bars were 9¼ to 11¼ lb lighter than the 25½ lb steel bar, while the 1½-in square aluminum bar was 16½ lb lighter.

Summary

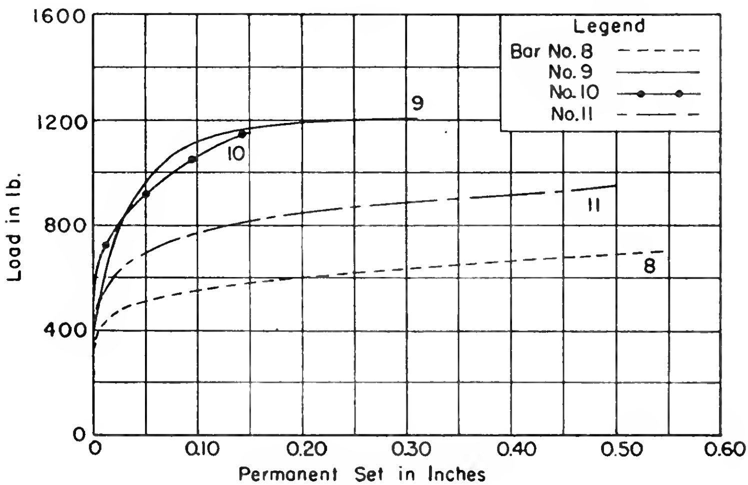
All three of the aluminum alloy bars exceeded the requirement of the AREA bend test previously described.

The 2-in square aluminum bars had considerably more resistance to taking permanent set than both of the 1½-in square bars, but they cannot be used in existing track jacks because the present design will not accommodate a bar larger than 1½-in square. One large manufacturer of track jacks advised that it would be a major change in design of the socket and connections to provide space for the 2-in square bar.



Bar No.	Metal Kind	Metal Desig.	Wt. (lb.)	Principal Dimensions A	B	C	D	E	F	Brinell Hardness 1	2	3	4	5
AREA*			26	66"	$1\frac{1}{2}$"	$\frac{7}{8}$"	14"	14"	3"			300–375		
11	C.Stl.	1060	$25\frac{1}{2}$	66"	$1\frac{1}{2}$"	1"	$14\frac{3}{8}$"	$13\frac{1}{2}$"	$3\frac{1}{4}$"	418	375	364	265	286
8	Al.	14ST6	9	$66\frac{1}{2}$"	$1\frac{1}{2}$"	$1\frac{1}{16}$"	$10\frac{1}{2}$"	$13\frac{1}{2}$"	$3\frac{1}{8}$"	143	136	130	119	136
9	"	"	$14\frac{1}{4}$	71"	2"	$1\frac{3}{16}$"	12"	20"	$4\frac{3}{8}$"	136	130	136	130	130
10	"	"	$16\frac{1}{4}$	$68\frac{1}{2}$"	2"	$1\frac{5}{16}$"	12"	21"	$4\frac{1}{16}$"	143	124	143	143	143

Note: Brinell Hardness readings on Bars No. 8, 9 and 10 made using a 500 kg load, and on Bar No. 11 with a 3000 kg load.



* AREA Plan 5-44-26 lb

Fig. 1—Principal Dimensions, Brinell Hardness, and Permanent Deflection Curves for Four Designs of Aluminum and Steel Lining Bars.

Acknowledgement

The Association is indebted to (1) Hubbard and Company for furnishing the carbon steel lining bar and forging the others, and (2) the Aluminum Company of America for providing the aluminum alloy for three of the test specimens.

Part 3

Bend Tests of the Nipping End of Claw Bars

The following report is presented as information.

The subcommittee requested the Engineering Division research staff to make an investigation to determine the extent to which the strength of the nipping end of claw bars was affected by the deformed safety hand stop. The following is a report of that investigation, and further consideration will be given by the subcommittee to possible changes in the design of the hand stop and heat treatment of the nipping end of the claw bar.

Introduction

The AREA design of claw bar (Manual Plan 11–51) has been in use for several years, and in recent years a few of them have been permanently bent when the nipping end was used. The sharp portion of the bend usually occurred close to the deformed safety hand stop which is located 10 in from the nipping end. Plan 11–51 specifies a Brinell hardness of 300–375 (3000 kg) on the claws and at a point 5 in from the point of the nipping end. The remainder of the bar length is not heat treated. Hubbard & Company furnished the specimens for these tests and advised that C–1060 steel was used for forging the claw bars. Each end of the AREA specification bars was heated for about 1 ft in length to 1600–1650 deg F and quenched in oil. Each end for a length of about six in was then drawn in a lead pot at 700 deg for 30 min.

It, therefore, was presumed that permanent bending of the bars near the nipping end was influenced by the deformed safety hand stop and the absence of heat treatment at that location. At the suggestion of the Subcommittee on Track Tools, the AAR research staff conducted a test with each of nine claw bars by bending them at the nipping end, and measuring stresses at and near the hand stop and the loss in deflection of the bars at the heel of the claw end.

Objective

The purpose of this investigation was to determine the most practical and economical changes in the design or the manufacture of the bars required to increase their resistance to becoming permanently bent near the nipping end.

Scope of Tests

These laboratory tests were made with three groups of bars. The first group of bars, consisting of specimens A and B, was tested in the winter of 1951. Bars A and B were of the AREA design and heat treatment, except that the safety hand stop was omitted from bar B. This comparison was for the purpose of determining if the bending strength of the bars at the nipping end was affected by the reduced bar section at the hand stop.

The second and third groups of bars were tested in a similar manner during the summer of 1952. The second lot consisted of four specimens, numbered 1 to 4, incl. Bars 1 and 2 were of the AREA design, except that the heat treatment at the nipping end was extended beyond the hand stop, and bar 2 was forged without the hand stop. Bars 3 and 4 were made according to AREA Plan 11–51 (without extended heat treatment), except that both bars had an elliptical section instead of an oval section for part of the transition between points E and G on the handle, as shown in Fig. 5, and the hand stop was omitted from bar 4.

The third group of bars, consisting of specimens 5, 6 and 7, was tested to determine the effect of changing the shape of the hand stop. All bars had the heat treatment extended from the nipping end to beyond the hand stop. The three designs of hand stops are shown in Fig. 7.

Test Procedure

SR–4 wire resistance strain gages, ¼ in. in length, were mounted on the bars at the locations shown in Figs. 3, 5, and 7. Gages 1T, 2T, 3B, 4T, and 7T were used for measuring the primary bending stresses, and gages 5TLS and 6TL were for measuring the localized stresses on the bars having a hand stop that involved a change in cross section. Gage 7T was used only on the bars having the extended heat treatment. Gages 2T and 3B were placed at the mid-length of the hand stop, or at the corresponding positions on the bars without the hand stop. A fulcrum was made and fastened to a tie for holding the bars in the testing machine.

The strain measurements were made with a static strain indicator for each 50 lb or smaller increment of load applied at the claw bar heel. After each increment of load the bars were fully released for the purpose of (1) checking each gage for its zero stress reading and permanent set in the steel, and (2) measuring the loss in deflection of each bar at the heel. The first two groups of bars were loaded to values between 350 and 400 lb. For the third group the fulcrum was changed to provide more clearance between the tie and the claw end of the bars, and these 3 bars were subjected to loads of 450 to 475 lb. Some of the strain gages went out of range, or failed, when the yield strength of the bars at the gage location was exceeded. However, the loss in deflection at the heel of the bars was measured for all loads. Figs. 1 and 2 show two of the bars being tested in the Baldwin–Southwark hydraulic testing machine.

Brinell hardness readings were taken on each bar after the bend test. Prior to the test, the dimensions and weights of all bars, except A and B, were measured for comparison with Plan 11–51.

Discussion of Test Data

Bars A and B

The results of testing these two AREA design bars, except that bar B had no hand stop, are shown in Figs. 3 and 4. Fig. 3 shows the gage locations, hardness readings and initial position of the bars. It will be noted that the heat treatment ended between gages 1T and 2T–3B at the hand stop. In Fig. 4 the load strain graphs are given for each strain gage on the bars. Strains were plotted instead of unit stresses for the purpose of showing more clearly the load at which the yielding occurred. The stresses shown in Fig. 4 (and also Figs. 6 and 8) for each load-strain curve, were the largest values that could be converted from the strain measurements at or below the point where each gage first failed to return to its zero reading upon release of the load. In cases where no yielding was indicated by a strain gage, the stresses shown are for the maximum load applied. Gage 1T was in the heat-treated portion of each bar, and no yielding of the steel occurred at that location in either bar. Some yielding of the steel occurred at all other gage locations on both bars. Corresponding load-strain curves for each gage location on the two bars were remarkably similar. Both bars had practically no permanent loss in deflection at the heel for a 250-lb load. Beyond that load the increase in set was more rapid. The bar without the hand stop, for the maximum load, sustained approximately 2 percent more load with 7 percent less permanent set than the one with the deformed section. The bend left in each bar near the nipping end was about the same.

The middle ordinate of the bend taken from a 12-in straightedge centered about a point 10 in from the nipping end was ¼ in for each bar.

It is evident from the test results that the bars yielded and bent just beyond the heat-treated portion at the nipping end. The deformed section at the safety hand stop had little effect on the resistance of the claw bar to become permanently bent for loads up to 370 lb. Extension of the heat treatment beyond the hand stop location would appreciably reduce the amount of bending in that portion of the bars.

Bars 1, 2, 3 and 4

Tests of these four bars were divided into two categories: First, to determine the benefit of extending the heat treatment beyond the hand stop location, and second to evaluate the effect of changing the cross section of the handle along the 36 ½-in length next to the heel of the nipping end. Bars 1 and 2 were of the AREA design, except both had extended heat treatment, and bar 2 was forged without the hand stop. Bars 3 and 4 were made according to Plan 11–51 (without extended heat treatment), except that the oval section at point E (Fig. 5) was changed to an elliptical shape which extended about half way to point G. For convenient comparison of all four bars, the test results are shown in Figs. 5 and 6.

In the lower table of Fig. 5 the principal dimensions and weights of the four specimens are given, and the same information for the AREA design is included for comparison. Point E was chosen to be at the section where the vertical thickness of the specimens was 1¼ in, which is the plan dimension for the section 36½ in from the heel of the nipping end. At that section the horizontal thickness is specified to be 1⅛ in on Plan 11–51. According to the plan, dimension D-E (Fig. 5) for the transition from the 1⅛-in by 1¾ in rectangular section to the 1⅛-in by 1¼-in oval section is 10½ in. From the table of dimensions (Fig. 5) it will be observed that dimension D–E for the four test specimens ranged from 20⅛ in to 31½ in. This deviation in dimensions provides a stiffer bar in the vertical direction. From the table of dimensions it will also be observed that the sections of the bars at other points were larger than the plan dimensions. The Brinell hardness readings shown in the upper table of Fig. 5 indicate that bars 1 and 2, with the extended heat treatment, were heat treated at all of the strain gage locations. Conversely, all of the strain gages on bars 3 and 4 were outside of the heat-treated zone. Gages 1T on bars A and B were on the heat-treated portion of the bars.

Bars 1 and 2

The load-strain curves at gages 1T for bars 1 and 2 (Fig. 6) are similar and closely spaced. At companion gages 2T and 3B at the mid-length of the hand stop, on the corresponding locations on bar 2 without the hand stop, the strain in bar 1 for a given load was greater than that for bar 2. This difference reflects the effect of the reduced section at the hand stop of bar 1. The curves at gages 4T and 7T also show a larger strain in bar 1 for the same loading. This difference may have been caused by the moment arm of the load on bar 1 for a given load being larger than for bar 2, because of a difference in the angularity of the bar when loaded. In these tests the bending moment at a gage location is not in direct proportion to the applied load, because in deflecting the bar downward, the moment arm increases as the bars approach a level position. The stress in bar 1 at gage 5TLS did not reach the yield point of the bar. The stress at gage 6TL in bar 1 was higher than at gage 5TLS, and there was a little yielding. Bar 1, for a maximum load of 390 lb, lost 2$\frac{1}{16}$ in deflection at the heel as compared with 2¾ in for a load of 400 lb for bar 2. Although the stresses were higher in bar 1 with the hand stop than in bar 2, the resistance of the two bars to being permanently bent was fairly comparable. After completion of the test of bars 1 and 2 there was no perceptible bend in either one at the hand stop location.

By comparing the results of the test of bars 1 and 2 with those for bars A and B (Fig. 4), it can be concluded that the extended heat treatment near the hand stop location of bars 1 and 2 has effectively strengthened the bars near the nipping end and greatly reduced the yielding of the bars at most of the gage locations.

Bars 3 and 4

The test of bars 3 and 4 was to determine if the change in section of part of the handle, previously described, would improve the strength of the bars. Otherwise the bars were made in accordance with Plan 11–51, except that bar 4 did not have the hand stop. The load-strain curves are also shown in Fig. 6 and can be compared with the curves for bars 1 and 2. Except at gage 4T, corresponding gages on bars 3 and 4 showed a greater strain, or stress, in bar 3 with the hand stop. Gage 5TLS showed a smaller stress for bar 3 than for bar 1, and it is possible that the gage on bar 3 was not located precisely at the stress concentration or at the same angle with the axis of the bar as on specimen No. 1. Gage 6TL showed considerably more yielding on bar 3 than on bar 1. In the upper right portion of Fig. 6, the loss in heel deflection of the bars is shown. After the gages had gone out of range of the strain indicator, bars 3 and 4 were further loaded to obtain greater yielding. Bar 3 yielded much more than bar 4 for the higher loads. In the case of bars A and B, bar A with the hand stop only yielded slightly more than bar B without the hand stop. Bars 3 and 4 had final loads of 350 lb and 375 lb, respectively. The sharpness of the bend left in the bars at the hand stop location was greater than for bars A and B. The middle ordinate of the bend at 10 in from the nipping end, as measured from a 12-in straightedge, was ¼ in for bars A and B, ⅜ in for bar 3, and 5/16 in for bar 4.

In the test of bars 3 and 4, the bar with the hand stop was weaker than the other one. The revision of the section along part of the handle was of no benefit so far as the loss in heel deflection was concerned. However, there is evidence from Figs. 6 and 4 that bars 3 and 4 had less yielding than bars A and B at gages 2T, 3B, 4T, 5TLS and 6TL. This improvement is of minor importance compared with the benefits that resulted from the extended heat treatment used for bars 1 and 2.

Bars 5, 6 and 7

The third group of bars had the heat treatment extended beyond the hand stop, and each specimen had a different design of hand stop. All of the bars were of the AREA design as to dimensions, except for the details at the hand stop which are shown in Fig. 7. Bar 5 was provided with a hand stop which eliminated the abrupt changes in cross section of the AREA design. Bar 6 had a hand stop similar to the AREA design, except that the excess steel squeezed out on the top and bottom sides in forming the deformed section was left in place after smoothing out the minor irregularities of the bulged metal. This design serves to strengthen the hand stop in a vertical plane. Bar 7 had the offset or bent type of hand stop which is standard on the Pennsylvania Railroad. The cross section of the hand stop was uniform, except for the slight taper in the transition portion of the handle. The initial position of the bars, principal dimensions and hardness readings are also shown in Fig. 7. All strain gages on the three bars were in the heat-treated portion of the nipping end. These bars, like the others, had several deviations from the plan dimensions, but in most instances the actual cross sections were larger than those specified on Plan 11–51. The major variations in the dimensions of the three specimens were in the lengths D–E and E–G. Dimension D–E, which is specified 10½ in on Plan 11–51, varied from 24 to 27½ in. These variations increased the stiffness of the specimens, but the added strength would be more advantageous when the claw end of the bars is used.

The load-strain curves for each of gages 1T, 4T and 7T (Fig. 8) are grouped together, and there was little difference in the strain in the three specimens for a given load and gage position. Companion gages 2T and 3B, located at the mid-length of the hand stop, had widely separated curves which reflect accurately the differences in the section moduli of the three bars about the horizontal neutral axis. Bar 6 had the greatest strength and bar 5 the lowest. There was no significant difference in bars 5 and 6 at gage position 6TL. Gage 5TLS for bar 6 was not operating properly because the strain values obtained were much smaller than recorded in other similar tests. It seems probable that only a portion of the ¼-in length of the gage was deformed as specimen bar 6 was loaded. All three bars lost approximately ½ in deflection at the heel for a load of 350 lb. Bar 6 lost 5 in of deflection for a load of 450 lb, compared to 4 in for bars 5 and 7 for 475 lb. Bar 6 had more strength at the hand stop, but it sustained the largest permanent set. As in the case of bars 1 and 2 with extended heat treatment, specimens 5, 6 and 7 were not perceptibly bent near the hand stop after completion of the tests.

The bend test of specimens 5, 6 and 7 effectively demonstrated that the shape of the hand stop, if in the heat-treated zone, had little effect on the resistance of the bars to becoming permanently bent when using the nipping end. From an engineering viewpoint, the hand stop on bar 5 is the best design, but from the standpoint of safety, it is the one that a man would most likely overlook when sliding his hand along the bar. Under the stress of cold weather and partially frozen gloves, the offset type of hand stop on bar 7 is the one that would least likely be overlooked. The hand stop of bar 6 is judged to be superior to the AREA design, both from the standpoint of strength of the bar and safety.

Summary

Bars Without Extended Heat Treatment

The results of the bend test of bars A and B, which were not heat treated at the hand stop location, indicated that the deformed section had no important adverse effect on the stresses and permanent bending of the bars, except for the localized strains at gages 5TLS and 6TL. The test of bars 3 and 4, having the revised section in the handle and no extra heat treatment, indicated that bar 3 with the hand stop was weaker than bar 4 when bent about the nipping end. No benefits were obtained by modifying the cross section of part of the handle between point E and the hand stop location.

Bars With Extended Heat Treatment

From the tests of bars 1 and 2 with heat treatment extending from the nipping end to about 5 in beyond the mid-length of the hand stop location, the results showed conclusively that the bars, regardless of the presence of the hand stop, had been strengthened sufficiently to reduce the permanent bending of the bars to an unimportant amount for loads up to 400 lb.

The tests results for bars 5, 6 and 7 indicated that, for all practical purposes, the shape of the hand stop had little effect on the resistance of the bars to becoming bent, provided the heat treatment extended through the hand stop location.

(Text continued on page 993)

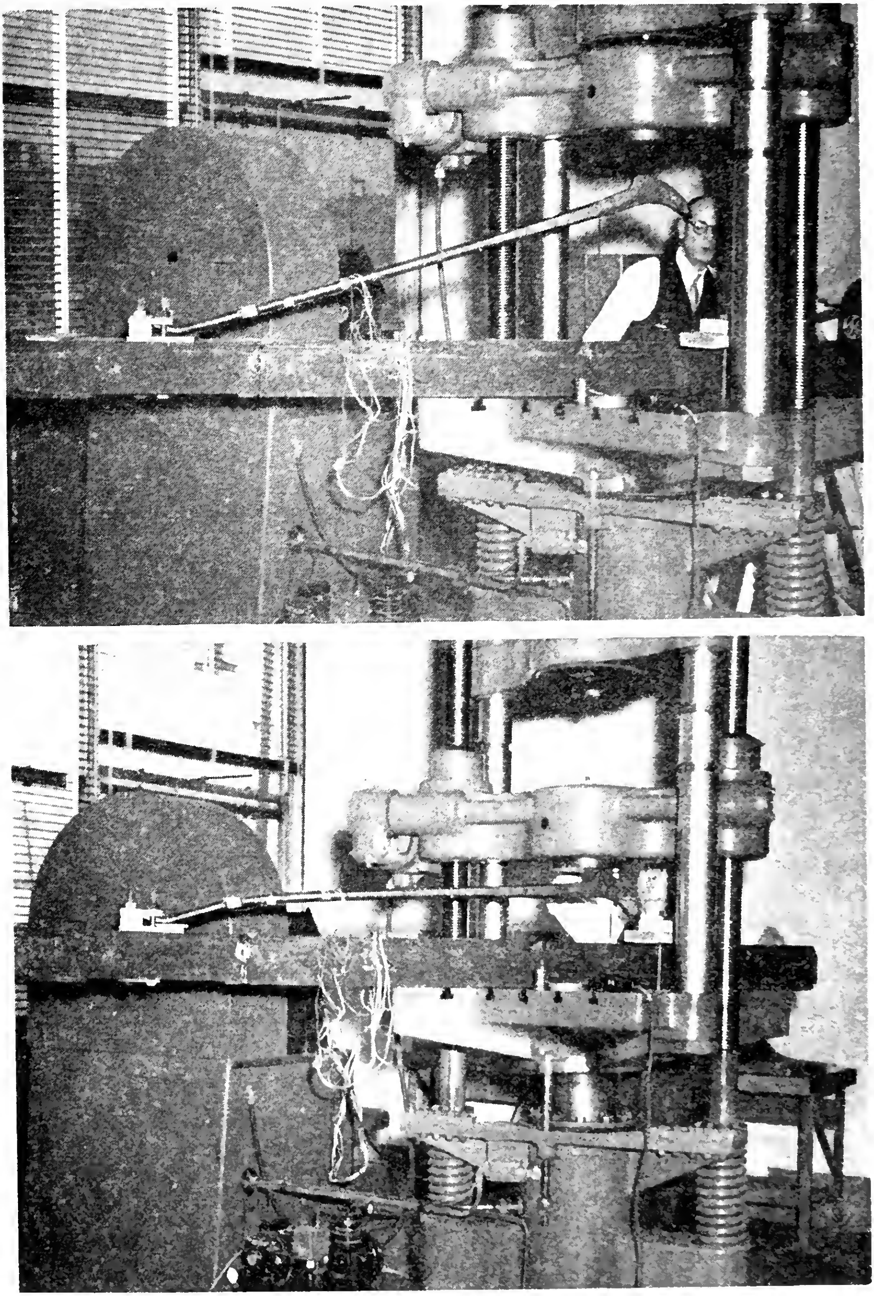


Fig. 1 - Testing AREA Claw Bar A with Safety Hand Step.
Upper View - Initial Position of Claw Bar
Lower View - Final Load at 370 lb. on Claw Bar with Fulcrum Shimmed.

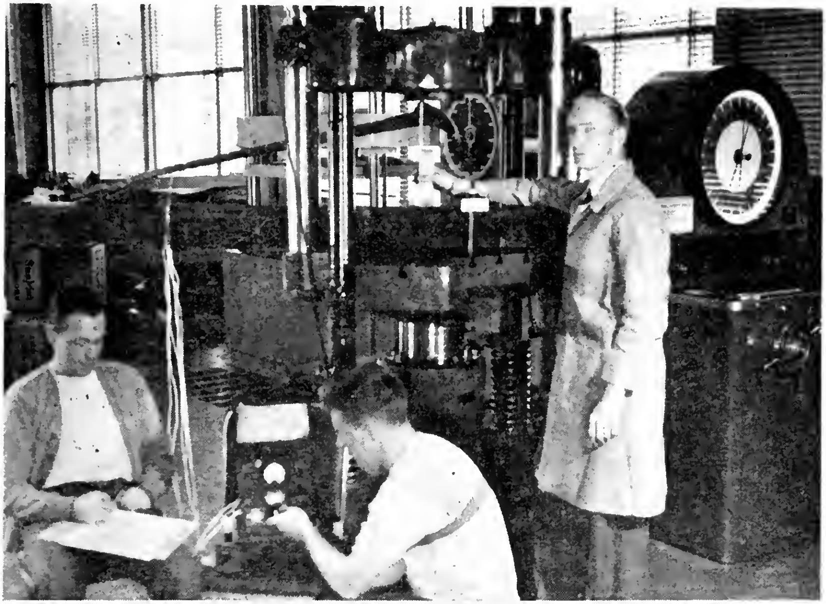
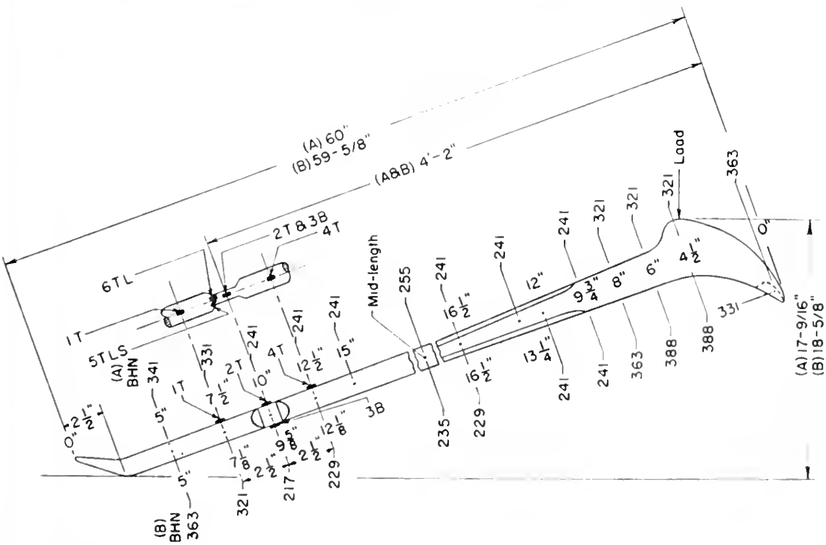


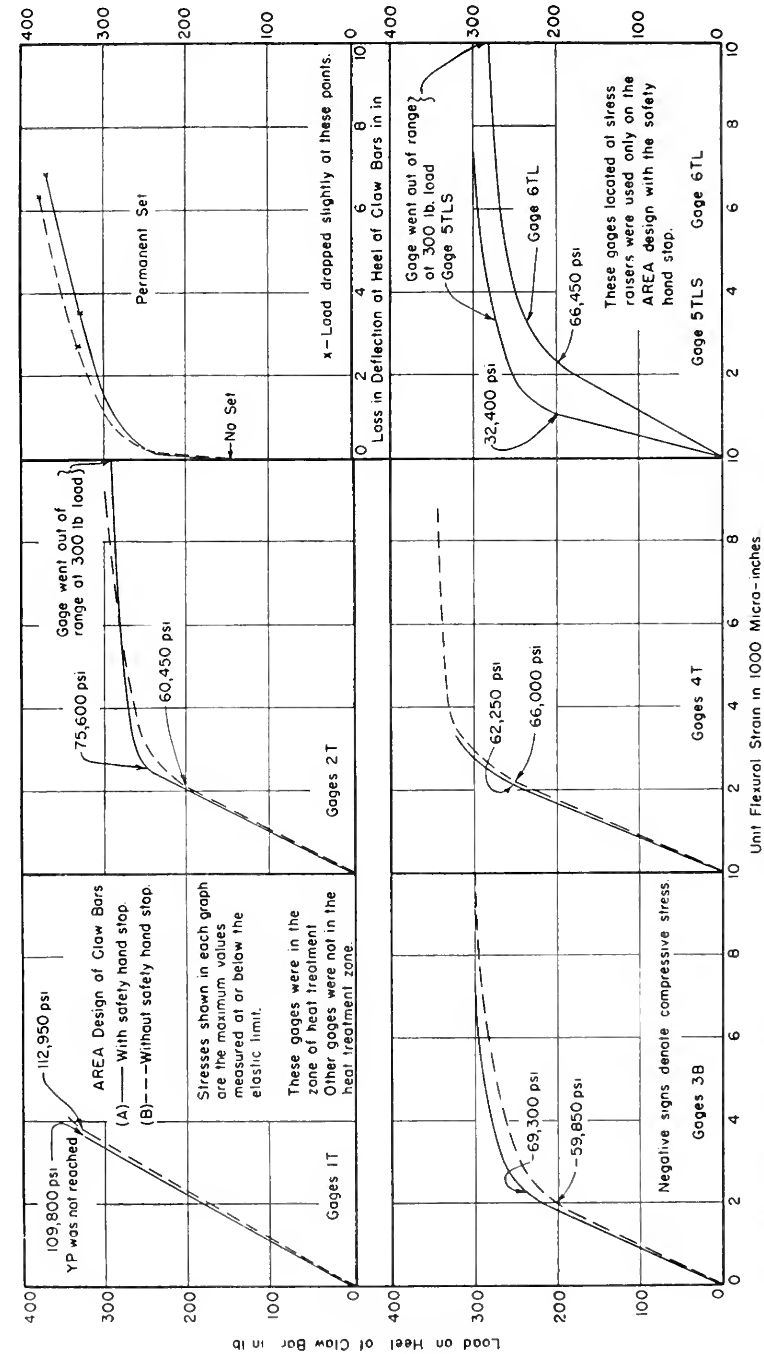
Fig. 2 — Bar 7 with Offset Safety Hand Stop Loaded to [illegible] lb.



(A) With safety hand stop
(B) Without safety hand stop

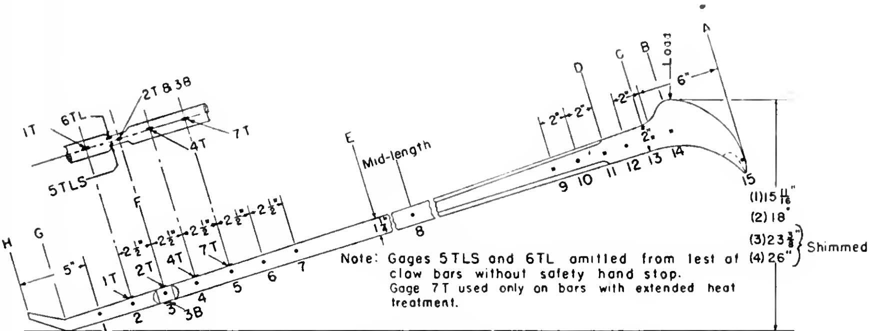
Note: Gages 5TLS and 6TL were omitted from the test of the claw bar without the safety hand stop.

Fig. 3 — Initial Position of Claw Bars Showing Strain Gage Locations and Hardness Readings (Bars A and B)



Note Below the elastic limit, the unit strain may be converted to stress in psi by multiplying the micro-inches by 30.

Fig. 4—Load—Strain Graphs for SR-4 1/4 in Strain Gages and Permanent Set of Claw Bars A and B.



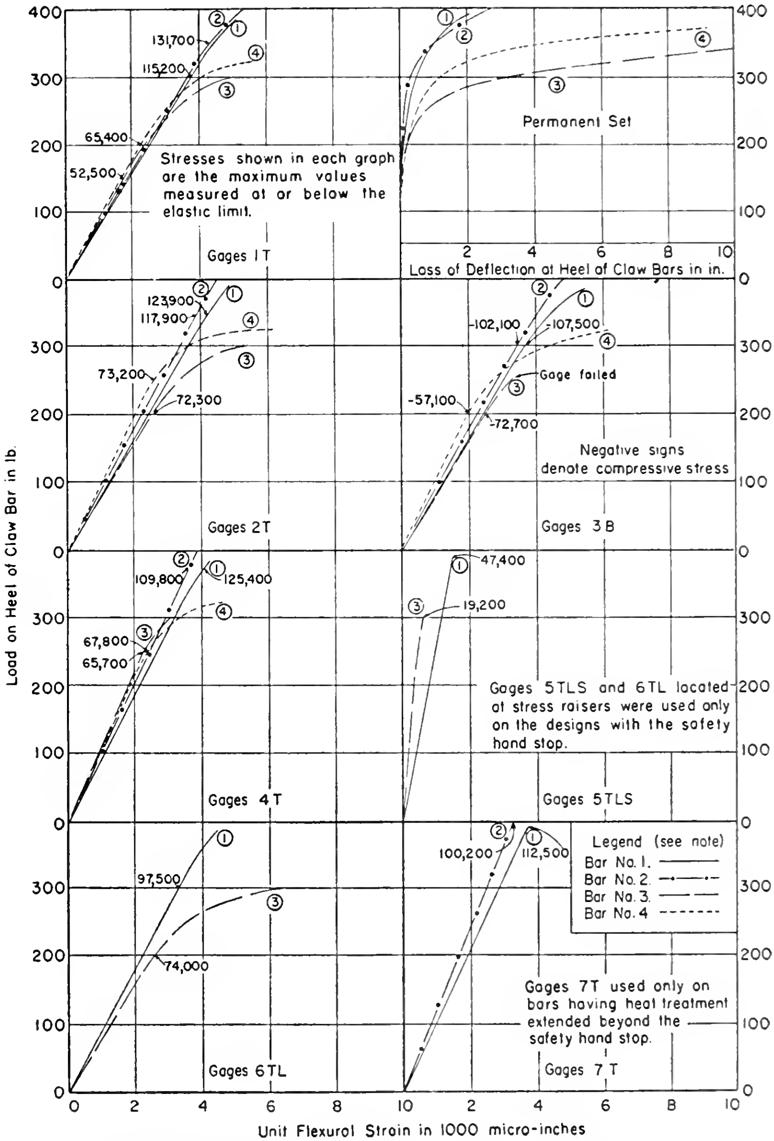
Bar	*1	2	3	4	5	6	7	8	9	10	11	12	13	14	*15
	Brinell Hardness (3000 kg.)														
1	375	340	321	321	302	241	229	241	217	212	229	340	342	364	375
2	327	364	293	302	311	207	207	241	217	217	302	277	332	340	340
3	364	207	229	229	229	212		223	187	201	282	332	340	302	387
4	340	229	229	241	235	207		229	189	212	293	302	340	335	337

Principal Dimensions in Inches																		
	Lengthwise								Cross Sectional									
									B		D		E		F		G	
Bar	A-B	B-C	C-D	D-E	E-G	G-H	A-F	A-H	V	H	V	H	V	H	V	H	V	H	Weight (lbs.)
AREA	4 3/8	1 7/8	4 1/4	10 1/2	36 1/2	2 1/2	50	60	3 9/16	1 1/8	1 3/4	1 1/8	1 1/4	1 1/8		5/8	1	1	27 ±
1	4 3/8	2 1/8	1 7/8	21 3/8	27 3/8	2 3/8	50	60	3 5/16	1 3/8	1 7/8	1 1/4	1 1/4	1 1/4		11/16	1	1 1/16	26.6
2	4 3/8	2 1/8	3 1/4	20 1/8	27 7/8	2 1/4		60 3/16	3 1/4	1 7/16	1 3/4	1 3/16	1 1/4	1 1/4			1	1 1/16	26.3
3	4 1/4	2 5/16	3 1/16	31 1/2	17 1/4	2 1/4	50 3/8	60 7/8	3 9/16	1 7/16	1 13/16	1 3/16	1 1/4	1 1/8		5/8	1	1	26.5
4	4 1/4	2 1/4	3 1/8	20 1/8	28 3/16	2 1/4		60 3/16	3 5/16	1 7/16	1 3/4	1 3/16	1 1/4	1 1/4			1	1 1/16	26.8

*Brinell hardness readings of 300-375 at points 1 and 15 are specified

AREA — AREA Plan 11-51
Bar No. 1 — AREA Plan 11-51 with heat-treatment extended beyond safety hand stop
Bar No. 2 — Same as Bar No. 1 except no safety hand stop.
Bar No. 3 — AREA Plan 11-51 except eliptical section handle.
Bar No. 4 — Same as Bar No. 3 except no safety hand stop.

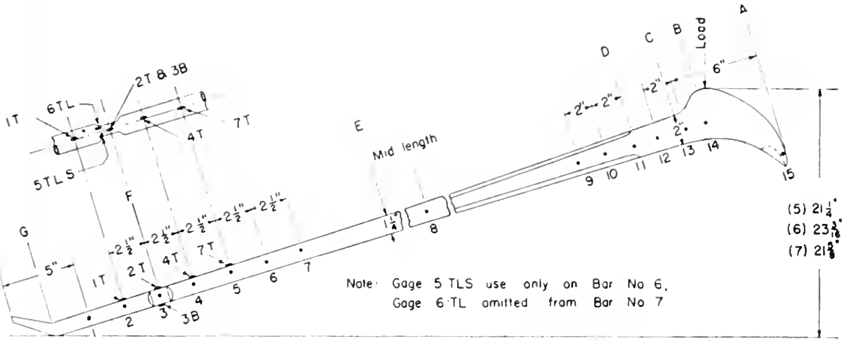
Fig. 5. Initial Position of Claw Bars Showing Strain Gage Locations, Hardness Readings and Principal Dimensions (Bars 1, 2, 3 and 4)



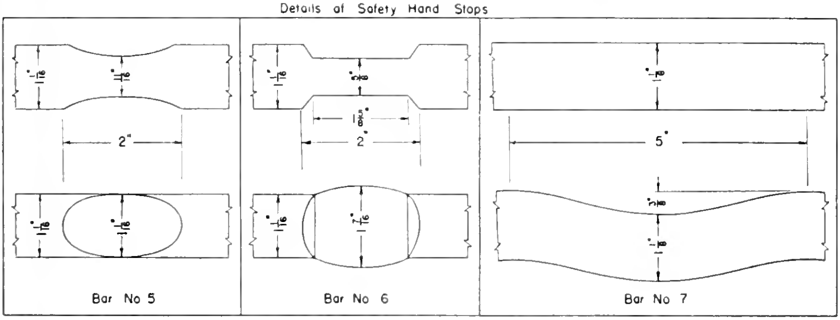
Note: Below the elastic limit, the unit strain may be converted to stress in psi by multiplying the micro-inches by 30.

Bar No. 1 AREA Plan 11-51 with heat treatment extended beyond the safety hand stop
No. 2 Same as Bar No. 1 except without safety hand stop.
No. 3 AREA Plan 11-51 except with an eliptical shape handle
No. 4 Same as Bar No. 3 except without safety hand stop

Fig. 6 Load-Strain Graphs for SR-4 1/4-in. Strain Gages and Permanent Set of Claw Bars 1, 2, 3 and 4.



Details of Safety Hand Stops



Brinell Hardness (3000 kg)

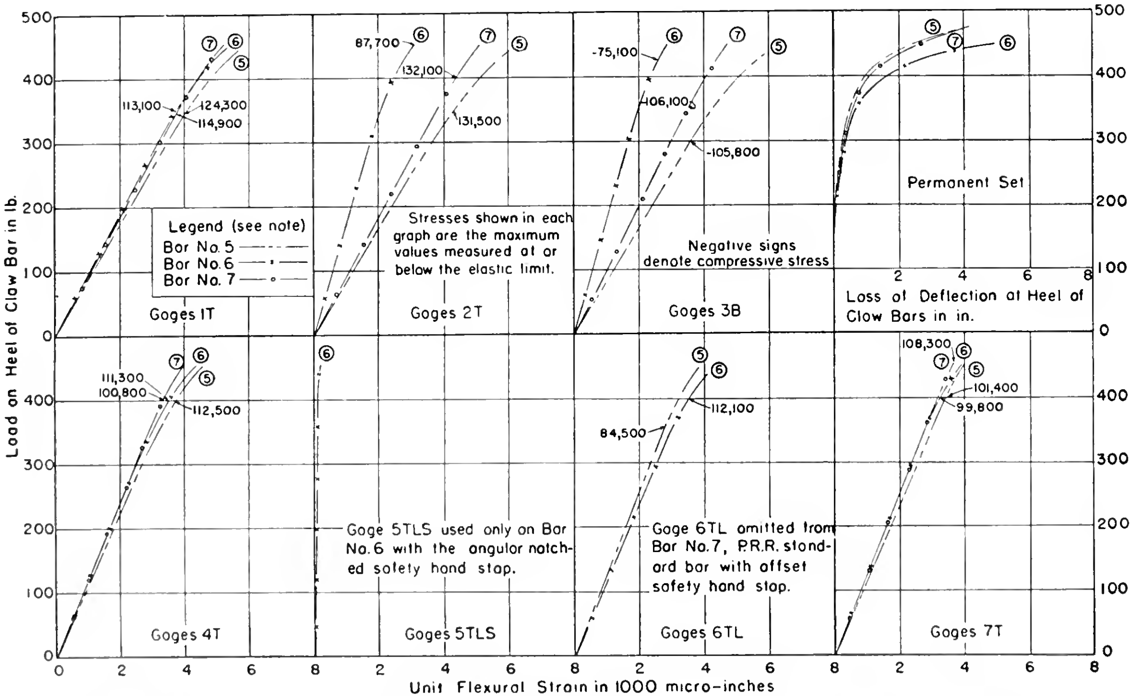
Bar	* 1	2	3	4	5	6	7	8	9	10	11	12	13	14	* 15
5	337	332	387	317	332	242	255	255	239	228	217	284	332	340	349
6	387	364	375	351	340	248	255	248	201	212	274	340	340	332	311
7	387	332	321	332	364	235	255	255	223	217	311	332	340	351	375

Principal Dimensions in Inches

	Lengthwise								Cross Sectional										
									B		D		E		F		G		Weight (lbs)
Bar	A-B	B-C	C-D	D-E	E-G	G-H	A-F	A-H	V	H	V	H	V	H	V	H	V	H	
AREA	4 3/8	1 7/8	4 1/4	10 1/2	36 1/2	2 1/2	50	60	3 5/16	1 1/8	1 3/4	1 1/8	1 1/4	1 1/8		5/8	1	1	27 ±
5	4 1/4	1 7/8	3 5/8	24	22 7/8	2 5/16	50	58 15/16	3 5/16	1 3/8	1 1/2	1 3/16	1 1/4	1 1/4	1 1/16	11/16	1 1/16	1 1/16	25 9
6	4 1/2	1 3/4	3	24 1/4	23 3/4	2 1/4	49 1/2	59 1/2	3 5/16	1 7/16	1 13/16	1 1/4	1 1/4	1 1/4	1 7/16	5/8	1	1 1/16	26 8
7	4 1/4	1 7/8	3 3/8	27 1/2	20 1/4	2 1/8	49 3/8	59 3/8	3 5/16	1 3/8	1 3/4	1 1/4	1 1/4	1 1/4	1 1/8	1 1/8	1	1 1/16	27 3

AREA – AREA Plan 11-51 * Brinell hardness readings of 300 - 375 at points 1 and 15 are specified
Bar No 5 – Notched safety hand stop with rounded corners
Bar No 6 – Notched safety hand stop with excess metal left on top and bottom of notch and rounded off
Bar No 7 – PRR Plan 77151-B with offset safety hand stop and uniform section

Fig 7 Initial Position of Additional Claw Bars Showing Strain Gage Locations, Details of Safety Hand Stops, Hardness Readings and Principal Dimensions (Bars 5, 6 and 7)



Note: Below the elastic limit, the unit strain may be converted to stress in psi by multiplying the strain in micro-inches by 30.

Claw Bars are AREA Plan 11-51 except for shape of safety hand stop and extended heat treatment of nipping end

Bar No. 5 Notched safety hand stop with rounded corners.

No. 6 Notched safety hand stop with excess metal left on top and bottom of notch and rounded off.

No. 7 PRR Plan 77151-B with offset safety hand stop and uniform section.

Fig 8 Load-Strain Graphs for SR-4 1/4-in. Strain Gages and Permanent Set Curves of Claw Bars with Three Designs of Safety Hand Stops. (Bars 5, 6 and 7)

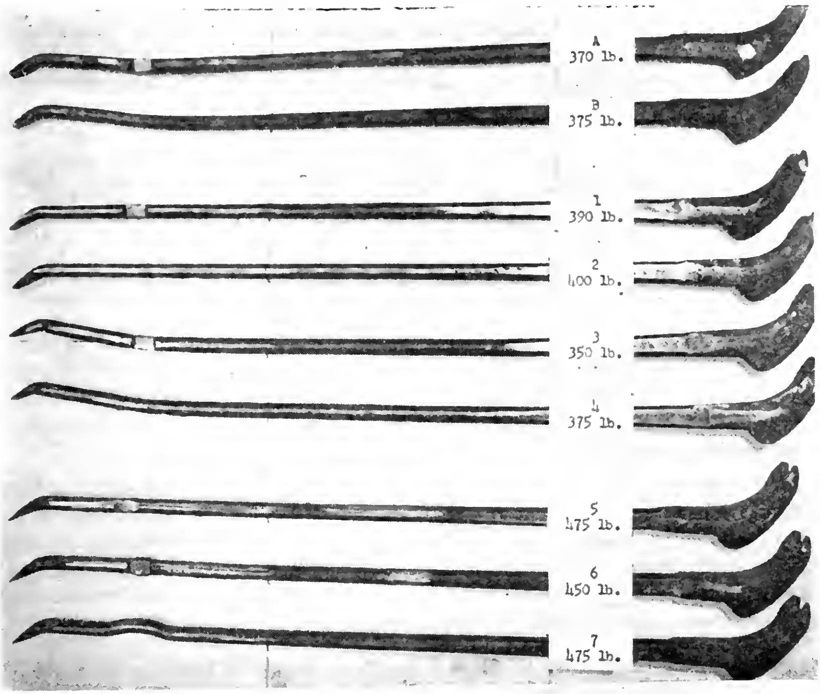


Fig. 9 - Shape of Claw Bars After Bend Tests.

Fig. 9 is presented to show the shape of the nine claw bars after the bend tests. The bars are arranged from top to bottom in the following order: A, B, 1, 2, 3, 4, 5, 6, 7. Maximum test load for each bar is shown below the designation for each specimen. The kinks near the hand stop location in bars A, B, 3 and 4 are prominently shown. The bend in bars 1, 2, 5, 6 and 7 is not perceptible. The lower view of Fig. 1 shows the shape assumed by bar A (AREA design) when loaded to the maximum of 370 lb. The sharp portion of the bend is centered close to the hand stop. Bar 7, with the offset type of hand stop and extended heat treatment, is shown in Fig. 2 with the shape it assumed when it was first loaded to 350 lb. There was no sharp bend in this bar.

Acknowledgement

The Association and the committee are indebted to Hubbard & Company for furnishing the claw bar specimens and for its cooperation with the subcommittee.

Report on Assignment 3

Plans for Switches, Frogs, Crossings, Spring and Slip Switches

Collaborating with Signal Section, AAR

M. J. Zeeman (chairman, subcommittee), L. L. Adams, D. B. Barge, Jr., T. H. Beebe, F. J. Bishop, W. R. Bjorklund, J. A. Blalock, H. F. Busch, E. W. Caruthers, H. B. Christianson, W. E. Cornell, E. D. Cowlin, H. W. Cox, Jr., P. H. Croft, J. W. Fulmer, W. E. Griffiths, A. E. Haywood, A. B. Hillman, A. F. Huber, W. G. Hulbert, C. H. Johnson, T. R. Klingel, C. Kuchel, E. E. Martin, R. E. Miller, W. N. Myers, H. B. Orr, M. P. Oviatt, G. A. Peabody, C. E. Peterson, S. H. Poore, J. A. Reed, R. D. Simpson, R. C. Slocomb, C. R. Strattman, R. H. Thomas, J. B. Wilson.

During 1952 the complete Portfolio of Trackwork plans was reprinted to replenish the supply in the secretary's office. A review of each plan in the Portfolio disclosed a number of minor inconsistencies due mainly to not having revised certain details to agree with similar details approved later on in other plans; also reference to items, such as rail sections, which were not up to date.

While knowing that changes in plans require convention approval before they become effective, your committee, nevertheless, considered it essential to make these revisions before reprinting, feeling that you would want it to do so. With this explanation, and in order to make these corrections official, your committee recommends for adoption as recommended practice the following eight plans (the last two plans are for information only) and the withdrawal of their previous issues:

Plan No. 190–52—Diagram illustrating Preferred Names of Parts for Split Switches.

Revision of Plan No. 190–42 to show "Hook Twin Tie Plates" conforming to Plan No. 241–51.

Plan No. 213–52—11′ 0″ Split Switch Point Derail.

Revision of Plan No. 213–41 to show "Hook Twin Tie Plates" conforming to Plan No. 114–51 and to delete in Note 1, "Plans Basic No. 121 and 122", since these plans cover 13′ 0″ Curved Split Switches.

Plan No. 220–52—Manganese Steel Points for Split Switches.

Revision of Plan No. 220–42 to correct Section AA to conform to Point Detail 6100 on Plan No. 221–51 as to location above base for Switch Point Bolts.

Plan No. 490–52—Diagram illustrating Preferred Names of Parts for Spring Rail Frogs.

Revision of Plan No. 490–42 to show the same design of Hold-down Housings, Two-Tie Base Plates, and Hook Twin Tie Plates as illustrated on Plans No. 401–51 and 405–51.

Plan No. 690–52—Diagram illustrating Preferred Names of Parts for Railbound Manganese Steel Frogs.

Revision of Plan No. 690–42 to show Flare Block details to conform to those shown on Plan 600–51 and to delete note on Plan No. 690–42 reading "For preferred names of details concerning frog point see plan basic No. 600–B", because dimensions on Plan No. 600–B are not now recommended for railbound frogs.

Plan No. 793–52—Data Sheet for AAR Standard Wheel Flanges, Treads and Gages.

Revision of Plan No. 703–40 after check with AAR Mechanical Division to conform to latest data issued on the details presented.

***Plan No. 1101–52**—Data for Tee Rail Sections.

Revision of Plan No. 1001–40 to include 115 RE, 132 RE and 133 RE and other new rail sections that have been rolled since its issue. A few of the more obsolete sections on the former plan are omitted, and roll locations for all rail sections brought up to date.

***Plan No. 1004–52**—Data for Head Free Rail Sections.

Revision of Plan 1004–40 to include new rail sections that have been rolled since its issue and to bring the roll locations for all rail sections up to date.

While reviewing each plan in the Portfolio in connection with the 1952 reprinting, referred to previously, it was found that there were 37 plans which required some minor changes, some to incorporate previously authorized changes, some to correct inconsistencies with other approved plans, and others to correct drafting or printing errors. In other to reduce considerably the cost of the 1952 Supplement to present holders of the Portfolio, an instruction sheet was included with the 1952 Supplement listing the plans and the changes to be made in each plan, and each purchaser of the supplement was asked to make these changes himself since only a little work was required. As a matter of record, the 37 plans involved and the changes made in each plan are as follows:

Plan No. 112–51

In Bill of Material change "Detail Number" for ¾″ side jaw clips for rails 110 lb to 90 lb, incl., from 3012 to 2012. In Note 1, fourth paragraph, delete lines reading: For rails lighter than 90 lb to 80 lb, incl., Spec. 112G.

Plan No. 221–51

In notes under Heel Block Assembly change line 7 to read: Thimble—minimum thickness $\frac{3}{16}$″; brinell hardness not less than 350 or equivalent hardness.

Plan No. 223–47

Delete drawing of Solid Base Slide Plates for Rails Lighter than 90 lb., including tabular matter immediately under the drawing. Also delete drawing of Shoulder Slide Plate—Detail 1130.

Plan No. 320–41

In plan view delete the designation: Forged Steel Filler. At the end of Note 2 add a sentence reading: Point filler shall be of steel. In Note 4, first line, insert the word "Hook" immediately before the word "Twin".

Plan Nos. 322–51, 323–51 and 324–51

In each of the plan views delete the designation: Forged Steel Filler. At the end of Note 2 add a sentence reading: Point filler shall be of steel. In Note 4, first line, insert the word "tie" between the words "twin" and "plates."

Plan Nos. 401–51 and 405–51

In Section A–A (also in Alternate Section A–A on Plan No. 401–51), immediately following the note reading; $\frac{3}{16}$″ + thick thimble, brinell hardness of not less than 350,

* These plans are for information only.

add the words "or equivalent hardness". In General Plan delete the designation: Forged Steel Filler. At the end of Note 2 add a sentence reading: Point filler shall be of steel. In Note 4, second sentence, insert the word "tie" between the words "twin" and "plates".

Plan Nos. 407–51 and 408–51

At the end of Note 2 add a sentence reading: Point filler shall be of steel. In Note 4, second line, insert the word "tie" between the words "twin" and "plates".

Plan No. 503–40

In plan view of Shoulder Tie Plate change the dimension reading: Head + Base + Flgy., to Head + Base + Flgy. + 1/8".

Plan Nos. 611–51, 612–51, 613–51, 614–51, 615–51, 622–51, 623–51, 624–51 and 625–51.

In Note 2, first line, insert the word "tie" between the words "twin" and "plates"

Plan No. 641–51

In Typical Plan View delete dimension "A". In Note 3, first line, insert the word "Tie" between the words "twin" and "plates".

Plan No. 670–51

In Note 5, first line, insert the word "tie" between the words "twin" and "plates".

Plan No. 700D–42

In plan view of Style 1 for Angles 90 deg to 60 deg, incl., change designation: Integral Plate, to Continuous Plate. Add note reading: Integral Extension, with arrow pointing to extension of the continuous plate, as shown in plan view of Style 1 for angles below 60 deg to 35 deg, incl.

Plan Nos. 701–40, 702–41, 703–41, 704–41, 705–41, 706–41, 782–47 and 783–47

Change date of plans to 1948. Delete the word "forged" in first line of Note 2 (d). Delete the word "forged" in title under plan view of corner braces (except on Plan No. 705–41, which has no corner brace drawing). Also, on Plan 783–47 change tread width of 4 1/8" shown on Section CC to 4 1/2".

Plan No. 768–51

In Note 3 (d), first line, insert the word "hook" immediately before the word "twin".

Plan No. 775–50

In Plan view delete reference to Section E–E. Change Note 3 (a) to read: END FROGS—Design 1 per Plan Basic No. 670. Change Note 3 (b) to read: END FROGS—Solid manganese self-guarded per Plan Basic 641. In Note 3 (g) insert the word "Hook" immediately before the word "Twin".

Plan No. 821–42

Change Note 2 (a) to read: Two railbound manganese steel frogs per Plan Basic No. 611 to 613, incl., or Plans Basic No. 622 and 623.

Plan No. 1002–40

Change date of plan to 1952. In table at far right-hand side of plan add an asterisk to Lorain sections 128–456, 159–517 and 174–518. Change footnote under the table to read: *Not rolled March 1952. Delete note immediately below reading: For details of joint bars and other data, see AREA Manual.

Plan No. 1003–40

Change date of plan to 1952. In table near lower right-hand corner of plan add an asterisk to Bethlehem section 82–311, and to Lorain sections 104–478, 122–491, 140–546, 134–522 and 152–547. Change footnote under the table to read: *Not rolled March 1952.

The collaboration of the Standardization committee of the Manganese Track Society in the review and correction of all of the plans in the Portfolio is gratefully acknowledged.

Your committee presents as information the following progress reports prepared by the research staff of the Engineering Division, AAR.:

Appendix 3–a, Service tests of designs of manganese castings in crossings at McCook, Ill.; Appendix 3–b, Service tests of solid and manganese insert crossings supported by steel T-beams and longitudinal timbers; Appendix 3–c, Crossing frog bolt tension tests.

These subjects were reported last year as Appendices 3–a, 3–b and 3–c, respectively, and published in the Proceedings, Vol. 53, 1952, pages 774 to 778, incl.

Your committee also presents as information a report prepared by H. B. Orr, assistant engineer, Union Pacific Railroad, with reference to a grooved stock rail for switches. Since this is a new idea it will be of interest to AREA members. This report is presented as Appendix 3–d.

Appendix 3–a

Service Tests of Designs of Manganese Castings in Crossings at McCook, Ill.

This is a progress report, presented as information.

This assignment has been continued by observing the service performance of one of the five original casting designs and the shot-peened frog installed in April 1949. The last report was published in the Proceedings, Vol. 53, 1952, page 774.

Inspection of August 1952

Shot-Peened Casting

This end-frog is of the same design as the original Morden–Ramapo casting, except that the flangeways were shot-peened by the American Wheelabrator and Equipment Corporation prior to installation in the test corner at McCook, Ill., April 1949. By August 1952 the casting had 9¾ in of flangeway cracks adjacent to the 2 receiving corners. The crack at the B&OCT receiving–Santa Fe leaving corner was 5 in long, of which 4½ in were in the Santa Fe flangeway. The crack at the Santa Fe receiving corner was 3¾ in long, with 3 in. in the B&OCT flangeway. In addition, there was a 1-in crack across the B&OCT flangeway floor which connected the 2 longer cracks. The original Morden–Ramapo design, after 3 years of service, had approximately 10 in of cracks. The shot peening appeared to have retarded the formation of the flangeway cracks during the first two years of service. After 3⅓ years, there was no significant difference in the extent of the cracks of the original Morden–Ramapo casting and the later one with the shot peening. It seems definite that the beneficial effect of the shot peening has been dissipated.

Another inspection of the shot-peened casting was made Oct. 1, 1952. At that time there was a total length of flangeway cracks of 11¼ in, or an increase of 1½ in since observations were made Aug. 11, 1952. The crack extensions were at the B&OCT receiving —Santa Fe leaving corner. In addition, two new cracks had formed in the top of the casting where the Santa Fe running rail abuts the frog. These cracks were 1 in and ¼ in long. They radiated from the inside corner of the casting next to the field side of the head of the running rail. After the test crossing was removed and dismantled, it was observed that the 1-in crack had progressed downward to the top fishing surface of the external arm of the casting. No cracks in the flangeways had formed at the guard rail junctions.

Revised Taylor–Wharton Casting

On April 21, 1952, after 5⅔ years' service, the revised Taylor–Wharton casting was retired. The B&OCT receiving corner of the frog was mashed down severely and showed evidence of pumping. All of the flangeway cracks at the receiving corners had been covered by welding beads. The casting had a ¼-in crack at the B&OCT guard rail junction and also a 1-in crack at the Santa Fe guard rail junction.

Summary

The service life of all five original designs of castings was as follows: Revised Taylor–Wharton, 5⅔ years; Morden–Ramapo, 4½ years; Carnegie–Illinois, 3 years; original Taylor–Wharton, 2½ years; and the Bethlehem casting, 8 months. It is possible that the damage done to the original Taylor–Wharton casting in a derailment may have shortened its service life. Those designs having an integrally cast base plate with a web between it and the running surface have shown superior performance.

Tests of Improved Designs

In the last progress report, two new casting designs were mentioned for inclusion in the test. One of these designs was developed by the Johnstown Works of the United States Steel Company. It has a solid integrally-cast pedestal under the corners of the casting, and an open-type casting base. The sponsor has furnished two identical castings, except that one was depth-hardened. The Ramapo Ajax Division of the American Brake Shoe Company has provided one of their depth-hardened castings with deepened flangeways at and near the flangeway intersection. The flangeway floors meet the base of the casting near the corners of the frog. All of the test castings are 6¼ in high, the same as the other castings tested during the last 8 years. The Santa Fe and the B&OCT agreed to permit the tests to continue with the same height of casting in order to have all of the tests on a comparable basis.

In connection with installing the three test castings, the B&OCT arranged to provide longitudinally framed timbers for each of the four crossings. Five additional new castings were obtained so that all three of the test castings could be placed in a service test in two completely rebuilt crossings. The test crossing and the diamond diagonally opposite the test crossing were completely renewed. All connecting rails were replaced with new material. The timber supports were made of two 8-in by 10-in creosoted oak timbers bolted together. The continuous timbers were placed under the Santa Fe rails. All castings were laid on new ¾ in thick bearing plates, and the continuous plates were placed under the B&OCT rails. Stress measurements were made in each of the two new designs of castings by the research staff, AAR. These measurements were taken when each casting was installed in the same test corner that was used for the original five test castings. The construction work and stress measurements were completed in October 1952. Next year, a report will be made on the results of the stress measurements and service tests of all of the test castings.

Acknowledgement

The committee and the Association gratefully acknowledge the splendid cooperation and assistance provided by the B&OCT.

Appendix 3-b

Service Tests of Solid and Manganese Insert Crossings Supported By Steel T-Beams and Longitudinal Timbers

This is a report of progress, submitted as information.

Installations of 1946

This test involves two crossings, each of the solid manganese and insert types, in the double-track lines of the Indiana Harbor Belt Railroad and the Chicago and Western Indiana Railroad (operated by the Belt Railway Company of Chicago), near 55th St. and Cicero Ave., Chicago. One crossing of each type has a structural steel T-beam support, and the second one of each type has longitudinally framed timbers, with the continuous timbers under the north and south tracks. Fig. 1 shows the extent of the flangeway cracks in the four crossings, and the length of the cracks has been drawn to the same scale as that of the flangeway width. Crossings A and B have steel substructures. They were maintained with an asphaltic concrete ballast until all four crossings were lined and surfaced in April 1952, at which time the back-fill was made with ¾-in stone. The timber-supported crossings (C and D) have been maintained with stone ballast. The asphaltic concrete ballast was not restored in order to expedite the work and to facilitate future maintenance.

The inspection of Aug. 1, 1952, showed for the solid manganese type that the crossing on the steel support had 74 in of flangeway cracks as compared with 57 in for the timber-supported crossing. In the case of the insert-type crossings, the one on the steel support had only a 3-in crack in one corner as compared with 8½ in of cracks in three corners of the other one supported on timber. The insert castings were in good condition. No welding has been done on the insert castings, but it has been necessary to grind the metal flow from the flangeways. A nominal amount of welding has been done on the receiving corners of the solid castings. The T-beam support was of no benefit to the solid crossing as to the formation of flangeway cracks. The T-beam support was moderately beneficial in assisting the insert castings resist the formation of flangeway cracks.

Installations of 1949

These two solid manganese crossings (AREA Plan 771–40) were installed in May 1949 and are located in the intersections between the north and south tracks shown in Fig. 1, and the Elsdon Branch of the C&WI, which is approximately 40 ft south of the eastward track of the IHB. The crossing having the improved design of T-beam support is in the northward track, and the other crossing is supported by longitudinal timbers under the rails of the southward track.

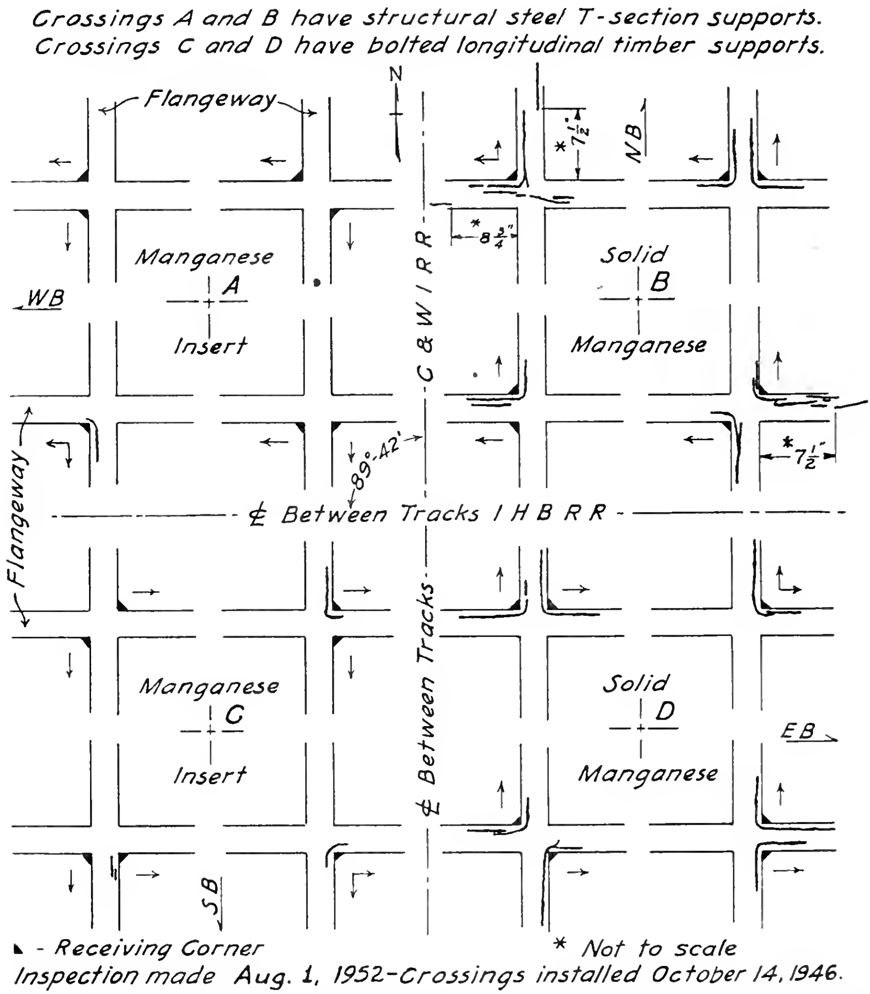


Fig. 1—Flangeway cracks in four crossings of the Chicago & Western Indiana Railroad and the Indiana Harbor Belt Railway near 55th St. and Cicero Ave., Chicago.

At the time of the inspection made in August 1952, no flangeway cracks had developed at the guard rail junctions in either crossing. Since the last progress report the flangeway cracks at the receiving corners of the steel-supported crossing increased from 13¾ in to 30 in. For the timber-supported crossing, the corresponding lengths of cracks increased from 8¾ in to 21¾ in. Some of this difference in the extent of flangeway cracks may be attributed to the larger tonnage carried by the northward track.

During the third year of service, ended April 30, 1952, the steel-supported crossing was surfaced with "black top" three times in the spring and summer of 1951. The timber-supported crossing required no surfacing during the third test period. The actual cost of maintaining the two crossings for the third year was $29.38 and $162.01 for the timber and steel-supported crossings, respectively. The corresponding costs for the 3-year period were $120.63 and $544.52, respectively.

Acknowledgement

The committee and the Association are indebted to the IHB and the Belt Railway for their assistance in conducting the service tests.

Appendix 3-c

Crossing Frog Bolt Tension Tests

Your subcommittee submits, as information, the following report covering the bolt tension service tests and the measurements of the dynamic variation of the tension in crossing frog bolts.

Service Tests of Bolt Tension

The objective of this investigation is to determine the reactive characteristics required of spring washers for the proper maintenance of adequate tension in crossing and turnout frog bolts. This assignment was first reported in the Proceedings, Vol. 52, 1951, pages 532–553.

Measurements of the loss in bolt tension, pull-in, or crossing assembly wear, and nut back off have been continued on three of the original seven crossings and one turnout frog. These tests will be repeated for another year on one each of the solid, manganese-insert and bolted-rail crossings, and the turnout frog.

During the past year the most important results obtained from the service tests were those concerning the use of harder materials on both sides of single-coil washers. Heat-treated, medium-carbon ASA heavy series nuts, and flat, heat-treated plate washers placed next to the corner braces were used with medium and high reactive pressure washers. For 2 consecutive and comparable seven-month winter test cycles, conducted in the heat-treated bolted rail crossing at Warsaw, Ind., the hardened materials increased the effectiveness of the medium reaction washers by reducing the loss in bolt tension 26 percent of that sustained without the hardened parts. The hardened parts were of no benefit when used with the high reaction spring washers. The high reaction washers were much stiffer than the medium reaction washers and evidently crushed the hardened parts more. However, the 26 percent reduction of the loss in bolt tension did indicate an appreciable advantage by providing harder bearing surfaces for use with medium reaction washers. Double-coil spring washers are being tested on crossing frog bolts for the purpose of checking their efficiency in retaining bolt tension and the advantage of their greater contact area in eliminating gouging and crushing of the bearing surfaces as in the case of single-coil washers.

It is planned to complete this investigation in 1953 and to render a final report as to a recommended specification for the reactive properties of a spring washer for frog bolts. The following report on the "Measurement of Shock Loads in Crossing Frog Bolts", developed in a practical manner valuable information as to the proper range of bolt tension that is required in crossings for good maintenance and minimum wear on the fishings.

Acknowledgement

The committee and the Association are indebted to the Pennsylvania Railroad and to the Indiana Harbor Belt Railway for their assistance and cooperation in conducting the bolt tension tests.

A

Measurement of Shock Loads in Crossing Frog Bolts

Digest

The field tests, involving the measurement of the dynamic variation of tension in the main bolts of a bolted rail crossing of the Pennsylvania Railroad and the New York Central System at Warsaw, Ind., were conducted primarily for the purpose of determining (1) the most suitable initial bolt tension necessary for proper support of crossing frogs, (2) the minimum tension required to avoid excessive looseness and wear on the assembled parts, and (3) the causes of unequal loss in bolt tension and wear of the assembly for the three basic bolt positions. Stress measurements were recorded for several classes of diesel and steam power and cars on the Pennsylvania rails in the moderate and upper ranges of speed, while on the New York Central side the traffic was slow speed, consisting of steam power and freight cars. A number of records were taken for three amounts of initial bolt tension: 40,000 lb, 25,000 lb, and 10,000 lb. In this report the shock load on a bolt will be considered as that portion of the cyclic operating load which is in excess of the static bolt tension. In other words, the shock load is that part of the cyclic load which actually elongates the bolt beyond its elongation due to the static tension. When a bolt is further elongated by a cyclic operating load, the assembled parts tend to become separated and have more freedom for relative movement, which results in wear or pull-in of the crossing assembly.

From an analysis of the shock loads, the following conclusions seem justified:

1. In the bolted rail crossing tested, each corner had 12 main bolts, 3 in each arm. The results of this test, except for 10,000 lb bolt tension, indicated that in bolt position 1, which was the nearest one to the flangeway intersection in each arm, the shock loads were several times larger than those that were measured in bolt positions 2 and 3. In the test frog, the magnitude of the shock loads in the Nos. 2 and 3 positions were fairly comparable to those measured in track joints when the frog bolts had more than 20,000 lb tension.

2. Initial static bolt tension of 40,000 lb was the most effective for maintaining the maximum cyclic net tightness of the assembly and minimizing the major shock loads in percentage of the static tension in the No. 1 bolts, which are those nearest to the flangeway intersection of a crossing corner. As a practical matter, the same initial tension should be used for the Nos. 2 and 3 bolts.

3. A minimum tension of 20,000 lb on the No. 1 bolts is required to avoid excessive looseness of the assembly and attendant wear on the areas in contact.

4. The greater loss in tension of the No. 1 bolts and larger pull-in, at the same bolts, as found from the bolt tension service tests, is explained by the fact that the shock loads on the No. 1 bolts with 40,000 lb or 25,000 lb tension were several times larger than those on the Nos. 2 and 3 bolts.

5. In series 1, with 40,000 lb tension, it was found that settlement of the crossing after a rain caused the major shock loads in the No. 1 bolts to increase in magnitude considerably.

6. It was found that many of the major impacts in the No. 1 bolts occurred when a pair of wheels struck the receiving arms of the crossing. It, therefore, seems desirable to keep the connecting joints well supported and maintained for the purpose of eliminating or reducing the increment of the shock load resulting from swinging joints and battered rail ends. This is particularly desirable where train operation over the crossing involves medium and high speed.

7. Unequal girder support of the two sides of a crossing, such as having longitudinal timbers under one track only, caused relatively higher shock loads in the No. 1 bolts under locomotives operating on the other track. It seems desirable to provide equal girder support for both sides of a crossing if a significant proportion of the total tonnage passes over the secondary side.

8. For speed over 40 mph the major shock loads on the No. 1 bolts showed a moderate increase in magnitude with respect to increasing train speed.

Foreword

During the first year of conducting bolt tension tests on belt line crossing frogs of three different types, viz., bolted rail, manganese insert, and solid manganese, it was observed that some of the bolts developed a much greater loss in static bolt tension and, generally, this was accompanied by a greater pull-in, or wear of the crossing assembly at the same bolts. In order to complete the field study of crossing frog bolt tension and to determine the causes of the unequal loss in tension at the several bolt positions, arrangements were made in the second year of this assignment to measure the dynamic variation of bolt tension in a main line crossing. It was believed that the results of such a test would develop information which would help to determine (1) the reason for unequal loss in tension and crossing assembly wear at the different bolt positions, (2) the magnitude of the most effective initial bolt tension, and (3) the minimum tension required for the proper support of crossing frogs.

Dynamic Loading of Bolts

In many mechanical installations, bolts have a dynamic loading imposed on them because of inertia forces, steam and gas pressures, and other disturbing forces. In a great number of instances, the cyclic operating loads on the bolts can be computed, and the designer can select a suitable bolt and static tension so as to reduce to an insignificant amount the tendency of the fastener to fail in fatigue, or to create excessive looseness which might possibly accelerate wear between the assembled parts. Consider, for example, the dynamic increase in tension on connecting rod bolts which are used to fasten a piston assembly to the main crankshaft of an internal combustion engine. These bolts are subjected to a fairly large cyclic increase in tension by the inertia forces at the upper end of the stroke. Because of space limitations, these bolts are usually rather highly stressed and are subject to fatigue failures if the applied bolt tension is well below the operating load. Assuming that the dynamic loading is 10,000 lb per bolt and the nuts are only finger tight, the load on the bolts will vary from zero to 10,000 lb. This will result in considerable looseness of the assembly and a large range of stress in the bolts. If the bolt is tightened to 10,000 lb or more, the stress range in the bolt and cyclic looseness of the assembly will be reduced to very small values.

In crossing frogs, the frequency of occurrence of broken bolts is small and fatigue failures are not an important problem. Crossing wear of the assembled parts brought about by flexing the structure, with the accompanying cyclic looseness resulting from the larger dynamic increases in bolt tension, is of greater concern in the economical maintenance of crossings.

The main bolts of the test crossing have the function of holding seven component parts together: three rails, consisting of the running, easer and guard rails, two fillers, and two corner braces. When the crossing assembly is flexed by a wheel at or near the flangeway intersection, the operating loads cause a further elongation of the bolts by the parts separating near the rail bases. Conversely, bolt elongation, which occurs between wheels, tends to separate the parts near the rail heads. In this test it was found that the behavior of the operating loads was somewhat different from the example cited above. Regardless of whether the static bolt tension was 40,000 lb, 25,000 lb or 10,000 lb, the operating loads on the bolts were always of sufficient magnitude to elongate them further. Although with 40,000 lb static bolt tension the major impacts on the No. 1 bolts were minimized as to percent of static tension, there was no indication that a further substantial increase in static tension would eliminate the impacts. In other words, because of the vertical flexure of the crossing and the fact it has a yielding support, there will always be sufficient separation of the assembly to further elongate the bolts. Therefore, in the maintenance of crossing frog bolt tension the practical solution seems to point to selecting a static bolt tension that will reduce to a practical minimum the dynamic increases in tension and the accompanying cyclic looseness of the assembly in order to minimize wear on the clamped parts.

In this report, the excess of the dynamic bolt load, or previously mentioned as the operating bolt load, over the simultaneous static bolt tension, will be referred to as the shock load. The shock loads were measured direct by the strain gages because the static bolt tension was represented by the base line for each trace on the oscillograms.

Test Crossing

One of the crossings between the double-track main line of the Pennsylvania and the single-track branch line of the New York Central at Warsaw, Ind., was selected for this test. In order to avoid disturbing the bolt tension test in the eastward crossing and the test of lock nuts in three corners of the westward crossing, the southeast corner of the latter crossing was used for measurements of the shock loads in the 12 main bolts having nominal dimensions of 1⅜ in diameter by 14 in. The westward crossing was 3 years old at the time of the test and had carried approximately 55 million gross tons of highspeed passenger and freight traffic on the PRR side. The traffic on the NYC operates at slow speed and the average gross tonnage per annum was approximately two million. The crossing frog is of the triple bolted rail construction with the 131 RE section. All of the rail and flangeway fillers had heat treatment in accordance with the AREA specifications for special trackwork. The crossing was originally fitted with drive-fit bolts in accordance with the PRR specifications. Each PRR rail was supported by three 7-in by 9-in by 10-ft creosoted oak switch ties bolted together. A view of the test crossing is shown in the top portion of Fig. 1.

Over one-half of the trains on the PRR were hauled by diesel locomotives, and diagrams for five classes of that power are shown in Fig. 2. Diagrams for three classes of PRR and two classes of NYC steam locomotives are given in Fig. 3. Most of the traffic on the NYC rails was hauled by class H5–T (2–8–2) steam locomotives. All of the diagrams show the axle loads and total weight in working order in 1000 lb.

The test crossing was in reasonably good line and surface and was not tamped up especially for the test. However, later it was necessary to tamp up the test corner once in each of the first two test series. The crossing was built with standard gage for the NYC track and ⅛ in tight on the PRR side.

Test Bolts

A set of 1⅜-in by 14-in heat-treated frog bolts was prepared for mounting the SR–4 wire resistance strain gages on the shank by turning down a portion of the bolt body to 1⅛-in diameter and drilling two ⅛-in diameter holes through the head and part of the shank to accommodate the gage leads. Two strain gages, ½ in. in length, were mounted axially and diametrically opposite each other near the mid-length of the 1⅛-in diameter portion of the special bolts, as shown in the bottom view of Fig. 1. The test bolts were also prepared for measurement of the static tension with the same extensometer as used in the crossing frog bolt tension service tests. The 12 existing bolts were removed from the test corner and replaced with the test bolts. Pennsylvania specification spring washers were used on the special bolts throughout the test. Views of the crossing, test corner and special bolt are shown in Fig. 1. In the middle view of the figure the bolt numbers are shown for the four arms of the test corner. In each arm the bolts are numbered in sequence from the flangeway intersection. The north and west groups of bolts are in the internal arms of the crossing corner, while the east and south bolts are in the external arms.

All of the test bolts were prestressed to 50,000 lb tension for a few days of traffic before taking records.

Electrical Testing Apparatus

The strain measuring equipment consisted of a 12-channel recording oscillograph, a 12-element strain gage balancing unit and amplifiers, and a regulated power supply having an oscillator. The equipment was set up in the AAR test truck near the crossing tower where 110-v ac-power was available for operation of the apparatus. For each bolt the two strain gages were connected in series for recording the sum or average of the two stresses, from which the change in the axial tension on the bolt could be readily obtained. Two wheel markers, shown in the upper view of Fig. 1, were connected to a solenoid in the oscillograph to register the position of each wheel on the oscillograms.

Static measurements of elongation of the bolts with the extensometer were compared with the stress measurements taken with the oscillograph. The results indicated that for a specified bolt tension, the elongation of the test bolts having the portion turned down to 1⅛-in diameter was 10 percent greater than that for the same bolts with uniform 1⅜-in body diameter. Accordingly, the elongation of the test bolts was made 10 percent greater than was obtained by calibration of the standard bolts of the same size and effective length.

Schedule of Tests

Three test series were schedued. The first series was made with 40,000 lb initial bolt tension. This load on a 1⅜-in bolt stresses the root area approximately the same as 20,000 lb on a 1-in track bolt. The second test series was conducted with 25,000 lb tension. The last, or third series, had 10,000 lb static bolt tension and was included to develop information on what might be considered inadequate bolt tension.

Static Bolt Tension

For each test series, all bolts were set to the desired initial tension immediately prior to taking records. If a series was run on consecutive days, the bolt tension extensometer readings were taken once a day without releasing the bolts. In the case of a test series extending over a week-end, the bolts were released and reset to the specified tension when testing was resumed. At the close of each test series the remaining bolt tension was obtained by taking a set of extensometer readings before and after releasing the bolts. From the foregoing data, the static tension for each bolt was determined for the middle of each day, and the values for a particular day were used to convert shock loads to percentages of static tension for test runs made the same day. Since the original bolts

(Text continued on page 1009)

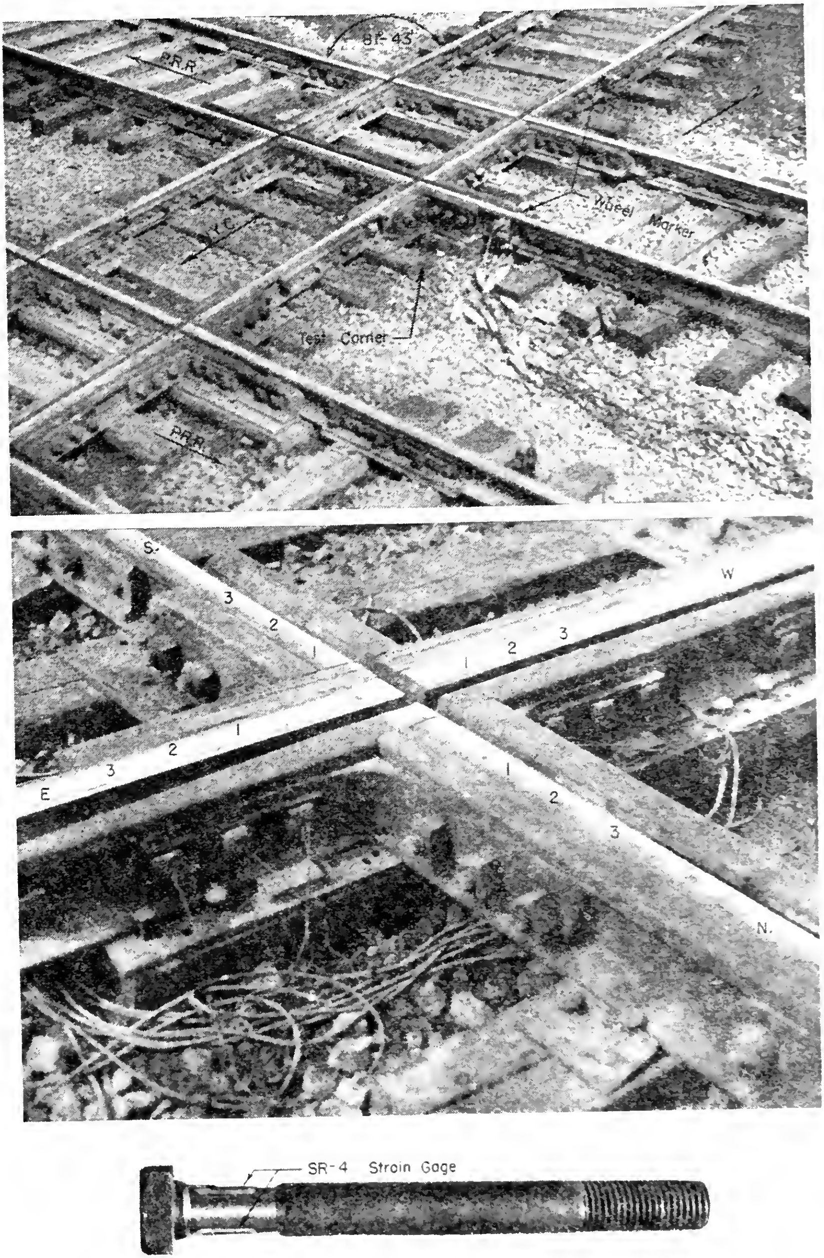


Fig 1. Top - General View of Test Crossing
Middle-Bolt Numbers and Strain Gage Leads at Test Corner
Bottom-Test Frog Bolt with Strain Gages

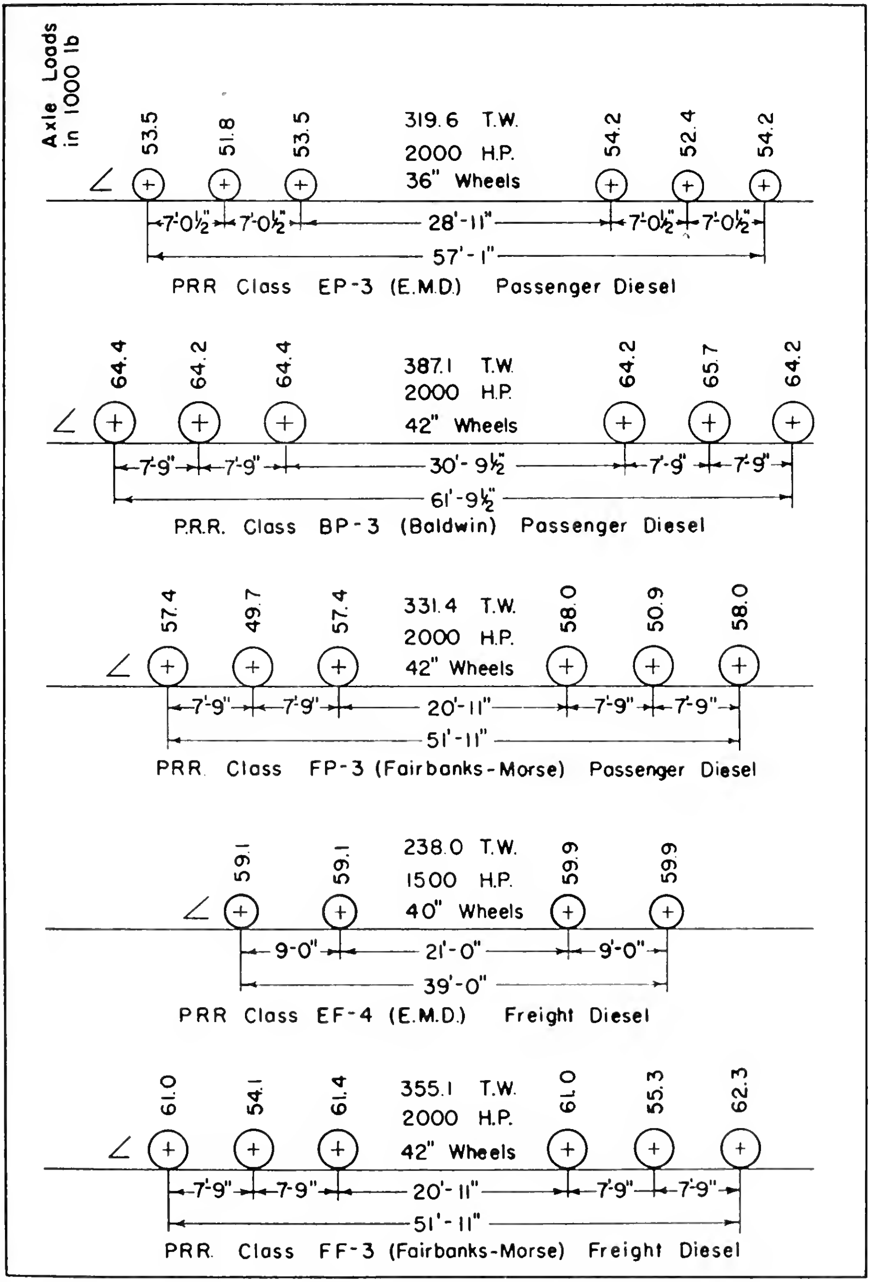


Fig. 2. Wheel Diagrams of Prevailing Types of Diesel Locomotives.

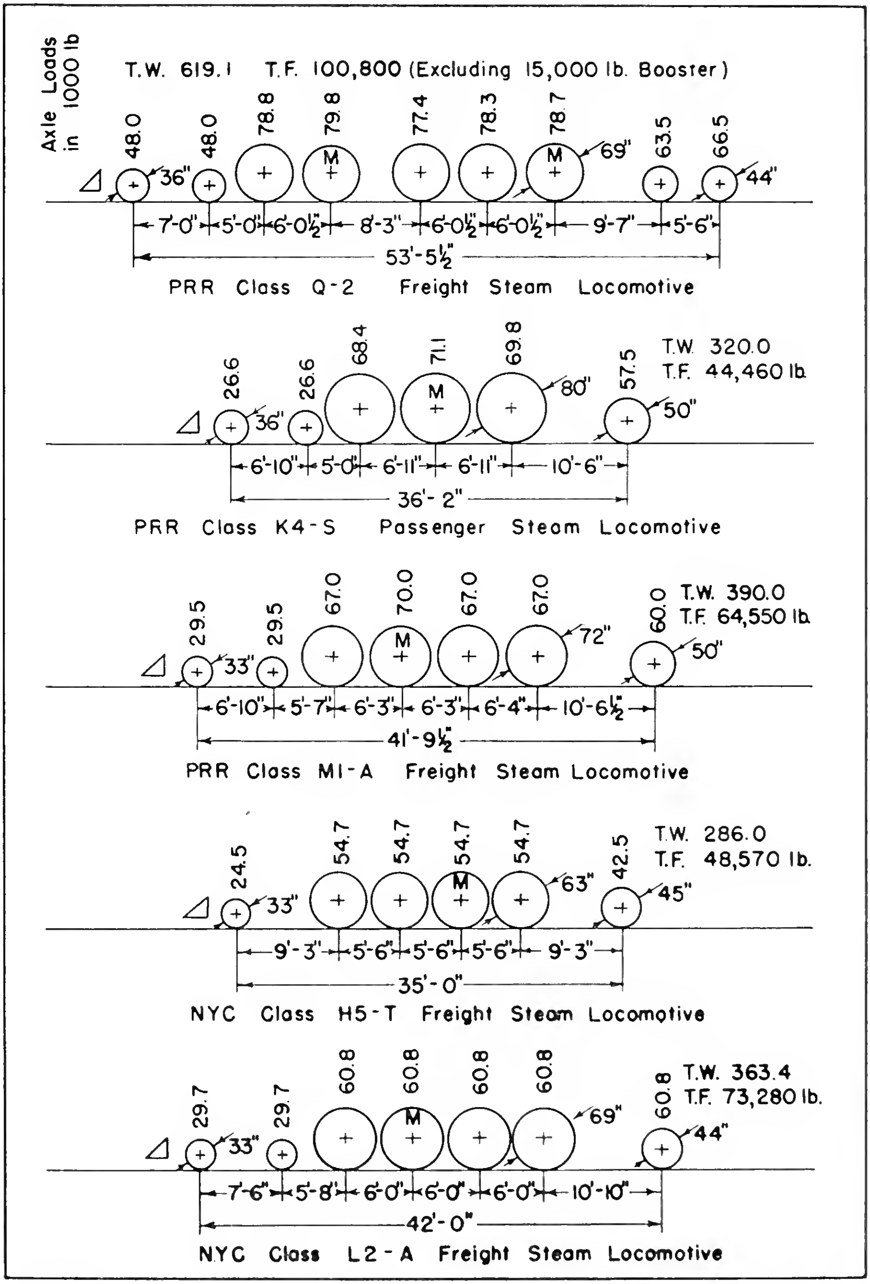


Fig. 3 Wheel Diagrams of Prevailing Types of Steam Locomotives.

were drive fit, some of the test bolts were difficult to drive into place. From the analysis of some of the records, it appeared that the tight fit of the bolts caused some distortion of the shock loads, but it is believed that the major impacts were not affected appreciably by that condition.

Test Runs

No test train was used because the PRR traffic included a wide range in operating speeds (except slow speed) and several daily passenger and freight trains with many types of power. It would have been desirable to have had some test data for slow-speed operation on the PRR track, but this was not requested because of the traffic density and a sag in grade line at the crossing. All of the NYC traffic operated under 15 mph but the locomotives on that line were lighter than the PRR power, and the crossing timbers provided better support for the PRR traffic than for the NYC rails. The foregoing conditions precluded an analysis of the speed effect on the shock loads, except for the medium to high-speed range on the PRR track.

Oscillograms were taken under 97 trains divided as follows: 29 for series 1, 38 for series 2, and 30 for series 3. Of the 97 movements over the crossing, only 18 were on the NYC side.

Discussion of Test Data

Typical Oscillograms and Shock Load Patterns

Four representative oscillograms will be presented in order to show the patterns of dynamic variations of bolt tension, sequence of events, and the complexity of the shock load measurements. It is not amiss to state that a crossing frog is subjected to more violent impacts than most any other part of the track structure. The same impacts are also imposed on the equipment. There are many variables, both in the track and equipment, that influence the shock loads on the bolts. Later, it will be shown that for almost identical movements of the same class of power, the major shock loads, particularly for the bolts in the No. 1 position, were appreciably different in magnitude.

Fig. 4 includes a part of an oscillogram to show the strains measured in the main bolts under a 2-"A" unit PRR class FP-3 (Fairbanks-Morse) (0-6-6-0) type diesel hauling a passenger train in series 1 with initial bolt tension of 40,000 lb. Axle spacing of the trucks is 7 ft 9 in (see Fig. 2). The top and bottom traces show the location of each axle on the record. The wheel marker for the PRR side was located 3 ft east of the gage intersection at the test corner, and the wheels of the 3-axle truck diesel units are shown when each wheel crossed the gage corner—or approximately at the beginning of the wheel jump across the NYC flangeway. The base lines represent the static tension in each bolt. Upward deflections from the base lines denote a release in static tension, and downward deflections dynamic increases in bolt tension, which have been designated as shock loads. The major impacts generally occurred when each wheel struck the receiving end of the east arm of the test corner, or the receiving end of the west arm (after the wheel jumped across the flangeway), or the receiving end of the west arm of the southwest crossing corner, and less frequently, when a wheel was directly over a bolt in the arms carrying the traffic.

In the PRR external arm of the test corner, the maximum shock loads in bolts 1-E and 2-E occurred when the wheels struck the west arm after crossing the flangeway. At some points between wheels the pattern of bolt 2-E was opposing that of 1-E. The shock loads (downward deflections) of bolts 2-E and 3-E were very small as compared

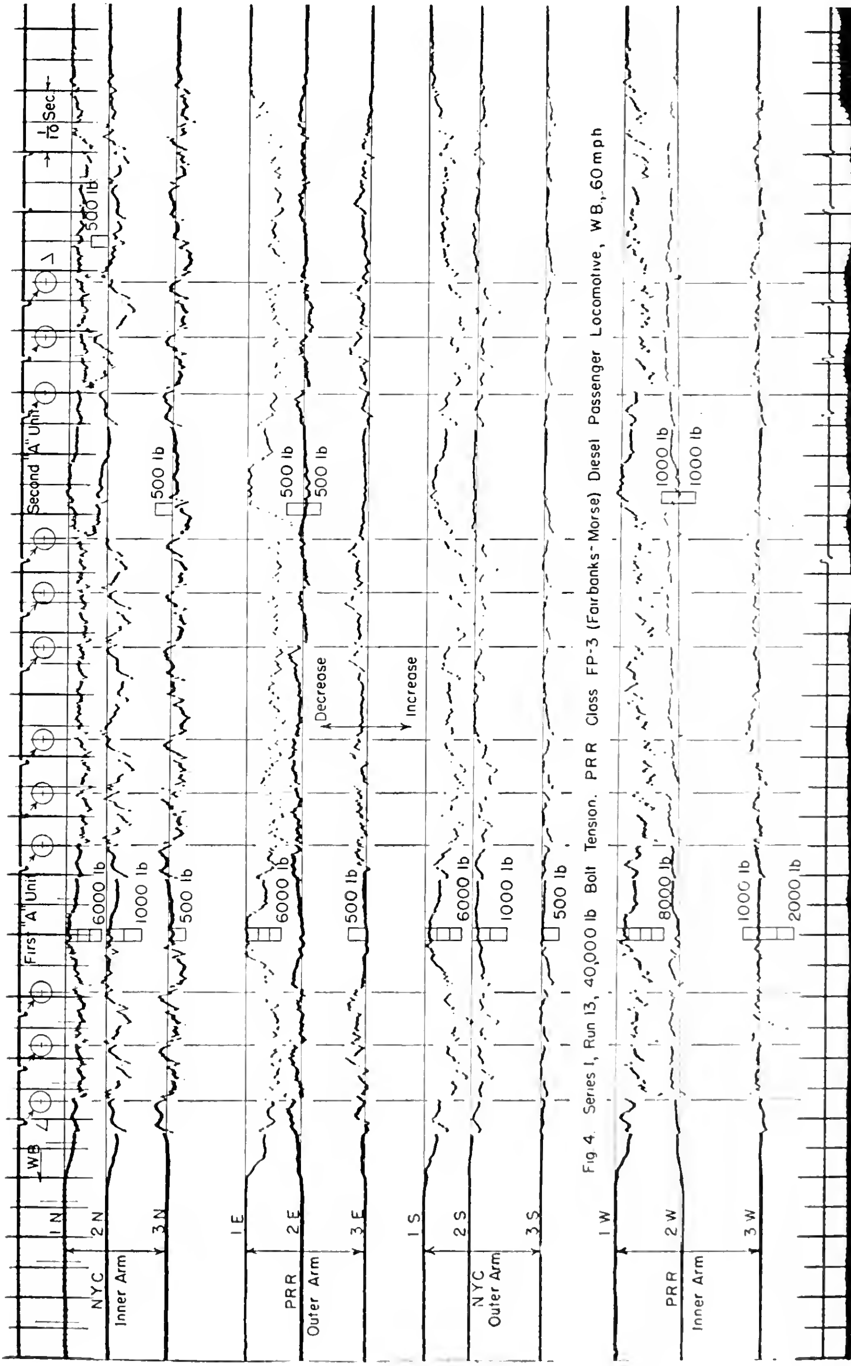


Fig. 4. Series I, Run 13, 40,000 lb Bolt Tension. PRR Class FP-3 (Fairbanks-Morse) Diesel Passenger Locomotive, WB, 60 mph

to those of 1–E. In bolt 3–E the major releases in tension (upward) occurred about when the wheel was directly over the bolt. In the west arm, bolts 1–W and 2–W had maximum shock loads when the wheels jumped the flangeway and struck that arm. In addition, bolt 1–W also had secondary impacts when the wheel struck the west arm of the southwest corner (in the west rail of the NYC). Bolt 3–W had its larger shock loads about when the wheels were over it. It will be observed from the vertical scales for dynamic tension changes in the bolts that the impacts occurring in positions 2 and 3 were quite small as compared with position 1. There were two larger downward peaks in bolt 3–W, one each under or near the leading truck of each diesel unit. These had no pattern with respect to a particular axle of a truck.

The patterns for the shock loads in the NYC rails (north and south arms) are somewhat different from those of the PRR arms. In the north arm, there were generally two major shock loads between the wheels, but for bolt 1–N the maximum values occurred when the wheel struck the receiving corner of the test frog. The first peak (downward) ahead of the lead truck wheel occurred when that wheel struck the receiving end of the east arm. Between axles of either span of the truck wheels the first peak on the left occurred when the trailing wheel struck the receiving end of the east arm of the test corner, and the second peak was the result of the leading wheel striking the receiving end of the west arm in the southwest frog. The above described pattern can be readily discerned on the traces for bolt 2–N. The pattern of the traces for bolts 1–S and 2–S are similar and also have their maximum shock loads between wheels or when the crossing corner is flexed upward. There was only one major shock load for each wheel and it occurred when the wheels struck the receiving end of the east arm of the test corner. The maximum shock loads in bolt 3–S were quite small and were the result of the wheels striking the receiving corner of the test frog. In the oscillogram it will be noted that bolt 1–N, which is in the NYC internal arm, had smaller shock loads than the other three bolts in position 1. In series 1, bolts 1–E and 1–W had the largest shock loads for PRR traffic.

For series 2 (25,000 lb initial bolt tension), Fig. 5 is included to show the shock load measurements for a PRR class K4–S Pacific-type (4–6–2) locomotive operating at a speed of 38 mph. The traces for bolts 1–E and 2–E are similar, and most of the maximum shock loads occurred when each wheel struck the receiving corner of the test frog. However, the third driver produced its maximum when it and the second driver were equally spaced about the gage corner. Secondary impacts also occurred between other wheels when straddling the test corner. Bolt 3–E had its largest deflections above the base line between wheels, which indicated releases in static tension when the two companion bolts had increases in tension. The maximum shock loads for 3–E were very small and occurred between wheels. In the west arm, bolts 1–W and 2–W received their major shock loads when each wheel struck the receiving corner of the test frog. In bolt 3–W, the peaks occurred a little later, or about when each wheel was directly over the bolt. In the north arm, all three bolts had similar patterns of shock loads, and the major values occurred between the wheels. Generally, there were two values: one when a given wheel struck the receiving end of the east arm, another when the wheel struck the receiving corner of the southwest frog. However, one exception to the foregoing was for the 10-ft 6-in spacing of the trailer and rear driver, where the single maximum occurred when the trailer struck the receiving end of the east arm a little after the rear driver struck the receiving corner of the southwest frog. In the north bolts the major shock loads were the result of flexing the test corner upward between wheels. This is further substantiated by the presence of upward peaks when the wheels were over the flangeway inter-

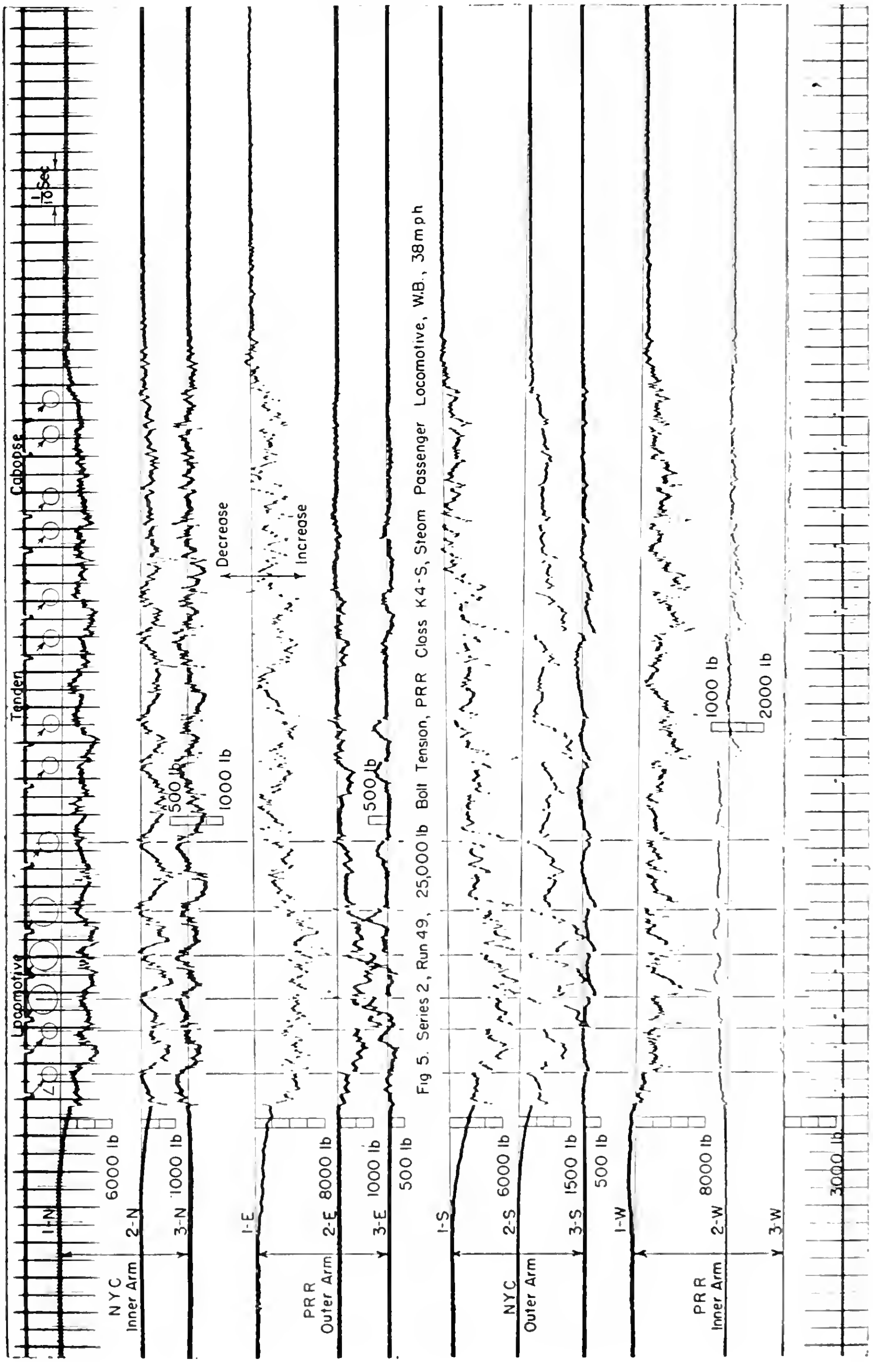


Fig 5. Series 2, Run 49, 25,000 lb Bolt Tension, PRR Class K4-S, Steom Passenger Locomotive, W.B., 38 mph

section. At those wheel positions the shock loads were released and 3–N also had releases in the static bolt tension. Releases in static tension indicate a tightening of the crossing assembly, and this action was probably the result of spreading the parts at 1–N and relieving the tension in 3–N. Generally, the maximum shock loads in bolt 1–S occurred when the wheels struck the receiving corner of the test frog.

Other impacts, almost as great, occurred between wheels when the following wheel struck the receiving end of the east arm or when the wheel was 3 ft east of the receiving corner, or when it was between the last joint tie and the receiving end of the longitudinal timber. These peaks can be observed ahead of the first engine truck wheel in all three traces for the south bolts, but were minor in magnitude until after the first wheel has crossed the test corner. In bolt 2–S the maximum shock loads were the result of two events, except between the rear driver and trailer where the spacing was larger. For a given wheel a downward deflection starts when the wheel strikes the receiving corner of the test frog, and the peak is extended shortly thereafter by the next following wheel striking the receiving end of the east arm, which is 5 ft long as measured from the gage intersection. For the second engine truck wheel, which is also 5 ft ahead of the first driver, the two events were simultaneous, and the deflection at the first mentioned wheel reached its maximum without a break. The largest value for the trailer occurred when it struck the receiving end of the east arm, or 5 ft before it reached the gage intersection. Bolt 2–S was the most active one in the No. 2 position, but the major shocks were always less than one-third of those in Bolt 1–S. Bolt 3–S had small maximum values when the wheels struck the receiving corner of the test frog. It will be observed that in all of the No. 1 bolts, except the north one, the greatest shock loads occurred under the drivers when the total load on the crossing was the greatest.

Fig. 6 is presented to show an oscillograph record of series 3 with 10,000 lb initial bolt tension. This record covers a movement of a 3-unit PRR class EF–4 (Electro-Motive) diesel with 2-axle trucks having a wheel base of 9 ft. With the lower tension there was an increase in the irregularity and vibration of the shock load measurements. Traces for the bolts in positions 2 and 3 were much more active than in series 1 and 2. Bolt 3–N in the NYC internal arm had larger variations than any of the bolts in positions 2 and 3. The shock loads in bolt 1–E were much smaller than in series 1 and 2. Bolt 1–N had larger variations than 1–E. Dynamic changes in bolt tension in this run were larger in bolt 1–S than in 1–W. With the low tension of 10,000 lb, the north or internal arm on the NYC side has lost some of its rigidity and tightness, as evidenced by the excessive activity of bolt 3–N. There were two major shock loads in the north bolts for each axle. One occurred when each wheel struck the receiving end of the east arm, and the other at the time the wheel struck the receiving corner of the southwest frog. Bolts 2–N and 3–N also had relatively large releases in static tension (upward deflections) when the wheels jumped the flangeway. Generally, the south bolts had maximum shock loads when each wheel struck the receiving corner of the test frog. Secondary major shock loads occurred when each wheel struck the east end of the crossing. A few minor releases in tension occurred between wheels. Most of the maximum shock loads in the three east bolts occurred when the wheels struck the receiving corner of the test frog. Other downward peaks of almost equal magnitude were produced about when the wheels were directly over each of the bolts. Smaller peaks were the result of the wheel striking the east end of the crossing. The latter peaks were in the upward direction for 1–E and 3–E, and downward for bolt 2–E. The pattern for the east bolts was not as distinct as for the other bolts. The west bolts had their maximum shock loads when the wheels struck the receiving corner of the test frog, the same as was the

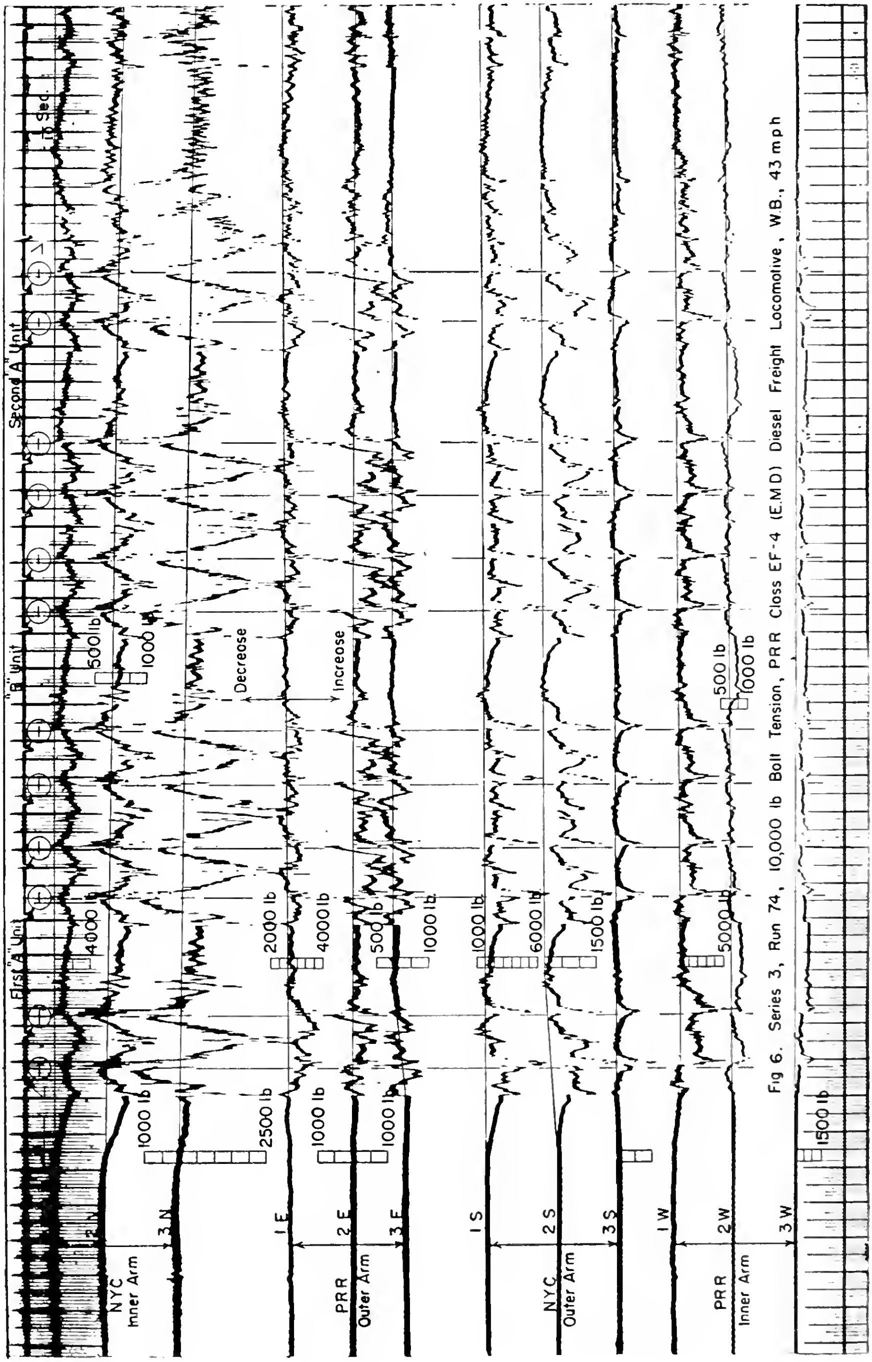


Fig 6. Series 3, Run 74, 10,000 lb Bolt Tension, PRR Class EF-4 (E.M.D) Diesel Freight Locomotive, W.B., 43 mph

case with the south bolts. For the west bolts, the effect of the wheels striking the east end of the crossing and the receiving corner of the southwest frog was minor in magnitude.

Fig. 7 is an oscillogram of a southbound run made by an NYC H5–T Mikado locomotive in series 2 with 25,000 lb initial bolt tension, backing at 10 mph. The north bolts had their maximum shock load when each wheel was directly over each bolt. These peaks occurred before the wheels crossed the flangeway of the test frog. As was the case of the PRR runs in series 1 and 2, bolt 1–N had smaller shock loads than in the other No. 1 positions. The south bolts had two major shock loads for each wheel. One occurred when the wheels struck the receiving corner of the test frog, and the other when the wheels were over each bolt. Maximum shock loads generally occurred in bolts 1–E and 2–E approximately as each wheel passed over the receiving edge of the longitudinal timbers, or before the wheels reached the flangeway. When the wheels jumped the flangeway there were distinct upward peaks, indicating a release of the shock load or, in some cases, the static tension (deflections above the base lines). The above position of the wheels was evidently at the point where the crossing had its maximum flexure and resultant separation of the crossing assembly. Bolt 3–E was inactive and had its major peaks when the wheels struck the receiving corner of the test frog. In this run bolts 1–E and 1–S had the larger shock loads. Bolt 1–W sustained maximum shock loads at the same time as bolt 1–E, or about when the wheels reached the receiving side of the longitudinal timber support under the test frog. Bolt 2–W had maximum shock loads between wheels and maximum releases in static tension when the wheels crossed the flangeway. Bolt 3–W was inactive and the shock loads were of small magnitude. The class H5–T locomotive has a driving wheel spacing of 5 ft 6 in and the spacing of the truck axles is 9 ft 3 in. Several of the traces show a larger release in static tension for the greater wheel spacing than for the smaller spacing.

The typical oscillograms indicate that some important major shock loads occurred when a pair of axles straddled the flangeway intersection as well as when the wheels struck the receiving corner of the test frog.

All Bolt Positions

At first, several records were analyzed completely for all of the bolts and several classes of power and freight cars on the PRR side. This method involved tabulating all of the changes in dynamic tension and included the disturbances caused by the wheel jump and bounce, car body bounce, and lateral forces on the crossing. The shock loads and releases in tension were averaged separately and converted into percentage of static bolt tension. Percent shock load determines the degree of relative cyclic looseness of the assembly, and percent release in tension is directly related to the increase in tightness of the assembly. A summary of this analysis is shown graphically in Fig. 8. In the upper portion of the figure, bar diagrams are shown for all three bolt positions in the three test series for diesel and steam power, and freight cars on the PRR rails. In the upper left block a comparison is shown for the diesel power. In order to have the speed fairly comparable for the three test series, one run each for a 2-unit BP–3 and EP–3 were averaged. The ordinate scale is in percent of static bolt tension, and figures on the bars are in 1000 lb of dynamic increases of tension. The other blocks to the right cover the PRR class Q–2 locomotives, PRR freight car movement, and the NYC class H5–T (2–8–2) steam locomotives. In general, for the PRR rails the average shock loads of the No. 1 bolts increased in percentage of the static bolt tension and decreased in magnitude as the tension was reduced from 40,000 lb to 10,000 lb.

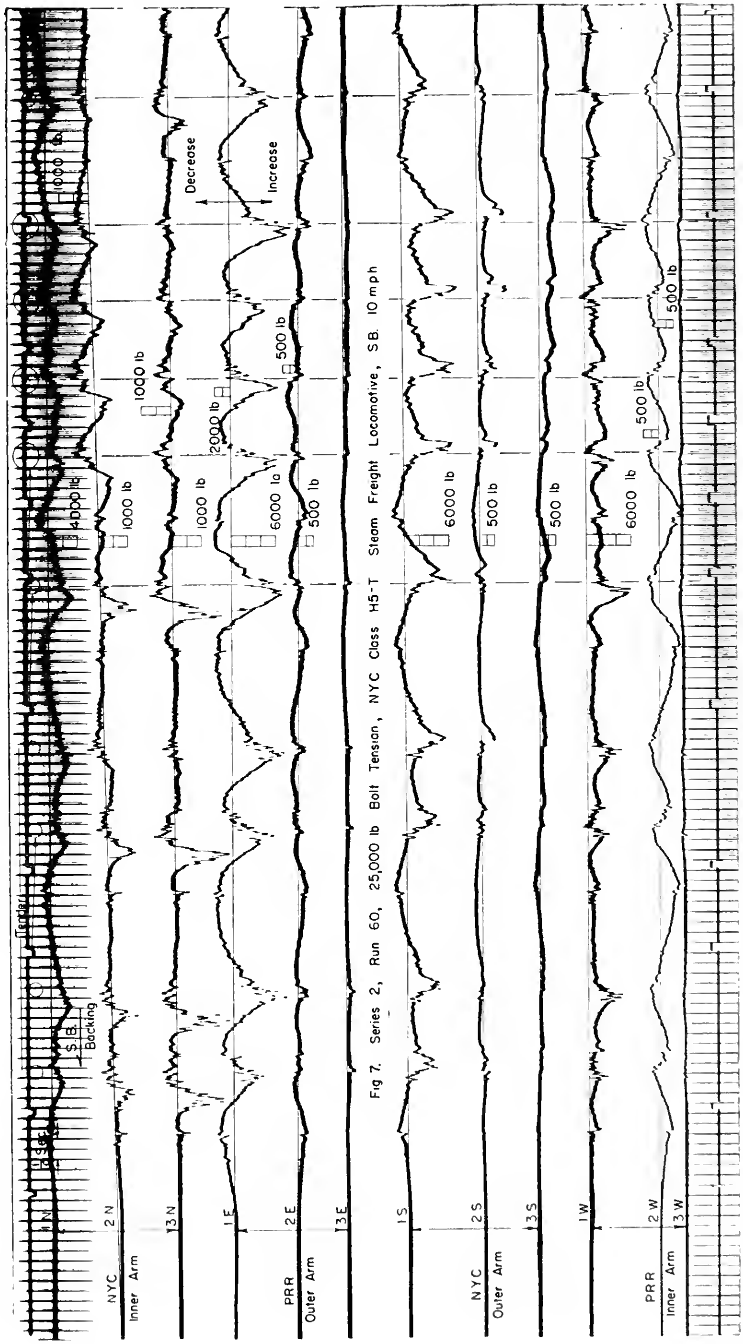


Fig 7. Series 2, Run 60, 25,000 lb Bolt Tension, NYC Class H5-T Steam Freight Locomotive, S.B. 10 mph

In series 1 and 2 it will be noted that the average values for bolts 2 and 3 were quite small as compared with the companion No. 1 bolts. For traffic on the PRR rails the shock loads in the Nos. 2 and 3 bolts increased percentagewise with decreasing bolt tension, while the magnitude also showed a tendency to increase moderately. Bolts 2 and 3 under NYC traffic also showed the same two tendencies. However, the No. 1 bolts under the NYC Mikado (2–8–2) locomotives showed an increase in the magnitude as well as the percentage of shock loads for decreasing bolt tension. For the PRR traffic the magnitude of the average shock loads on the No. 1 bolts decreased as the bolt tension was reduced. This difference is attributed to the PRR rails having better girder support than the NYC rails.

The dynamic releases in tension (negative values in the figure) for all bolts under PRR traffic had an increasing tendency with a reduction in static bolt tension. Only the Nos. 2 and 3 bolts on the NYC had the same tendency. In all four categories for series 1 and 2, it will be observed that the shock loads in bolts 2 and 3 were quite small and present no problem as far as the dynamic variation in bolt tension is involved. The shock loads in track bolts were found in previous tests to be greater than those in bolts 2 and 3 for series 1 and 2. In series 3, the shock loads in bolts 2 and 3 increased appreciably, but were much lower than those for the companion No. 1 bolts. This demonstrates clearly that regardless of the amount of static tension, the Nos. 2 and 3 bolts failed to relieve the No. 1 bolts of their larger shock loads to an important extent. It will be observed that with the lighter loads of the PRR freight cars, there were only moderate increases in shock loads percentagewise in series 3. In series 3 with 10,000 lb bolt tension, the medium weight NYC Mikado-type locomotives had a higher average shock load in the No. 1 bolts than in the case of the heavy Q–2 class.

The lower tier of bar diagrams in Fig. 8 shows the frequency of the shock loads in the No. 1 bolts by increments of percentage of static tension. In general, series 1 had the lowest percentage of impacts in the medium and higher percentage increments, and series 2 was the next best. The greatest aggregate percentage of large shock loads occurred under the NYC Mikados in series 3. This was probably influenced by the crossing timbers not giving the NYC rails as much girder support as on the PRR side. There were very few impacts over 40 percent under the freight cars, regardless of the amount of static bolt tension. Because of the limited number of test runs included in each classification shown in Fig. 8, an accurate comparison of the shock loads with respect to kind of power cannot be made. More information on that subject will be presented in connection with a study made of the major shock loads in the No. 1 bolts with respect to classes of power.

By the foregoing analysis, a study was made of the effect of loosening bolt 1–E in series 1, and 1–E and 1–S in series 2, for the purpose of ascertaining if it would be possible to transfer larger shock loads to bolt positions 2 and 3. In series 1, two runs with NYC class L2–A (4–8–2) locomotives were investigated: one had all bolts tight, the other 1–E loose. Because of the tight drive fit of the new test bolts in the crossing, bolt 1–E, when loose, sustained shock loads, but they were appreciably smaller than when the bolt was tight. The shock loads in bolts 2 and 3 increased moderately when 1–E was loose, but they were well below the average shock load of the other No. 1 bolts. The No. 3 bolts showed a very slight increase when 1–E was loose.

In series 2, bolts 1–E and 1–S were released and a comparison was made with a 2-unit class EP–3 (0–6–6–0) passenger diesel. In this instance bolts 1–E and 1–S were struck with a maul to be certain there was no static tension left. However, when loose, these bolts still carried an average shock load about one-half as large as that of bolts

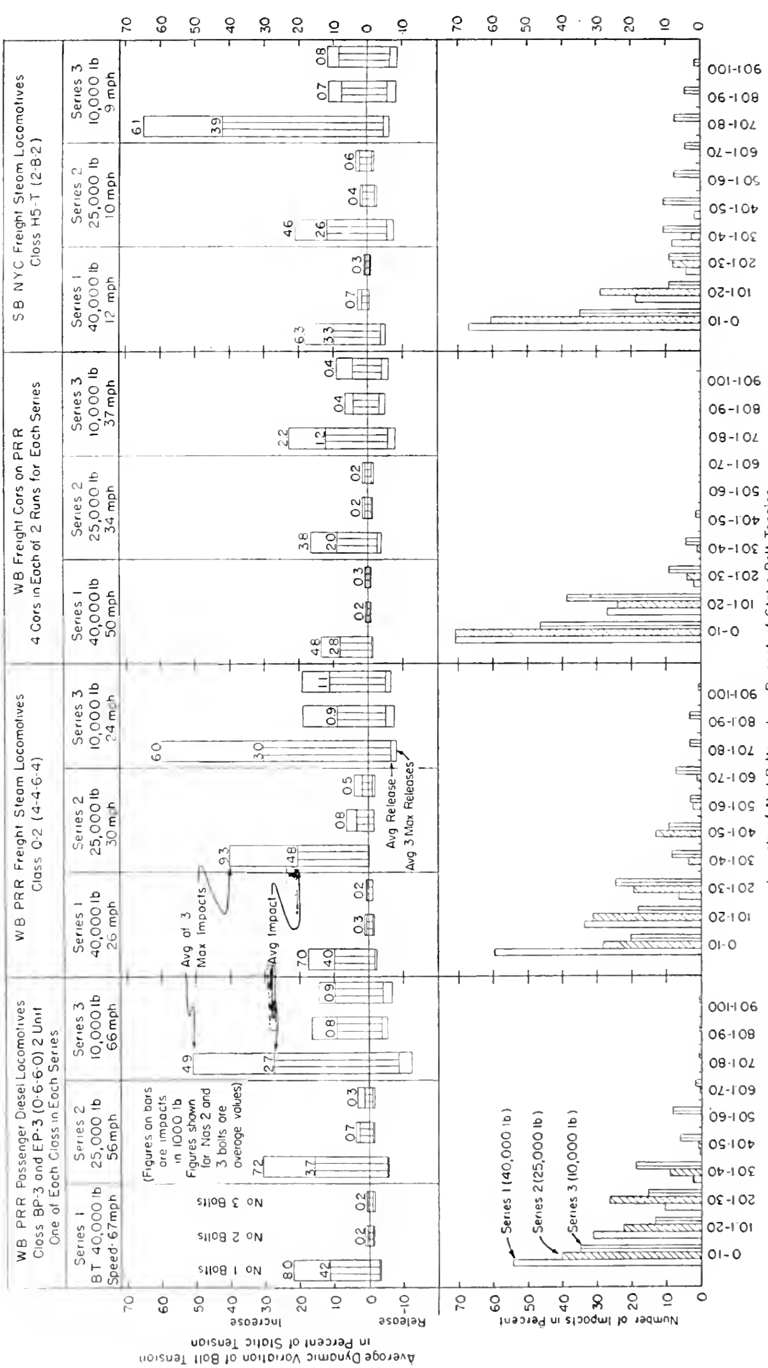


Fig 8 Dynamic Variation of Tension with Respect to Static Tension in the Main Bolts and Impact Frequency in the No 1 Bolts only.

1–N and 1–W. All of the No. 2 bolts, except 2–W, showed a slight increase in the average shock load when the two bolts were released, and 2–S had the largest increase. There was very little effect on the No. 3 bolts when 1–E and 1–S had no static tension. The foregoing demonstrates the futility of attempting to reduce the severity of the shock loads at the No. 1 position by transferring them to the other bolt positions. In the service tests of crossing frog bolt tension, it was determined that an excess of bolt tension could be dissipated in positions 2 and 3 only by running a long test cycle and permitting the No. 1 bolts to sustain a greater loss in tension than would be considered satisfactory for good maintenance.

No. 1 Bolts

Locomotives

The first method of analysis of the shock loads indicated that the dynamic variations in bolt tension in the No. 1 bolts were quite large, and the values in the Nos. 2 and 3 positions very moderate, except in series 3 with 10,000 lb static bolt tension. Accordingly, further study was made of the No. 1 bolt variations by reading the maximum values chargeable to each axle of several types of locomotives and freight and passenger cars. The service tests conducted on crossing frog bolt tension had indicated that the bolts in position No. 1 of the bolted-rail crossing and the manganese-insert type lost, by far, the greatest amount of bolt tension and seemed to be the chief problem in maintaining adequate tension in crossing frog bolts. These data, involving the individual maximum values of shock loads for each No. 1 bolt and axle, are presented graphically in Figs. 9 to 14, incl. Each of the figures has the locomotive wheel diagram and axle loads shown in the upper portion. The individual values of maximum shock loads for the four No. 1 bolts in the test corner are grouped directly below each axle in the order of 1–E, 1–W, 1–N and 1–S, from left to right. The shock loads are shown in 1000 lb in the graph portion of the figures, and a summary is included in the right portion of each figure. For a given static bolt tension the most significant factor for judging the shock loads with respect to the resultant cyclic looseness (which is closely related to the wear of the assembled parts), is the percentage of the values with respect to the static bolt tension. Those percentages are given in the next to last column in the right portion of the figures. Percentages of shock load with respect to the average wheel load, shown in the extreme right column, will be used later for the purpose of examining the shock loads with respect to train speed.

Because of the predominance of passenger diesel power, a separate figure is presented for each of the test series covering the PRR 6-wheel truck diesels built by Electro-Motive Division, General Motors Corporation, and the Baldwin Locomotive Works. This information is shown in Figs. 9, 10 and 11 for series 1, 2 and 3, respectively. In series 1 (Fig. 9), the east and west bolts, generally received the two highest shock loads for each axle. With a few exceptions, the north bolt recorded the lowest maximum values. Service tests of bolt tension in the eastward crossing of Warsaw, Ind., which is of the same construction as the one in which the shock load measurements were made, indicated that all of the main bolts in the PRR rails lost more tension than in the NYC rails. There is no definite pattern for the average maximum shock load for the 3-axle trucks, except in the case of the front truck of the first "A" unit where the lead axle had the lowest average for that truck. This is judged to be accidental, because the trailing trucks of both units are spaced sufficiently behind the leading trucks to progressively load the crossing in a comparable manner and produce the same pattern. In this investigation, no special test train was used, and, as a result, an insufficient number of comparable records for the several types of power was obtained for the purpose of accurately comparing the shock loads for one class of power with another.

Fig. 10 covers the same two classes of diesels for series 2 with 25,000 lb static tension. In this series there was no pattern of the average shock loads with respect to the axle position in a truck. In addition to having the higher stresses on the east and west bolts, the south bolt also sustained high values. Bolt 1–N continued to have the lower values. The shock load percentages with respect to the static bolt tension varied from 15.2 to 25.5 in series 2, compared with 14.8 to 18.8 in series 1, which indicates a moderate increase for series 2. In series 3, Fig. 11, there is no pattern of the average shock load for the axles of a truck. The higher values were generally divided between the east, west and south bolts, with the north bolt generally lower, but relatively higher than in series 1 and 2. With 10,000 lb static bolt tension, the percentages of shock loads with respect to the static tension ranged from 26.5 to 40.4, or somewhat higher than was obtained in series 1 and 2.

Fig. 12 gives information on the maximum shock loads measured in the No. 1 bolt position for the heavy PRR class Q–2 (4–4–6–4) steam locomotives in all test series. Under this class of power the west and south bolts generally had the higher values of shock loads in all test series. Even though the front trailer was about 15,000 lb lighter than the drivers, the shock loads were comparable to those of the drivers. This was influenced by the wider spacing between the back main driver and the front trailer. There were some high shock loads in series 2 and 3, and in the latter one value was equal to the static tension.

Data for the PRR class K4–S Pacific-type (4–6–2) locomotives are shown graphically in Fig. 13 for the three test series. From an analysis of several runs in series 1, the values shown for run 18 are judged to be higher than normal. In series 1, the east and west bolts sustained the higher shock loads, series 2, the west and south bolts, and in series 3 the larger values were measured in the east and south bolts. The north bolt generally had the lower shock loads in all three test series. Except in series 2, the main driver caused the highest shock loads. The maximum computed depression of the crossing would occur when the three drivers are on the crossing. With 10,000 lb tension in series 3, the average shock load in percent of the static tension was 46.8, which was rather high, but was not as large as that for a lighter locomotive on the NYC rails operating at slow speed.

Fig. 14 gives information on the principal shock loads for the NYC class H5–T Mikado-type (2–8–2) locomotives for all test series. In series 1, all of the larger shock loads were in the east and west bolts, the same as found for the diesels and Pacific-type locomotives on the PRR rails. For series 2, the larger values were sustained by the east and south bolts, while in series 3 they were generally in the west and south bolts. The percentages of the shock loads based on the static tension were 14.6, 26.9 and 55.3 for series 1, 2 and 3, respectively. The latter value was quite high and was influenced by the crossing support which favored the PRR rails.

A summary by test series and classes of power of the information shown in Figs. 9 to 14, incl., together with additional runs, is presented in Fig. 15. An inspection of the diagrams for series 1 indicates considerable scatter in the average magnitude of the maximum shock loads measured in the No. 1 bolts. This is particularly evident with the PRR K4–S and NYC H5–T locomotives. In series 1, a heavy rain fell during the night after run 4. On the second day after the rain, the crossing had settled noticeably and the test corner was tamped up before run 20. Run 18 was high speed, and 22 was moderate speed for the K4–S locomotives. The values in run 18 were rather high for the speed and low in run 22. It is therefore assumed that tamping up the crossing effected a considerable proportion of the reduction in the shock loads. Shock loads under the NYC H5–T locomotives were also reduced by the tamping. This can be observed by comparing runs 19, 21 and 23. The effect of tamping up the test corner in series 2 had no important influence on the shock loads because the scatter in the results was about normal for the shock load measurements. No tamping was required during series 3. The scatter was quite moderate in that series. This is considered due largely to the low bolt tension which was insufficient to cause the bolts to function normally.

In series 1 the average values for the three classes of diesels were about the same. However, in the case of the 6-wheel truck diesels there were 50 percent more values of major shock loads than for class EF–4 with 4-wheel trucks. Series 2 shows only small differences between the two classes of 6-wheel truck diesels, and also that the class Q–2 locomotives had higher shock loads than classes EP–3 and BP–3. The NYC H5–T locomotives operating at low speed in series 3 had a little higher average shock load than the Q–2 and K4–S classes at somewhat greater speeds.

In connection with the foregoing analysis of the major shock loads measured in the No. 1 bolts under the locomotives, a study was made to determine the effect of train speed on the magnitude of the values. Because of the limited number of records taken for each class of power, and no class of power operated throughout the entire range of speed, it was decided to consider all of the PRR runs by plotting the average shock loads in percentage of the average static wheel load versus train speed for several classes of power. It is realized that the major impacts do not increase in direct proportion to the wheel load, but there was no other logical method to make adjustments for the variables of wheel loading and spacing. Accordingly, the speed effect study is presented graphically for the three test series in Fig. 16. The NYC values are also shown as a matter of information, there being very little variation in speed on that side of the crossing. Series 1 is shown in the upper portion of the figure, and the trend line of the estimated speed effect is shown for the speed range from 40 to 90 mph. The rate of increase of shock loads based on the trend line is about 0.7 percent per mph., or 28 percent increase from 40 to 80 mph. The trend line in series 2 gives a corresponding value of 0.8 percent per mph, or a 32 percent increase in the shock loads by doubling the speed from 40 to 80 mph. The plotted points in series 3 for the PRR runs indicated that there was no increase in shock load in the range of speed shown.

It is of interest to note that some of the plotted points for the NYC locomotives in all three series were quite high with respect to values for the larger PRR locomotives running at much higher speeds. In series 3, the NYC values were above all of the values for the PRR locomotives. This comparison confirms that discussed for Fig. 8, in that the average magnitude of the shock loads in the No. 1 bolts tended to decrease for PRR traffic and to increase for NYC traffic as the static bolt tension was varied from 40,000 lb to 10,000 lb. It is believed that the higher percentage of shock loads with respect to wheel load produced by the NYC locomotives was because the crossing was not supported as well on that side as on the PRR rails, which has the longitudinal timbers.

The speed effect trend curves shown for series 1 and 2 for the PRR locomotives in Fig. 16 are not precise, but will serve to demonstrate that the impacts did increase to some extent with the train speed. In series 3, the analysis indicated there was no speed effect with 10,000-lb initial static bolt tension. That tension was so inadequate for clamping the assembly securely that the parts had so much freedom to move with respect to each other as to prevent the bolts from responding to the effect of speed on the shock loads. It is judged that 10,000-lb static tension in the No. 1 bolts is inadequate for the proper maintenance of the test crossing.

Passenger and Freight Cars

Fig. 17 is included to give information on the major shock loads measured in all three bolt positions under each axle of two modern 85-ft bedroom cars running about the same speed in the three test series. This exhibit was prepared in the same manner as in the case of Figs. 9 to 14, incl., except that bolts in positions 2 and 3 were also included. The bedroom cars have an 8-ft 6-in truck wheel base and weigh approximately 150,000 lb each. In series 1 and 2 the average shock loads for the No. 1 bolts were 5640 lb and 4680 lb, respectively. These values are quite comparable to those of some of the locomotives shown in Figs. 9 to 13, incl. The average shock load of 2250 lb for the No. 1 bolts in series 3 was considerably smaller than the corresponding figures for the locomotives. Percentagewise, the major shock loads in the No. 1 bolts in series 3 increased moderately over that for series 2. In the case of the steam locomotives, the corresponding percentage increase in the No. 1 bolts was much greater than that for the bedroom cars and the freight cars. The average magnitude of the shock loads in the three test series was quite consistent in that the values for the No. 1 bolts progressively decreased, and those for the Nos. 2 and 3 positions increased moderately as the static bolt tension was set at 40,000, 25,000 and 10,000 lb. Shock loads in the Nos. 2 and 3 bolts in series 1 were quite small, while in series 2 they were larger, but neither present a serious problem as far as crossing wear is concerned. In series 3, the average shock loads in the Nos. 2 and 3 bolts increased appreciably with respect to the average value for the No. 1 bolts. Ordinarily, this condition can be avoided in day-to-day maintenance if the bolts are kept tighter.

The average maximum shock loads in the No. 1 bolts for series 1, 2 and 3, expressed in percentage of the average wheel load of 18,750 lb, are 30, 25 and 12 percent, respectively. By comparing these percentages with those plotted in Fig. 16 for the PRR locomotives, it will be observed that in series 1 and 2 the shock loads measured under the bedroom cars were relatively higher than for the heavier locomotives. However, in series 3 the 12 percent value was quite comparable to the percentages plotted in Fig. 16 for the PRR locomotives. In other words, except in series 3, the average major impacts in the No. 1 bolts measured under the bedroom cars tended to be relatively larger with respect to the average wheel load than for the PRR locomotives.

A comparison was made of the maximum shock loads measured in the No. 1 bolts under freight cars on the PRR track for the three test series. Although the weights of the several cars analyzed for each test series were not determined, the average values of the shock loads for the three series progressively reduced in a consistent manner with decreasing static bolt tension when compared with the trend of the values for the No. 1 bolts under the bedroom cars. Therefore, it is believed that the data presented in Table 1 gives a reasonably good comparison of the shock loads with respect to the static bolt tension. It was not possible to have all of the train speeds the same; consequently, the effect of speed was not entirely eliminated as in the case of the bedroom cars. The average magnitude of the shock load in series 1, 2 and 3 was 3770 lb, 2800 lb, and 1710 lb, corresponding to 10.8, 12.4 and 17.6 percent, respectively, of the static bolt tension. In series 1 and 2, the freight car averages were considerably less than the corresponding figures for the bedroom cars. In series 3, the freight car average shock load of 1710 lb was fairly comparable to 2250 lb for the bedroom cars.

Conclusions

It has been shown that with approximately 40,000 lb or 25,000 lb static bolt tension, the shock loads measured in the No. 1 bolt positions were several times greater than the companion impacts in positions 2 and 3. The larger shock loads in the No. 1 bolts permit a greater separation of the clamped parts and more relative movement of those parts, which results in a greater amount of wear or pull-in at those bolts and more loss in tension than at the other bolt positions. The No. 1 bolts are the closest to the flangeway intersection, which is the weakest part of the assembly as far as the vertical loads are concerned.

Assuming for a given tonnage of traffic that crossing wear or pull-in of the assembled parts is directly related to the shock loads and the net cyclic tightness of the assembly, as gaged by the difference between the magnitude of the static bolt tension and the shock loads in the No. 1 bolts, the higher tension of 40,000 lb should be the most effective for minimizing wear and the attendant dissipation of the bolt tension. Although, in some comparisons of the shock loads the major values in the No. 1 bolts in series 2 (25,000 lb tension) are almost as favorable as those in series 1, the higher tension will be more effective, especially when the crossing needs tamping up. It is probable that even a static tension in excess of 40,000 lb would be more effective for minimizing wear and cyclic looseness, but it is not practical to maintain extra high static tension economically, unless harder materials are provided on both sides of the spring washers. Furthermore, the bolt tension service tests have indicated that the heavy-duty spring washers go solid for all practical purposes well below the load of 40,000 lb. This amount of static tension can be applied by one man with the standard frog wrench if the bolts are in reasonably good condition and free of battered threads behind the nut. As a practical matter, the initial tension of all of the main bolts should be set at about the same value, but in order to avoid undesirable large shock loads in the No. 1 bolts, they can be retightened at least twice as often as the others. However, in the service tests of crossing frog bolt tension it was found that occasionally a No. 2 or No. 3 bolt would lose more tension than expected. Therefore, in retightening only the No. 1 bolts, the others should be checked and wrenched if required.

The results in series 1, before and after tamping up the test corner, definitely as a minimum tension for the No. 1 bolts and not desirable for the other two positions. From a study of the major shock loads in the No. 1 bolts measured under the locomotives for the three test series, most of the objectionable large shock loads can be eliminated by retightening the No. 1 bolts at such a frequency as to keep the static tension from dropping below 20,000 lb.

The results in series 1, before and after tamping up the test corner, definitely showed that the crossing should be kept in good surface in order to minimize the detrimental effect of the larger shock loads. The crossing was in better surface during series 2 and 3 and there was no rainfall that might have caused it to settle. Consequently, no information was obtained in those two test series concerning the effect of poor surface.

The test runs with loose bolts in the No. 1 position revealed that very little of the shock load could be transferred to the Nos. 2 and 3 positions.

(Text continued on page 1034)

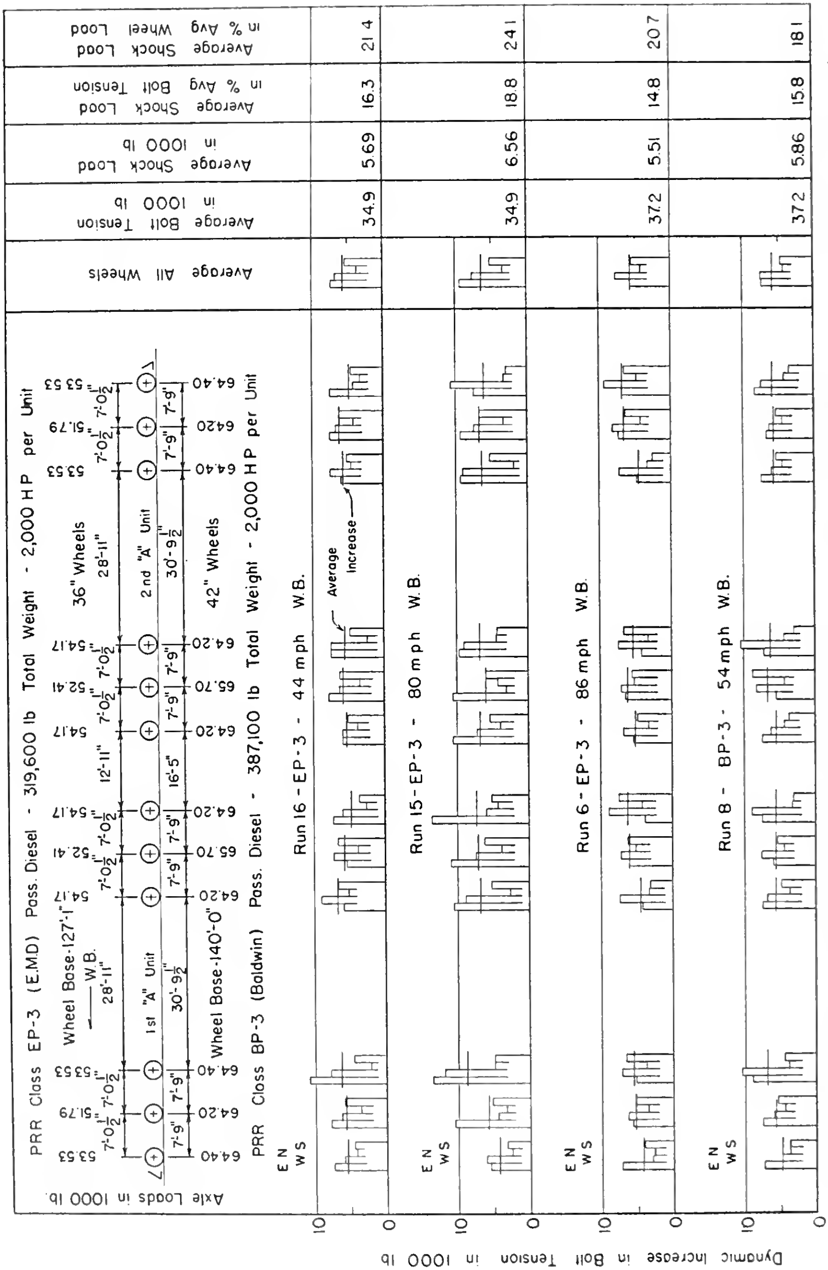
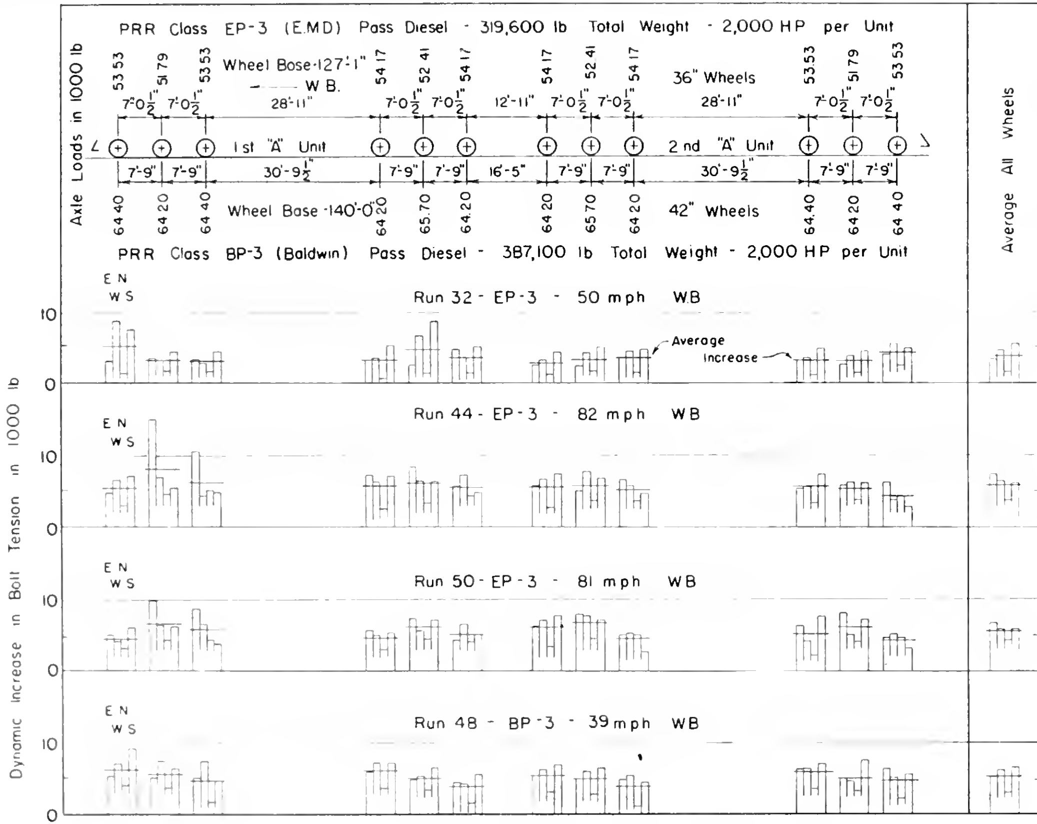


Fig 9. Series 1, 40,000 lb Bolt Tension. Maximum Dynamic Increase in Tension Measured in the No. 1 Bolts Under Each Axle of Two Classes of PRR Passenger Diesel Locomotives.



Run	Average Bolt Tension in 1000 lb	Average Shock Load in 1000 lb	Average Shock Load in % Avg. Bolt Tension	Average Shock Load in % Avg Wheel Load
Run 32 - EP-3 - 50 mph W.B.	24.3	3.70	15.2	13.9
Run 44 - EP-3 - 82 mph W.B.	23.1	5.89	25.5	22.2
Run 50 - EP-3 - 81 mph W.B.	23.1	5.70	24.7	21.1
Run 48 - BP-3 - 39 mph W.B.	23.1	5.48	23.7	17.0

Fig. 10. Series 2, 25,000 lb Bolt Tension. Maximum Dynamic Increase in Tension Measured in the No. 1 Bolts Under Each Axle of

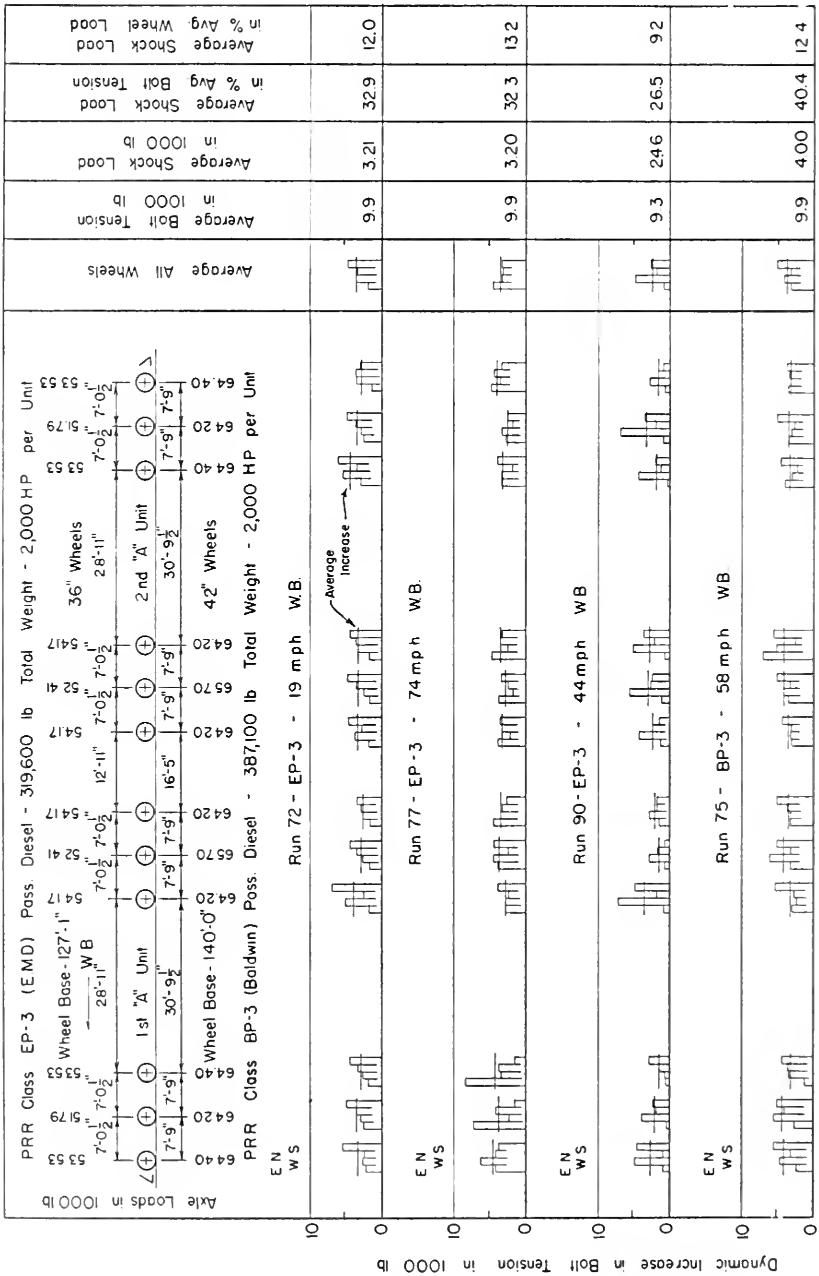


Fig. 11 Series 3, 10,000 lb Bolt Tension. Maximum Dynamic Increase in Tension Measured in the No. 1 Bolts Under Each Axle of Two Classes of PRR Passenger Diesel Locomotives.

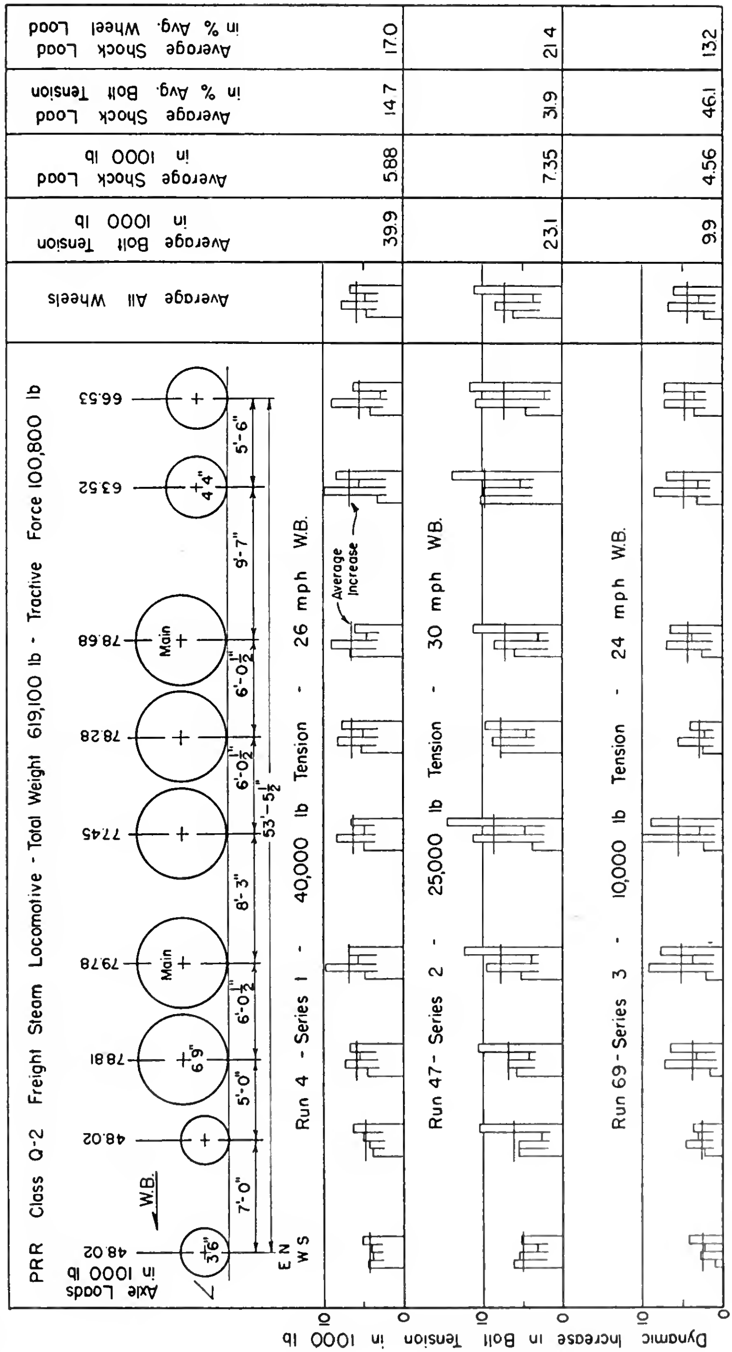


Fig. 12. Maximum Dynamic Increase in Tension Measured in the No. 1 Bolts Under Each Axle of PRR Class Q-2 (4-4-6-4) Freight Steam Locomotives.

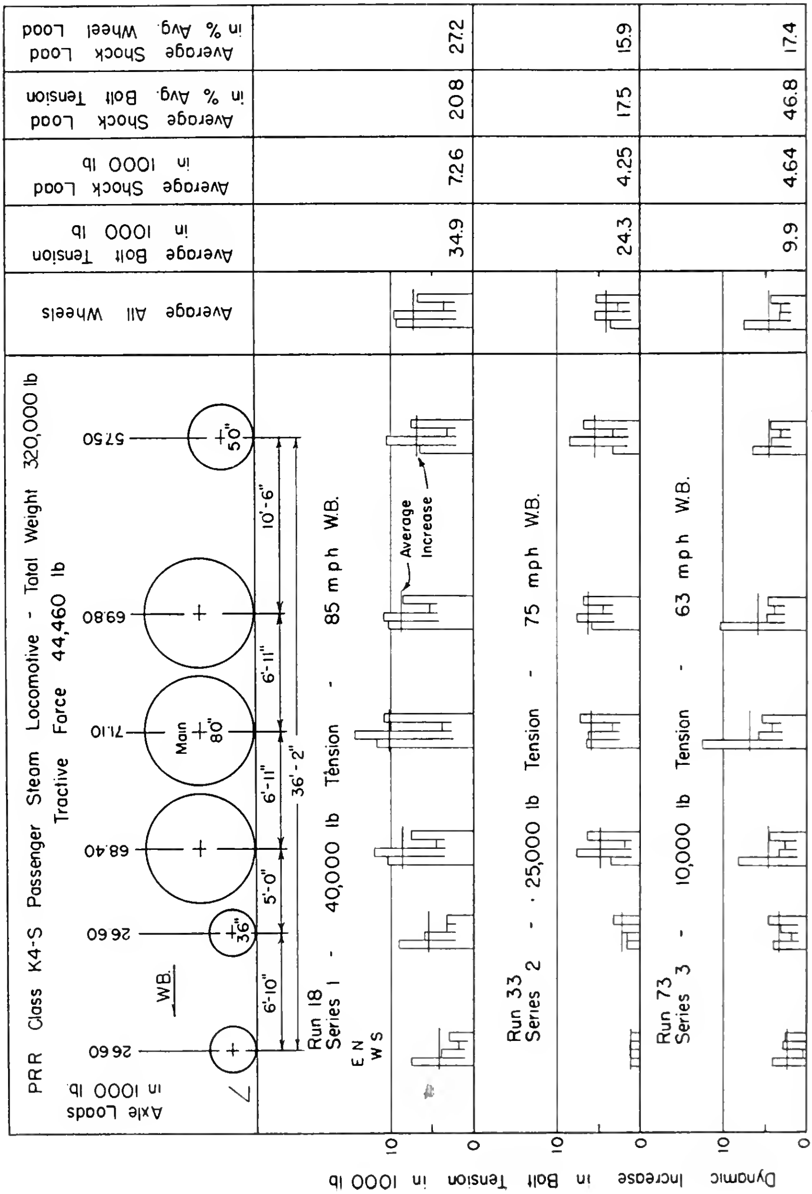
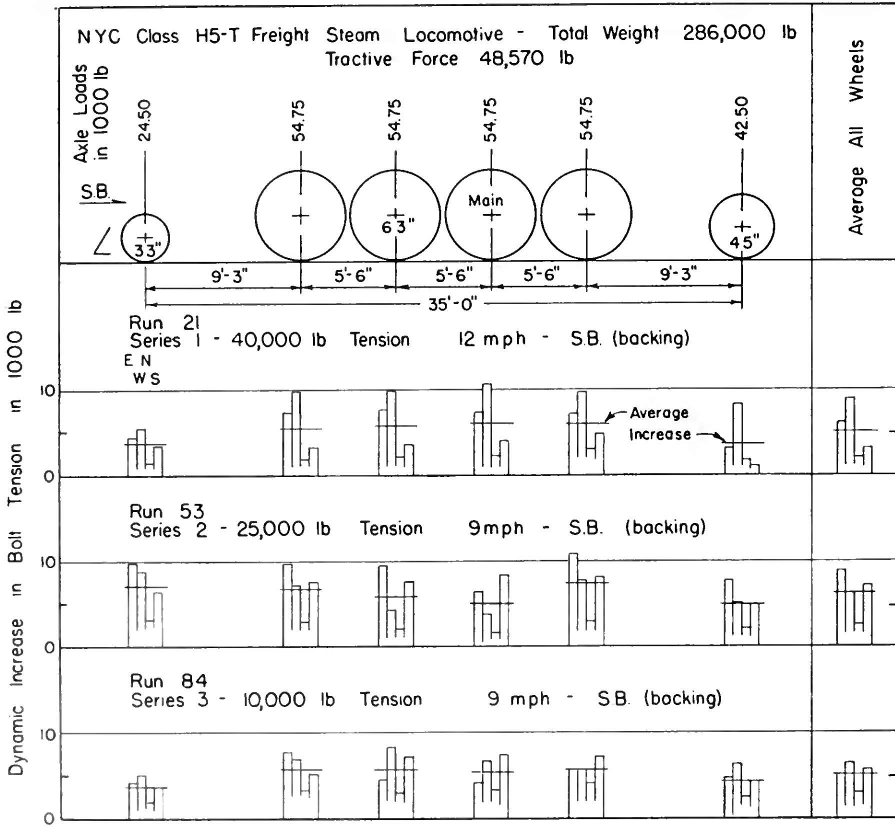


Fig 13 Maximum Dynamic Increase in Tension Measured in the No. 1 Bolts Under Each Axle of PRR Class K4-S (4-6-2) Passenger Steam Locomotives.



Run	Average Bolt Tension in 1000 lb	Average Shock Load in 1000 lb	Average Shock Load in % Avg. Bolt Tension	Average Shock Load in % Avg. Wheel Load
Run 21	34.9	5.10	14.6	21.0
Run 53	23.1	6.22	26.9	25.6
Run 84	9.3	5.15	55.3	21.2

Fig 14 Maximum Dynamic Increase in Tension Measured in the No. 1 Bolts Under Each Axle of NYC Class H5-T (2-8-2) Freight Steam Locomotives.

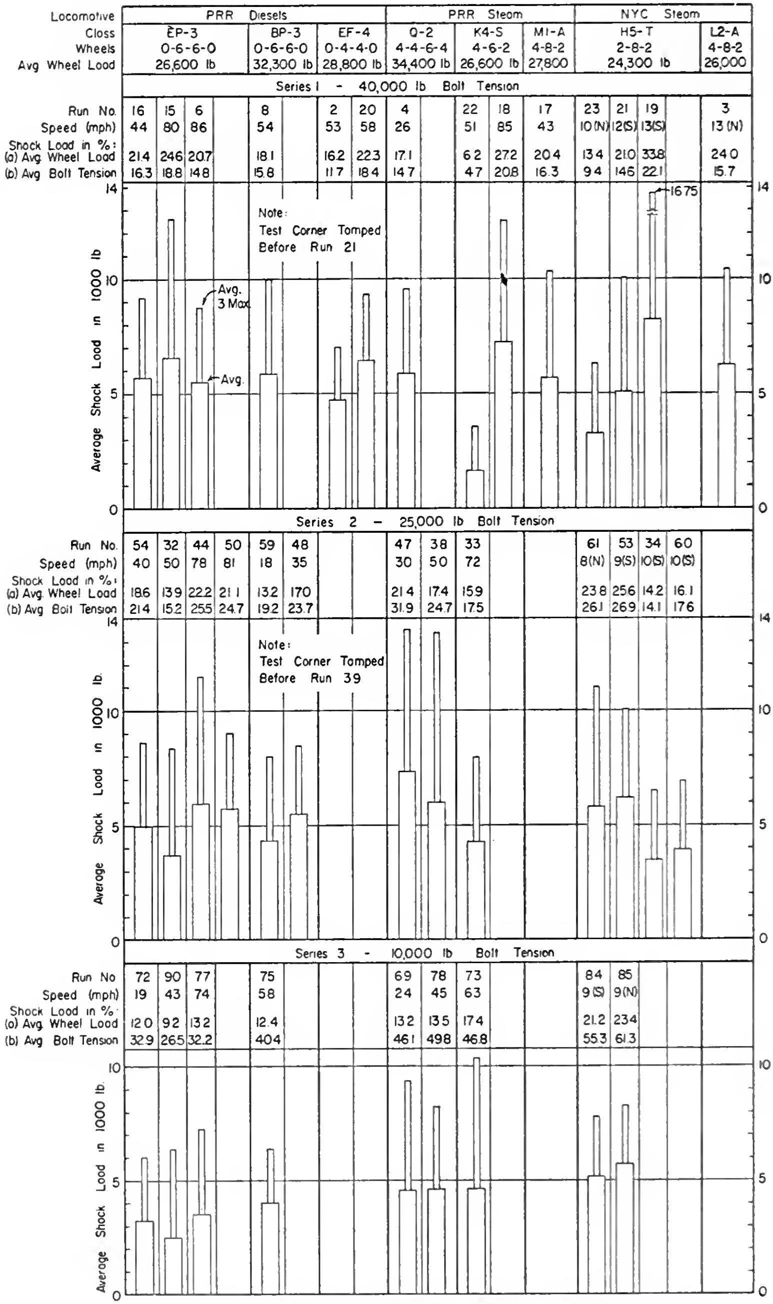


Fig 15. Summary by Test Series of Maximum Dynamic Increases in Tension Measured in the No 1 Bolts Under Each Axle of Eight Classes of Power

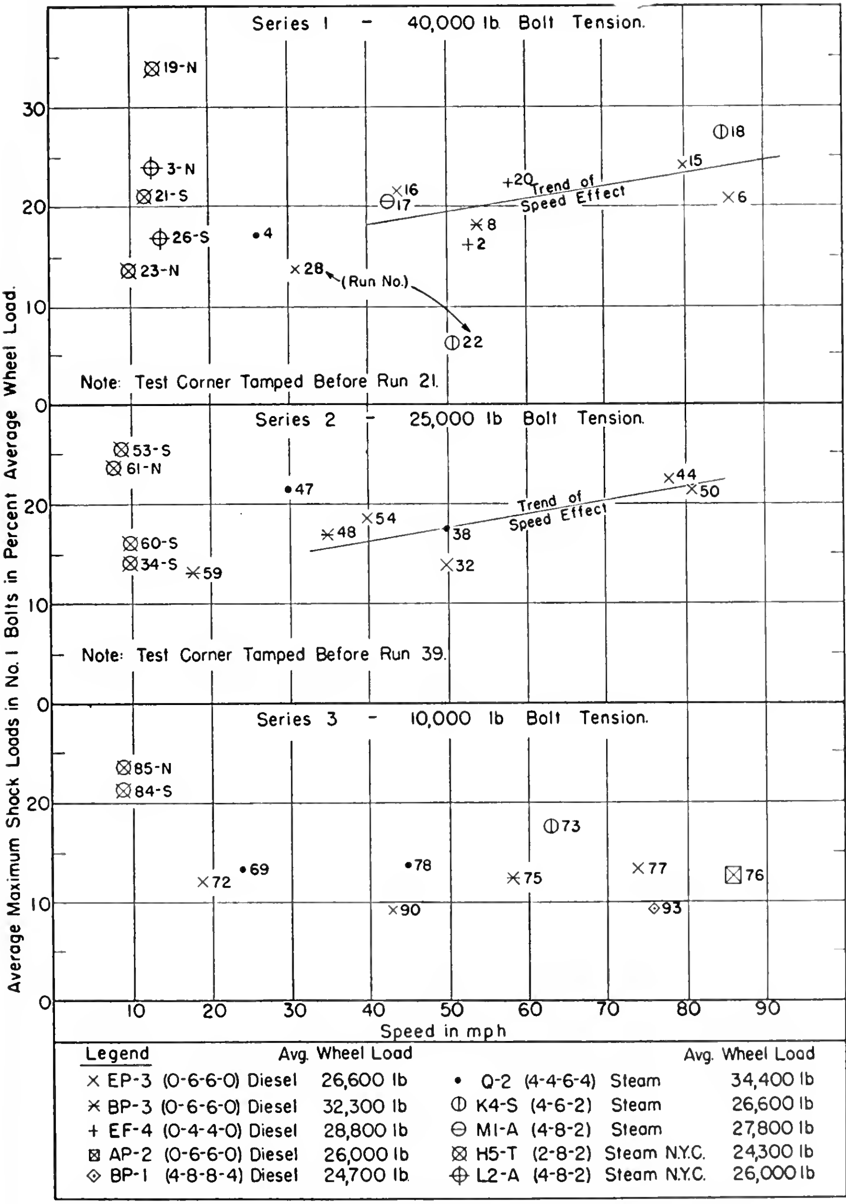
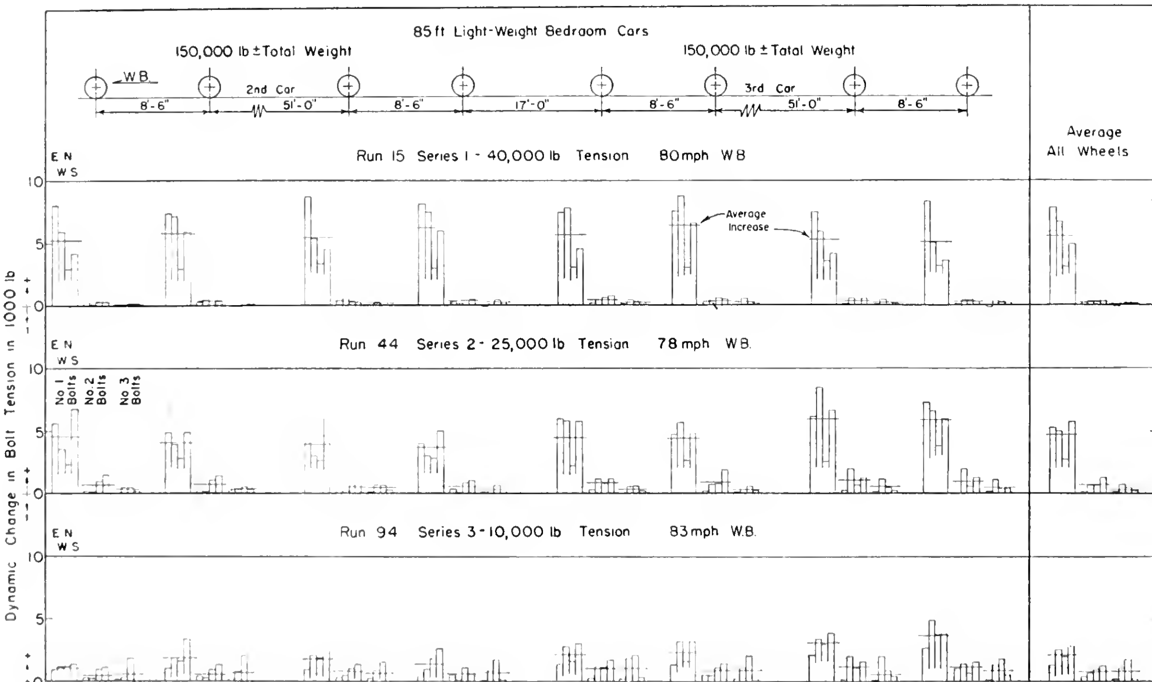


Fig. 16. Speed Effect of Locomotives on Major Impacts in the No. 1 Bolts



Run	Average Bolt Tension in 1000 lb	Average Shock Load in 1000 lb	Avg Shock Load in % Avg Bolt Tension	Bolt Number
Run 15	34.9	5.64	16.2	1
	34.9	0.38	1.1	2
	39.9	0.18	0.5	3
Run 44	23.1	4.68	20.3	1
	24.1	0.77	3.2	2
	23.6	0.37	1.6	3
Run 94	9.3	2.25	24.2	1
	9.3	0.90	9.7	2
	9.7	0.79	8.1	3

Fig. 17. Maximum Dynamic Increase in Tension Measured in all Main Bolts Under Each Axle of 85 ft Light-Weight - Bedroom Cars.

TABLE 1.- SUMMARY OF MAXIMUM DYNAMIC INCREASES IN TENSION MEASURED IN THE NO. 1 BOLTS UNDER EACH AXLE OF FREIGHT CARS ON P.R.R. TRACK

Bolt Position	Static Bolt Tension (1000 lb.)	Average All Values		Average Max. Values (1 per Car)		Average Min. Values (1 per Car)	
		1000 lb	Percent Static Tension	1000 lb	Percent Static Tension	1000 lb	Percent Static Tension
Series 1.- Average of 4 Cars in Run 17 at 43 mph and 4 Cars in Run 20 at 58 mph. Average Speed of Two Runs - 50 mph.							
1-E	37.7	5.87	15.6	6.78	18.0	5.08	13.5
1-W	29.2	3.61	12.4	4.49	15.4	2.78	9.5
1-N	35.5	2.55	7.2	2.96	8.3	2.01	5.7
1-S	37.1	3.06	8.3	3.50	9.4	2.01	5.7
Series 2.- Average of 2 Cars in Run 52 at 52 mph and 4 Cars in Run 58 at 17 mph. Average Speed of Two Runs - 34 mph.							
1-E	21.5	3.14	14.6	4.24	19.7	2.14	10.0
1-W	20.7	1.94	9.4	2.70	13.0	1.31	6.3
1-N	24.2	2.59	10.7	3.33	13.8	2.04	8.4
1-S	23.5	3.55	15.1	4.06	17.3	3.06	13.0
Series 3.- Average of 4 Cars in Run 69 at 24 mph and 2 Cars in Run 88 at 50 mph. Average Speed of Two Runs - 37 mph.							
1-E	9.6	0.86	9.0	1.24	12.9	0.50	5.2
1-W	9.1	1.36	14.9	1.80	19.8	0.96	10.6
1-N	10.0	1.53	15.3	1.80	18.0	1.34	13.4
1-S	10.0	3.09	30.9	3.82	38.2	2.19	21.9
Average of All No. 1 Bolts							
Series 1	34.9	3.77	10.8	4.43	12.7	2.97	8.5
Series 2	22.5	2.80	12.4	3.58	15.9	2.14	9.5
Series 3	9.7	1.71	17.6	2.16	22.3	1.25	12.9

For train speeds above 40 mph in series 1 and 2, the major shock loads in the No. 1 bolts under PRR traffic manifested a tendency to increase moderately with the speed (see Fig. 16).

From Fig. 16 it will be observed that the major shock loads in the No. 1 bolts under PRR traffic decreased slightly in magnitude between series 1 and 2, and appreciably more in series 3. However, the values for the NYC power were about as high in series 3 as in series 1. Because the NYC rails were not supported with longitudinal timbers, the low tension of 10,000 lb apparently was insufficient to cause the 7 clamped parts of the crossing to flex integrally. This suggests the desirability of having equal support under both sides of a crossing if the secondary line handles a significant part of the total tonnage passing over the diamond.

The receiving end of the east arm of the test corner had a 6-hole insulated joint. It was battered some and generally swinging a little. The upper fibers required frequent renewal. Judging from the many major shock loads that occurred when the wheels struck the receiving rail (east arm of test corner) in that joint, it seems probable that improved maintenance of connecting joints of crossings, particularly in high-speed territory, would be beneficial in reducing the magnitude of some of the impacts on the main bolts.

Acknowledgement

The committee and the Association gratefully acknowledge the fine cooperation and assistance rendered by the PRR and its employees in conducting this test.

This project was conducted under the general direction of G. M. Magee, director of engineering research, Engineering Division, Association of American Railroads. M. F. Smucker, assistant electrical engineer, was in charge of the field work. H. E. Durham, research engineer track, planned the test and prepared this report with the assistance of R. E. Purnell, assistant research engineer track, and other members of the research staff.

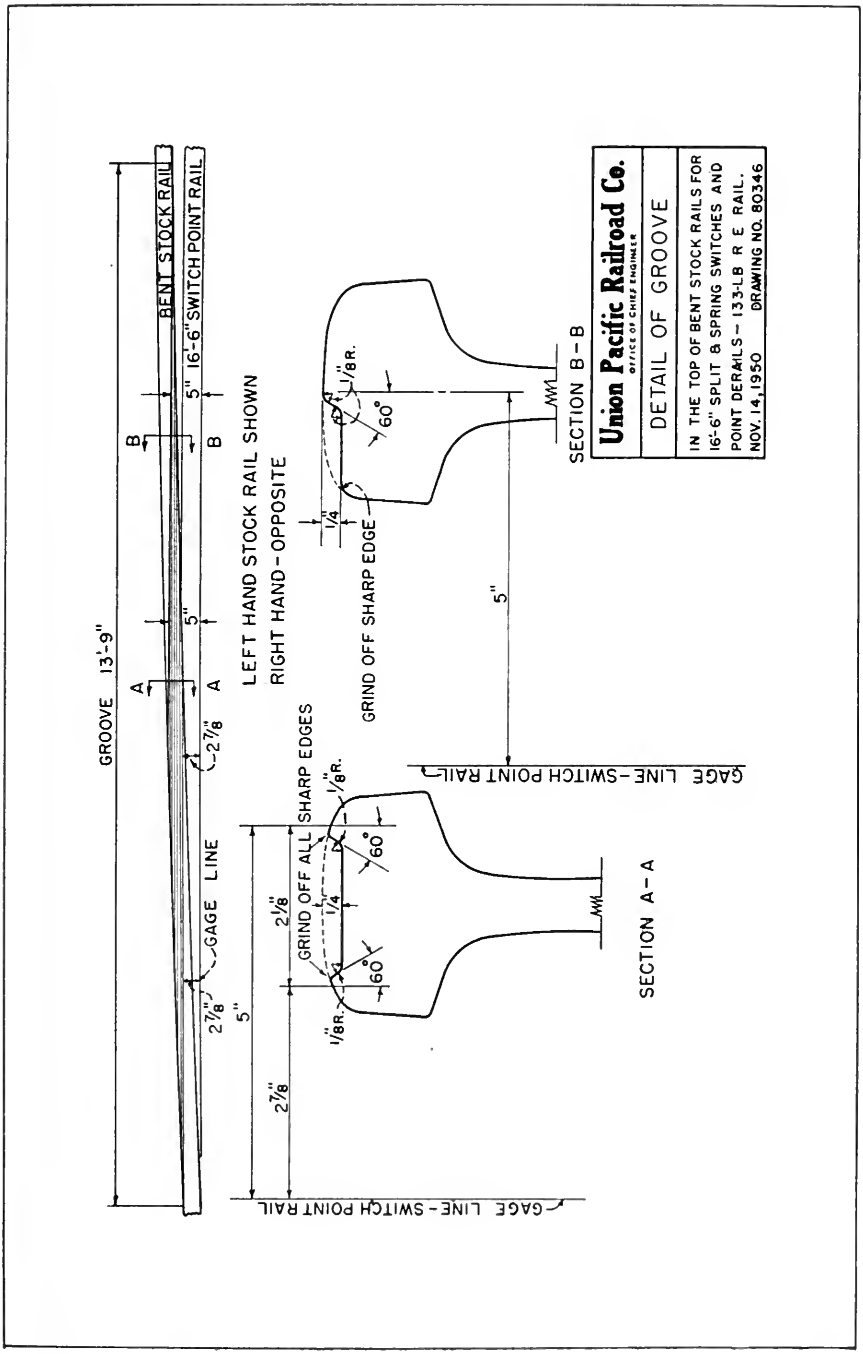
Appendix 3–d

Grooved Bent Stock Rails for Switches

Since a number of Track committee members evidenced interest in a new type of stock rail designed and installed by the Union Pacific Railroad, the following brief description of the design and results of the test installations is submitted for the information of AREA members.

Plan 80346 herewith shows the details of the groove in the top of bent stock rails for 16-ft 6-in split and spring switches and point derails for 133 RE rail. This plan is self-explanatory.

Trial installations of four grooved bent stock rails, 131 lb, for 16-ft 6-in split switches, were made in heavy-traffic main lines a short distance west of Omaha, Nebr., in 1949. At the beginning of 1951 grooved bent stock rails for 16-ft 6-in switches in 133-lb and 131-lb sections were made standard. At the beginning of 1952 grooving was adopted as standard in bent stock rails for 24-ft split switches in 133-lb section, and later in the year grooving was extended to 131-lb bent stock rails for 24-ft split switches so that, at the present time, the grooved bent stock rail is standard for all turnouts in 131-lb and 133-lb sections.


GROOVE 13'-9"
BENT STOCK RAIL
5" 16'-6" SWITCH POINT RAIL
B
B
5"
A
A
2 7/8"
GAGE LINE
2 7/8"
5"
LEFT HAND STOCK RAIL SHOWN
RIGHT HAND - OPPOSITE
GRIND OFF SHARP EDGE
1/4"
1/8"R.
60°
5"
SECTION B-B
GAGE LINE - SWITCH POINT RAIL
GRIND OFF ALL SHARP EDGES
1/8"R.
60°
1/4
2 1/8"
60°
1/8"R.
2 7/8"
SECTION A-A
GAGE LINE - SWITCH POINT RAIL
Union Pacific Railroad Co.
OFFICE OF CHIEF ENGINEER
DETAIL OF GROOVE
IN THE TOP OF BENT STOCK RAILS FOR
16'-6" SPLIT & SPRING SWITCHES AND
POINT DERAILS - 133-LB R E RAIL.
NOV. 14, 1950 DRAWING NO. 80346

The original trial installations of four grooved stock rails for 16-ft 6-in switches are still in place, having given better than six times the service previously obtained from ungrooved stock rails in the same locations. As yet there are no indications that the stock rails will require replacement in the very near future. At these locations 10 percent or less of the trains take the siding.

The grooved bent stock rails for the 16-ft 6-in switches are now in use over the entire system, several of them being at locations where the traffic on the turnout side is equal to or greater than that along the main track. At all these locations the grooved stock rail has given excellent service and apparently will far outlive the ungrooved stock rail.

The grooving of bent stock rails for 24-ft switches was only adopted at the beginning of this year. Installations have been principally in centralized traffic control territory where a substantial proportion of the traffic is over the turnout side. To date, service has been favorable and there has been no apparent disadvantage from the grooving in such locations.

The conclusion of the Union Pacific at this time is that grooved bent stock rails for 16-ft 6-in switches (No. 10 turnout) in locations of normal traffic on the turnout side are of undoubted advantage and will far outlast ungrooved stock rails.

Further observation will be required before arriving at a definite conclusion on grooved bent stock rails for 24-ft switches.

Report on Assignment 4

Prevention of Damage Due to Brine Drippings on Track and Structures

Collaborating with Committee 15 and Mechanical Division, AAR

W. E. Cornell (chairman, subcommittee), L. L. Adams, H. S. Ashley, L. E. Bates, F. J. Bishop, Blair Blowers, H. F. Fifield, A. E. Haywood, H. F. Kimball, E. R. Murphy, J. S. Parsons, S. H. Poore.

During the past year a laboratory has been built and equipped. The Association's chemical engineer has spent considerable time reviewing contemporary information on the subject of corrosion, which included several visits to industrial laboratories that are active in these researches; he also attended lectures given by such ranking research men of the country as Frank LaQue of the International Nickel Company, Professor Uhlig, in charge of corrosion research at M.I.T., Mars Fontana, director of Ohio State University Corrosion Laboratories, and Dr. Norman Hackerman of the University of Texas. A patent search, covering the last ten years, has been made of all compounds and mixtures recommended as corrosion inhibitors for steel and alloys.

The need for using non-toxic inhibitors limits the available compounds and thereby necessitates greater search for the non-toxic materials. Additional techniques for the evaluation of these materials are being used. Instead of constant immersion of the metal speciman or the use of large droplets (approximately 1 in. in diameter), droplets of $\frac{1}{32}$ in to $\frac{1}{8}$ in. in diameter will be applied by spraying. Such droplet size will allow for evaluation of the effect of atmospheric oxygen. Also the use of electrode potentials, requiring the use of potentiometers, voltmeters, ammeters and galvanometers, will make possible measurements not otherwise obtainable. Such techniques will shorten the period necessary to evaluate the usefulness of a compound.

The last report on this subject is given in the Proceedings, Vol. 51, 1950, page 661.

Report on Assignment 5

Design of Tie Plates

Collaborating with Committees 3 and 4

M. D. Carothers (chairman, subcommittee), L. L. Adams, F. J. Bishop, Blair Blowers, E. W. Caruthers, C. A. Colpitts, F. W. Creedle, J. W. Fulmer, A. E. Haywood, J. P. Hiltz, J. W. Hopkins, Charles Kuchel, J. A. Reed, R. D. Simpson, R. C. Slocomb, R. H. Timmins, C. E. Weller, M. J. Zeeman.

Your committee offers the following recommendations with respect to the Manual.

Pages 5–1 to 5–3, incl.

SPECIFICATIONS FOR LOW CARBON STEEL TIE PLATES

Reapprove without change.

Pages 5–4 to 5–8.9, incl.

TIE PLATES FOR RA-A AND RE RAIL SECTIONS

Reapprove without change.

Pages 5–14.1 to 5–14.3, incl.

SPECIFICATIONS FOR HOT-WORKED HIGH CARBON STEEL TIE PLATES

Reapprove without change.

Your committee submits, as information, (1) a progress report on the service tests of seven designs of tie plates for the rail base width of 5½ in, and (2) the results of a field test in which the magnitude and eccentricity of tie plate loads in tangent track under diesel and steam power were measured with calibrated dynamometer tie plates.

(1) Service Tests of Seven Tie Plate Designs

Foreword

This test installation is located in the southward main of the Illinois Central Railroad near Curve and Henning, Tenn., and was last reported in the Proceedings, Vol. 52, 1951, pages 556–563. The original 28 test track panels were placed in October 1944, and the total traffic carried by the track to June 1952 was 143 million gross tons. All traffic over the test sections is being hauled by steam locomotives, except that four passenger train schedules have multiple-unit diesels. The 4-deg test curve has approximately 4 in elevation, and some of the heavy tonnage freight trains operate as low as 20 mph. Both freight and passenger trains operate close to their maximum authorized speeds over the tangent test sections at Henning.

Tie Plate Penetration

Subsequent to the measurements made in May 1950, all test panels in the 4-deg curve were regaged and, in addition, the inner rail was relaid with 112-lb relay rail. In the pine tie panels, the ties were mechanically adzed on the low side for the purpose of placing in the test the 15-in tie plates with 1¼-in eccentricity, similar to AREA Plan 20, except that the tie plates were made of 1-in plates with shoulders welded in place. The inner rail was gaged in on the softwood ties and the outer rail was set in on the hardwood ties.

A summary of the tie plate penetration measurements, which give the total depth of plate cutting for the 91-month service period, is presented in Table 1. In July 1951,

TABLE 1. SERVICE TEST OF MECHANICAL WEAR OF TIES WITH SEVEN DESIGNS OF TIE PLATES FOR 112-LB RE RAIL IN THE SOUTHBOUND MAIN OF THE ILLINOIS CENTRAL SYSTEM NEAR CURVE AND HENNING, TENN.

Tie Plate Design No.	Tie Plate Dimensions in	Rail Seat	Tie Plate Penetration from Oct. 1944 to June 1952 in 0.001 in - 143 million gross tons						
			Inner or West Rail			Outer or East Rail			Average Both Rails
			Field End	Gage End	Avg.	Gage End	Field End	Avg.	
			4° Curve - Creo. Oak Ties						
419	7 3/4 x 13 x 27/32	Flat	293	163	228	195	268	232	230
419-Z	7 3/4 x 11 x 27/32	Flat	398	198	298	219	309	264	281
419-Y	7 3/4 x 11 x 11/16	Flat	450	175	312	211	395	303	308
419-X	7 3/4 x 11 x 9/16	Flat	414	204	309	295	403	349	329
366	8 x 11 x 23/32	Beveled	433	146	290	190	315	252	271
400	7 3/4 x 11 x 23/32	Rolled Circular	425	102	264	242	288	265	264
3170	8 1/2 x 11 x 3/4	Pressed Circular	405	216	310	177	360	268	289
			4° Curve - Creo. Pine Ties						
419	7 3/4 x 13 x 27/32	Flat	15-in Tie Plates with 1 1/4-in eccentricity omitted			259	321	290	
419-Z	7 3/4 x 11 x 27/32	Flat				321	460	390	
419-Y	7 3/4 x 11 x 11/16	Flat				332	427	380	
419-X	7 3/4 x 11 x 9/16	Flat				373	397	385	
366	8 x 11 x 23/32	Beveled				226	404	315	
400	7 3/4 x 11 x 23/32	Rolled Circular				296	435	366	
3170	8 1/2 x 11 x 3/4	Pressed Circular				354	326	340	
			Tangent - Creo. Pine Ties						
419-Y	7 3/4 x 11 x 11/16	Flat	259	427	343	333	221	277	310
419-X	7 3/4 x 11 x 9/16	Flat	285	403	344	361	225	293	318
366	8 x 11 x 23/32	Beveled	270	420	345	392	259	326	336
400	7 3/4 x 11 x 23/32	Rolled Circular	256	369	312	383	265	324	318
3170	8 1/2 x 11 x 3/4	Pressed Circular	226	351	288	322	198	260	274

All tie plates have flat bottom and 3/8-in eccentricity except pattern No. 3170 which has pressed circular bottom and 1/2-in eccentricity.

the 9 north test panels of the original 14 in tangent track at Henning were destroyed by a derailment. Only 5 panels of 11-in tie plates on creosoted pine ties are now in the test. It was decided not to restore the 9 panels because all of the 7 tie plate designs were still in service on the 4-deg curve where more conclusive results are anticipated.

In the last report, it was found that the rate of tie wear on the test curve, for both the pine and oak ties, had accelerated. For the past two years the accelerated rate of wear was about the same, except that there was a slight reduction on the inner rail of the oak ties. Previously, there had been no increase in the rate of tie wear in either the oak or pine tie sections on tangent track. During the last service period, tie wear in the five remaining sections on pine ties showed a moderate acceleration with respect to the traffic tonnage.

The 419-X tie plate, which is ⅛ in thinner than the current AREA 11-in plate for the 5½-in rail base, had values of tie plate penetration in the upper range on the curve for both oak and pine ties, and on tangent with pine ties. Tie abrasion by plate 3170, 8½ in by 11 in, with pressed circular rail seat and bottom, was in the lower range of values in the outer rail of the oak tie sections and on pine ties in tangent, but was in the upper range of values on the inner rail of the oak tie sections.

The 13-in tie plate was effective in reducing tie abrasion on the curve when compared with the five 11-in designs with ⅜-in eccentricity. The inverse ratio of the 13-in and 11-in length plates is 0.85, equivalent to a theoretical expected reduction in plate cutting of 15 percent. The actual percentage reduction as compared with the average of all of the 11-in plates, except pattern 3170, was 21 percent for the average of both rails on the curve sections with oak ties, and the same reduction obtained for the outer rail on the pine ties.

For making a comparison of the depth of plate cutting, the average tie plate penetration for the five 11-in designs left in tangent track will be used. For oak ties on the curve, plate cutting was only 3 percent greater on the inner rail than on the outer rail. In the last report the corresponding figure was 25 percent. The outer rail was gaged in on the oak ties after the 1950 measurements and the 1952 data show that, percentagewise, the penetration increased more on the gage end of the plates than on the field end. It is difficult to have the hand adzing done perfectly so as to avoid the gage end of the plates temporarily setting on a ledge of wood. A comparison between the oak and pine ties on the outer rail of the curve showed an excess plate cutting on the pine ties of 24 percent. The plate cutting on the pine ties in the outer rail of the curve was only 15 percent greater than for tangent track. There was no significant difference in the penetration measurements of the 11-in plates with respect to whether the rail seat was flat, beveled or rolled circular crown.

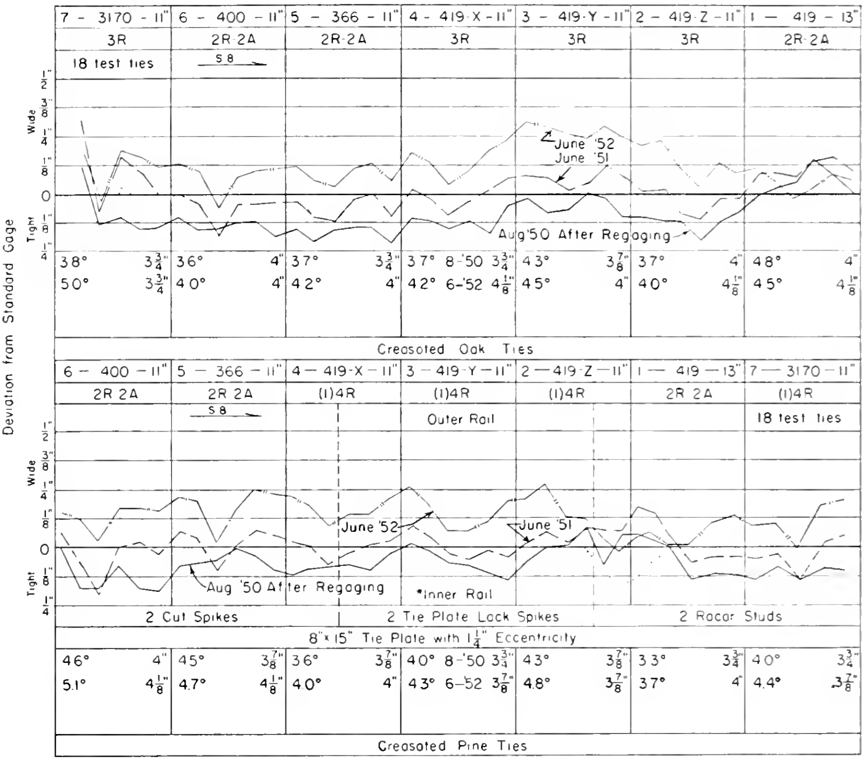
Because of tie plate tilt after the initial penetration readings were taken for the 15-in tie plates on the inner rail of the 4-deg curve, the measurements of the plate cutting for the 22-month service period will not be used. At the time of re-adzing the ties with a power adzer, it was observed that in many instances the adzed surface had a convex upward shape along the tie lengthwise. This condition permitted the major lateral forces on the inner rail to tilt the field end of the plates downward, which resulted in an abnormal depth of apparent plate cutting at the field end of the plates when compared with that for the gage end. Therefore, the past service period will be considered as one for seating the plates, and the set of penetration readings taken in 1952 will be used as the initial or base readings. The 15-in tie plates were checked for looseness on the ties with a hammer. There were 34, 4, and 55 percent loose plates, respectively, in the sections with Racor Studs, Tie Plate Lock Spikes, and cut spikes for hold-down fastenings.

Tie Plate Bending

From the measurements taken in June 1952 there was no indication that any further bending of the seven designs of tie plates had occurred. The 11-in, 419–X tie plate design is ⅛ in thinner at the outer shoulder than the plate shown in AREA Plan 4, but none had become bent since the last progress report. Four of those plates were found bent on the inner rail of the 4-deg curve with pine ties when the plates were removed in 1950.

Gage of Track

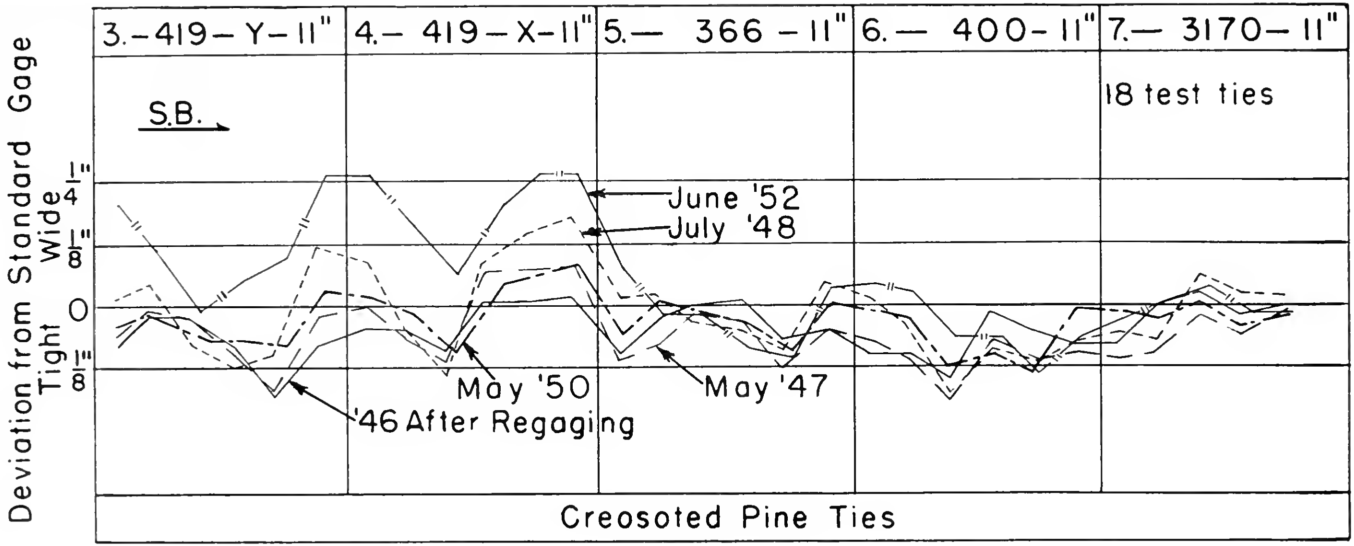
A graphical record of the gage of track for the original 14 test panels in the 4-deg test curve since they were last regaged in August 1950, is shown in Fig. 1. In the upper



Panels divide at joints in outer rail. 2R,3R, or 4R indicate the number of line spikes per tie plate, 2A the number of anchor spikes per tie plate. (1) The fourth line spike was driven September 1, 1948 * Rail was relaid, all pine ties mechanically adzed, and 15-in plates with 1-1/4-in. eccentricity were installed July 25, 1950. ········ Regoged August 1951

Fig 1. Gage, curvature and elevation of each panel of test track on the 4-deg curve, Mile L-333, I C R R

portion of the figure for the oak tie sections the gage has widened more where only three spikes per plate were applied. The average gage for the 7 oak panels has increased 0.2 in during the past 22 months. The gage on the softwood ties is more irregular than on the hardwood ties, and also has widened an average of 0.2 in. The inner rail on the pine ties has the special 15-in plates for use on curves, 3 second-hand cut line spikes, and 2 anchor spikes, as described in the figure. During the last service period there was a tendency for the gage to widen the least in the section with Racor Studs and the most in the cut spike section on the pine ties. Later reports may develop more important differences in the gage-holding properties of the special anchors as compared with cut spikes, insofar as the special construction on the low rail is concerned. The original test tie plates with cut spikes remain in service on the outer rail opposite the special construction on the inner rail. Curve wear on the outer rail during the 22-month period was less than $\frac{1}{32}$ in. A record of the gage of track on tangent in the remaining five panels of softwood ties is shown in Fig. 2. The gage has widened more, and with greater irregularity, in panels 3 and 4, and in the north portion of panel 5.



Each tie plate has 2 rail and no anchor spikes. Panels divide at joints in west rail. Each panel of test track has 23 ties except panel No. 7 which has only 18 test ties. All panels have 39 ft. rails.

Fig. 2. Gage of Each Panel of Test Track on Tangent at Henning, Tenn., I C R.R.

Test of 12-In Tie Plates, with ⅞-In Eccentricity

Completion of the regaging of the 3½ panels of 12-in tie plates with oak ties in the 4-deg test curve was delayed until August 1951. A record of the gage of track since that time is shown in Fig. 3. Panel 8 in the right portion of the figure adjoins the north end of the 1944 installation with oak ties. Panel 11 is used for tie plate penetration measurements, and the wider gage there may have been caused by the sharp place in the curve at that location. The 12-in plates were obtained by shearing off 1 in at the gage end of 13-in—419 plates having ⅜-in eccentricity. The compromise eccentricity of tie plate loads of the 2 rails of the 4-deg curve, as obtained from measurements with the dynamometer tie plates, was approximately 1 in. The ⅞-in eccentricity plates were placed in this test on both rails to determine if gage widening caused by unequal plate cutting could be minimized as effectively in this manner as in the case of using on the inner rail only special plates with a greater eccentricity, such as the 15-in length with 1¼-in eccentricity. The 12-in plates were applied on new hardwood ties in January 1947, and initial, or base, readings for tie plate penetration were taken in May 1947. These measurements, in inches, are tabulated below for the 5-year period ended June 1952, in which the traffic carried by the test track was 91 million gross tons.

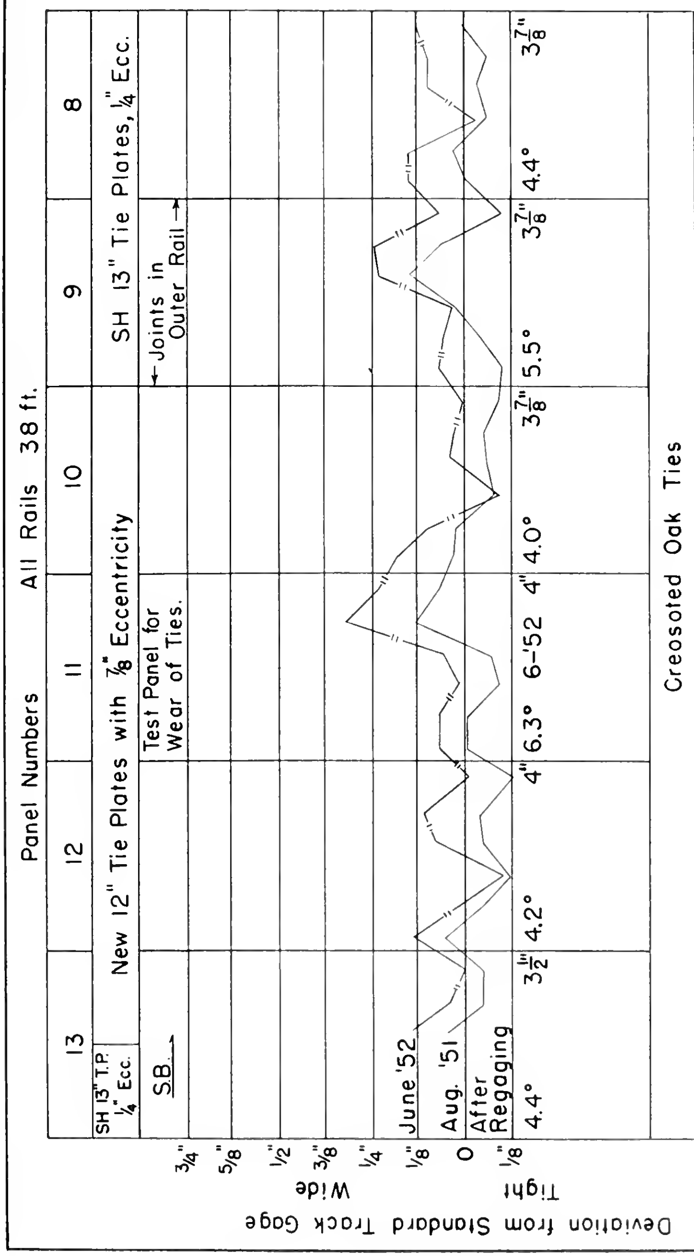
Inner Rail			*Outer Rail*			*Average*
Field End	*Gage-End*	*Average*	*Gage End*	*Field End*	*Average*	*Both Rails*
0.166	0.062	0.114	0.166	0.162	0.164	0.139

The average plate cutting of 0.139 in for both rails compares fairly well with 0.128 in for the 13-in tie plates on oak ties after 105 million gross tons of traffic. The cutting of the plates on the outer rail has been equalized at the plate ends. Based on the dynamometer tie plate determinations, the ⅞-in tie plate eccentricity is too large for the outer rail and too small for the inner rail, and the gage end of the outer rail plates would be expected to cut more than the field end. The measured eccentricity of the tie plate loads on the inner rail with the dynamometer tie plates was 1.4 in outward from the center line of rail base; and with ⅞-in eccentricity plates, the field end would be expected to cut more than the gage end, but should not be as much as was found in June 1952. It is possible that the tie plates had not become well seated on the ties when the base readings were taken, although the seating period of four months was considerably longer than that provided in all other tests of this character. The rate of plate cutting for the past 2 years was 50 percent greater than for the previous 3-year period.

Summary

The 13-in length plates as compared with the 11-in designs on the 4-deg curve effected a greater reduction in plate cutting than would be expected from the inverse ratio of the plate lengths. Excluding the 3170 plate with the pressed circular rail seat and bottom, the shape of the rail seat of the other 11-in designs had no important influence as to the amount of plate cutting. So far, the 3170 design of tie plate, which has approximately 10 percent more area than the 7¾ in by 11 in plates, has shown no superiority for reducing plate cutting. No conclusion can be drawn from the small number of the 419-X plates becoming bent. Assuming that tie plates should have a service life of not less than 20 years, it will require several more years to develop the effects of corrosion on the resistance to bending of the plates.

A few more years of service are needed to develop information for final conclusions.



Tie Plates of 12" Length have 7/8" eccentricity, and 3 line and 1 anchor **spikes** (On new ties).
Tie Plates of 13" Length have 1/4" eccentricity, and 2 line and 2 anchor spikes (On old ties).

Fig. 3. Gage, Curvature, and Elevation of 4° Curve with Tie Plates of Two Eccentricities, Mile L-333, I C R R.

Acknowledgement

The committee and the Association gratefully acknowledge the splendid cooperation and assistance rendered by the Illinois Central in conducting the service tests.

(2) Measurement of Tie Plate Loads

Foreword

The first report covering the use of the calibrated dynamometer tie plates was published in the Proceedings, Vol. 50, 1949, pages 18–40. That report gives the results on the measurement of tie plate loads and eccentricities in a 4-deg curve and tangent track on the Illinois Central Railroad near Curve and Henning, Tenn. The report also included a description of the dynamometer tie plates, the test procedure, and method of determining the tie plate loads and the position of their centroids. The results given in this present report cover measurements of the tie plate loads in tangent track under both steam and diesel power and will supplement the previous report.

Location of Test

This test was made in the single-track main line of the Chicago, Milwaukee, St. Paul & Pacific Railroad at a location two miles west of Kansasville, Wis. The two dynamometer tie plates were operated in two of the test series involving measurement of the rail creepage forces that are transmitted from the rail to the ties by rail anchors. In those test series there were a sufficient number of vacant oscillograph channels to provide strain gage circuits for the two cantilever arms of the dynamometer tie plates. The track was laid with 112 RE rail, 4-hole joints, creosoted oak ties, 11-in tie plates, and gravel ballast containing about 40 percent sand. The dynamometer tie was placed in one of the test panels that was scheduled for a static test of tie resistance to movement in the ballast. The track needed surfacing, but the work was not done as it was not desired to disturb the ballast because of the static test of the rail anchors. The location was in a shallow cut where the grade was 0.60 percent ascending westward.

Test Procedure

For the first series of runs, the track play was shimmed out on three ties each side of the dynamometer tie. That condition of rail support, designated condition A, was intended to make the tie plate loads equal to the average for several consecutive ties, uniformly supported. In the second group of runs (condition B), the shims under the rails above the dynamometer tie plates were adjusted to permit the dynamometer tie to swing as much as the first tie each side of it. The track play shims were removed from the three ties each side of the test tie, and the track was restored to its former condition. Several consecutive ties were swinging ¼ in to ⅜ in. Several records were taken under 6-wheel and 4-wheel truck diesels and medium weight Mikado-type (2–8–2) locomotives, mostly of the L2—a class having weight on drivers of 216,400 lb. Additional information on the three kinds of locomotives is given in Table 1, which summarizes results of this test.

Discussion of Test Data

Part 1 of Table 1 gives information on the tie plate loads for power or equipment in seven categories. Data for the average tie plate load eccentricity are shown for three classifications. The extreme right and left columns of the table show a comparison of the average values with respect to the condition of rail support. Average tie plate loads measured on the swinging dynamometer tie for 6-wheel and 4-wheel truck diesels and

TABLE 1. - DYNAMOMETER TIE PLATE LOADS MEASURED IN TANGENT TRACK ON THE SINGLE TRACK LINE OF THE MILWAUKEE RAILROAD NEAR KANSASVILLE, WIS.
(112-lb. RE Rail, Creosoted Oak Ties and Gravel Ballast with 40% ± Sand)

Part 1. Mean Tie Plate Loads and Eccentricity of the Centroid of Pressure from the Centerline of Rail.

CONDITION OF RAIL SUPPORT - A						CONDITION OF RAIL SUPPORT - B				
Avg. Tie Plate Loads (1000 lb)			Avg. Speed mph	Avg. Static Wheel Load 1000 lb	Equipment	Avg. Static Wheel Load 1000 lb	Avg. Speed mph	Avg. Tie Plate Loads (1000 lb)		
Both Rails	North Rail	South Rail						North Rail	South Rail	Both Rails
12.0	12.1	11.8	53	27.3	6-Wheel Truck Diesels (1)	27.3	54	16.4	17.2	16.8
12.3	12.8	11.8	40	28.8	4-Wheel Truck Diesels (2)	28.8	47	18.0	17.3	17.6
12.4	10.7	14.2	26	24.0	Mikado (2-8-2) Locos. (3)	25.4	32	15.6	17.2	16.4
9.2	8.0	10.4	26	-	Locomotive Tenders	-	32	13.2	12.1	12.6
7.3	7.1	7.5	26	-	Loaded Freight Cars	-	35	11.0	10.5	10.8
3.5	3.0	4.0	26	-	Empty Freight Cars	-	35	5.1	4.2	4.6
7.4	8.0	6.9	53	-	4-Wheel Truck Pass. Cars	-	54	10.3	9.4	9.8
Average Eccentricities of Tie Plate Loads in in. (+ = Outward from ℄ Rail Base, - = Inward)										
+0.41	+0.03	+0.79	46	-	All Diesel Power	-	51	-0.29	+0.39	+0.05
+0.64	+0.86	+0.41	26	-	Steam Power, Incl. Tenders	-	32	-0.01	+0.46	+0.22
+0.63	+0.43	+0.83	35	-	All Cars	-	43	-0.11	+0.58	+0.24
+0.56	+0.44	+0.68	36	-	Averages	-	42	-0.14	+0.48	+0.17

Part 2. Frequency of Tie Plate Loads in Percent by Increments of 5,000 lb as Measured in Both Rails.

Increment Limits in 1000 lb						Avg. Speed mph	Equipment	Avg. Speed mph	Increment Limits in 1000 lb					
0 to 4.95	5.00 to 9.95	10.00 to 14.95	15.00 to 19.95	20.00 to 24.95	25.00 to 29.95				0 to 4.95	5.00 to 9.95	10.00 to 14.95	15.00 to 19.95	20.00 to 24.95	25.00 to 29.95
	4	96				46	All Diesel Power	51				98	2	
12	18	50	12	8		26	Steam Power, Excl. Tenders	32		17	12	50	17	4
25	73	2				35	All Cars	43	13	47	38	2		

Track Condition A. Track play was shimmed out on three ties each side of the dynamometer tie plates.
Track Condition B. Dynamometer tie was swinging the same amount as the first tie each side of it.
(1). Fairbanks-Morse 2000 hp (0-6-6-0) "A"-unit, weight on drivers 222,600 lb, total weight 327,250 lb
(2). Electro-Motive 1350 hp (0-4-4-0) "A"-unit, total weight 230,800 lb
(3). Class L2a (2-8-2) locomotives, weight on drivers 216,400 lb, total weight 287,700 lb and Class L3 locomotives, weight on drivers 243,000 lb, total weight 320,000 lb

the steam power were, respectively, 40, 43 and 32 percent greater than the corresponding values for condition A. For condition A the average tie plate loads for the three kinds of power were, respectively, 44, 43 and 52 percent of the respective values of average wheel loads. The corresponding figures for condition B were, respectively, 62, 61 and 60 percent. The swinging ties caused the diesel tie plate loads to increase in magnitude appreciably more than those for the (2–8–2) locomotives. This was caused principally by the wider wheel spacing of the diesel power. The 6-wheel truck diesels had 7-ft 9-in axle spacing, the 4-wheel truck diesels had 9-ft axle spacing as compared with 5-ft 6-in spacing of the drivers of the (2–8–2) steam locomotives. For condition A there was little difference in the average tie plate loads for the three kinds of power. In condition B there was a slight tendency for the diesel average tie plate loads to be larger than for the steam power.

The general average eccentricity of all tie plate loads for conditions A and B was + 0.56 in and + 0.17 in, respectively. The value of + 0.17 in. in condition B compares very closely with + 0.2 in which had been previously determined from the depth of tie penetration on three railroads at four locations. When the dynamometer plates were shimmed to support each edge of the rail base for condition A, it is probable that the rail had assumed an abnormal cant.

In Part 2 of Table 1 the frequency of tie plate loads in percent by increments of 5000 lb is given. It will be noted for the diesel power that for each condition of rail support 96 to 98 percent of the loads were in one increment. Those values are very uniform in comparison to the scatter under the steam locomotives. Approximately 20 percent of the tie plate loads under the Mikado locomotives were of greater magnitude than those measured under the diesel locomotives. For condition B the majority of the tie plate loads were in the 15,000-lb to 20,000-lb bracket, while in condition A the majority were in the next lower increment.

Summary

Condition B, with swinging ties, resulted in an average increase in tie plate loads of 4000 lb for the steam locomotives, as compared with approximately 5000 lb for the diesel locomotives. The individual tie plate loads measured under the diesels were more uniform in magnitude than for the medium weight Mikado locomotives. The steam locomotives produced higher individual tie plate loads than those of the diesels. The general average eccentricity of the tie plate loads was + 0.17 in for condition B, which agrees well with previous data obtained from tie plate penetration measurements taken at other locations.

Acknowledgement

The Association extends its appreciation to the Milwaukee Railroad for its assistance and cooperation in conducting the field tests.

Report on Assignment 6

Hold-Down Fastenings for Tie Plates, Including Pads Under Plates; Their Effect on Tie Wear

Collaborating with Committee 3

Blair Blowers (chairman, subcommittee), L. L. Adams, H. S. Ashley, L. E. Bates, F. J. Bishop, M. C. Bitner, J. A. Blalock, E. W. Caruthers, H. B. Christianson, C. A. Colpitts, E. D. Cowlin, P. H. Croft, H. F. Fifield, J. W. Fulmer, R. G. Garland, C. E. R. Haight, J. P. Hiltz, J. W. Hopkins, A. F. Huber, E. E. Martin, W. N. Myers, M. P. Oviatt, J. A. Reed, M. K. Ruppert, R. E. Tew, C. E. Weller, Troy West, J. B. Wilson, M. J. Zeeman.

This report of progress, submitted as information, covers the service performance of several types of hold-down fastenings, tie pads, etc., on the Lousiville & Nashville Railroad.

Foreword

The service test installations are located in the northward main track of the Louisville & Nashville near London and East Bernstadt, Ky. This investigation is, primarily, for the purpose of developing information on the efficiency and economy of the several tie plate fastenings and pads in extending the service life of ties by minimizing plate cutting. The major portion of these installations was constructed in 1947. Additions and alterations to the test sections have generally been made each year since that time. The progress report on the tests for the year 1951 was published in the Proceedings, Vol. 53, 1952, pages 785–798. This report will cover the additions and alterations made to the installations, and the more important results of the inspection of the summer of 1952. Fig. 1 and Table 1 show the location and description of all the test sections south of East Bernstadt, and Fig. 2 and Table 2 give the same information for the test sections in the 5-deg curve at the depot. The tables and figures have been revised to reflect all changes made in 1952.

Additions in 1952

Section 47

This section was installed in the south portion of the 5-deg test curve (Fig. 2, Table 2) with 48 new creosoted oak ties, S.H. 14-in, Plan 6B, flat-bottom tie plates, Burkart fiber pads with an adhesive coating on the bottom side, and two each of cut line and anchor spikes. The original installation of Burkart pads in section 27 had no coating and were of a green color. The new pads are black and are said to be of the same materials, except for the addition of the coating. The new pads were punched with ⅜-in diameter holes for 2 staggered line spikes. There were no splits in the pads after installation on June 18, 1952, and none was found on July 25 when the initial penetration readings were taken.

Sections 48 and 49

On July 3, 1952, one freight car truck was derailed to the inside of the long 4-deg 30-min test curve and damaged some of the tie plates, line spikes, anchor spikes and track bolts in all of the sections north of section 9, except in section 30 where the 11-in tie plates were not struck by the wheel flanges. Most of the damage was done along the inner rail where the wheel flanges passed over the field shoulder and extension of the

(Text continued on page 1052)

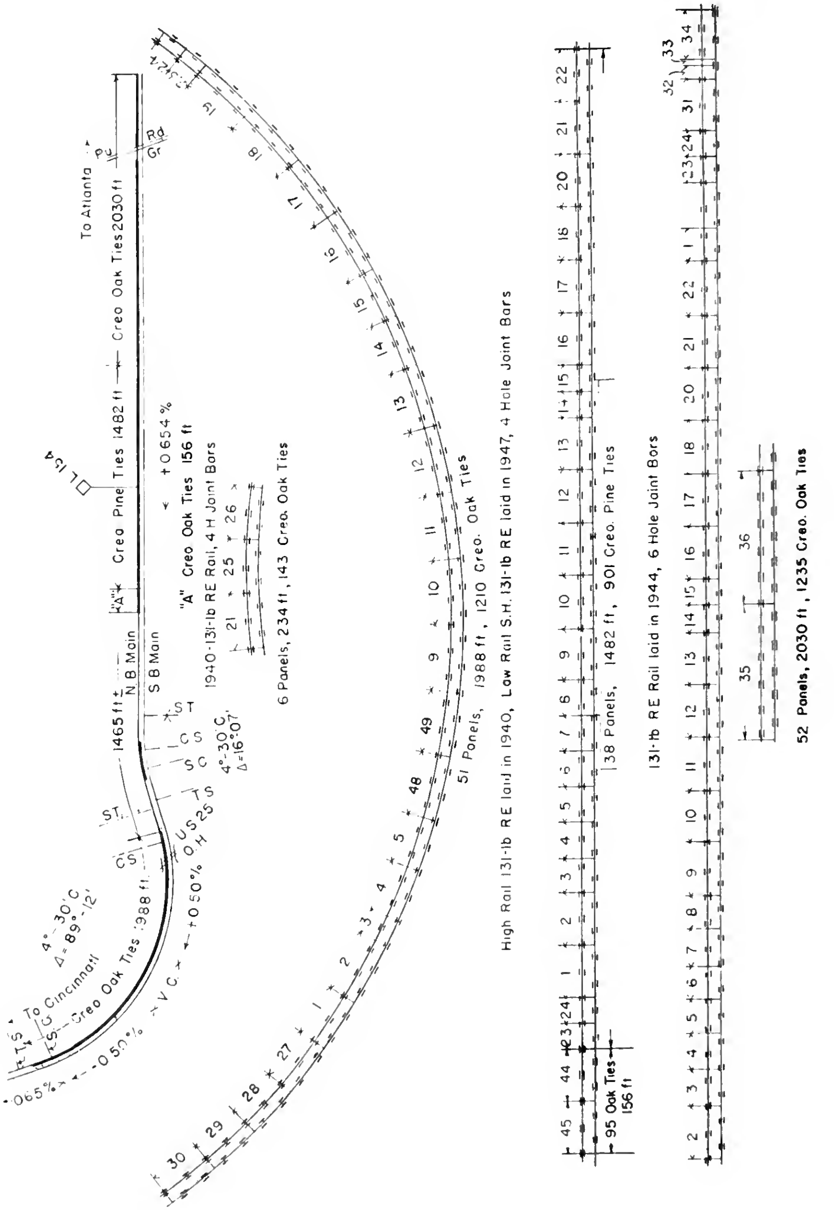


Fig. 1 - Plan of Test Track

TABLE 1. DESCRIPTION OF TEST SECTIONS SHOWN IN FIG. 1

Section No.	No. of Test Ties: Creo. Oak Curve	No. of Test Ties: Creo. Oak Tang.	No. of Test Ties: Pine Tang.	No. of Test Ties: Total	Tie Plate Length in	Date Built	Number and Type of Hold-Down Fastenings per Tie Plate, Tie Pads and Coatings (131-lb RE Rail)
1							Coatings and adhesives - no anchor spikes - subdivided as follows:
1.1	11	6	12	29	13	9-47	Beckosol No. 40. Hot paddle coat applied to bottom of tie plate
1.2	9	9	9	27	13	9-47	AREA Specification Waterproofing Asphalt applied as in subsection 1.1
1.3	0	4	6	10	13	9-47	CASCO Flexible Cement NT-442 applied to tie plate and tie in the field
1.4	3	3	6	12	13	9-47	NT-442 Cement applied to tie plate as a primer and CASCOPHEN RS-216 applied to tie plate and tie in the field
1.5	9	9	9	27	13	9-47	Same as subsection 1.4 except the tie plates were cemented to the ties before creosoting
1.6	2	0	0	2	13	9-47	Premolded sheet of asphalt, 1/8 in thick, made of regular Bird tie pad coating, designated No. 52
1.7	2	0	0	2	13	9-47	Premolded sheet of asphalt, 1/8 in thick, made of regular Bird tie pad coating modified to further reduce flow, designated No. 53
1.8	2	0	0	2	13	9-47	Same as subsection 1.7, except the asphalt was formed around brass screening, designated No. 54
1.9	2	0	0	2	13	9-47	Same as subsection 1.7, except the asphalt was formed around 1/4 in mesh galvanized screening, designated No. 55
1.10	6	0	0	6	13	8-48	Solvated Sealz Coating. Heavy brush coat applied to tie and tie plate
2	59	47	48	154	13	8-47	No anchor spikes (Rubber line spike cushions were applied to the north 24 ties of each tangent section 12-49)
3	0	31	32	63	13	8-47	1-ply duck pad with asphalt coating (Made by Bird & Son), no anchor spikes
3	(b)24	0	0	24	13	6-52	Bird improved fiber-rubber pads (1-ply duck pads were in service on the same ties from 8-47 to 6-52)
4	(b)27	0	0	27	13	6-52	Bird vinyl pads on N. 27 ties (5-ply duck-felt pads were in service on the same ties from 8-47 to 6-52)
4	0	32	32	64	13	8-47	5-ply Bird duck-felt pads, no anchor spikes
4	20	0	0	20	13	8-48	5-ply Bird duck-burlap pads on the south 20 ties of curve test section (Duck-felt pads in test 8-47 to 8-48), no anchor spikes
5	20	0	0	20	13	8-48	7-ply Bird duck-burlap pads on the north 20 ties of curve test section (Duck-felt pads in test 8-47 to 8-48), no anchor spikes
5	29	31	32	92	13	8-47	7-ply Bird duck-felt pads, no anchor spikes
6	0	32	32	64	13	8-47	2 each of cut spikes for line and Racor Studs for anchors, (Changed from 2 Racor Drive Tight line spikes 12-49)
7	0	32	32	64	13	8-47	2 each of Racor Drive Tight (Sandberg) line and anchor spikes. (Anchor spikes replaced 11-48)
8	0	31	32	63	13	8-47	2 each of cut spikes for line and Racor Drive Tight (Sandberg) for anchors. (Anchor spikes replaced 11-48)
9	59	48	48	155	13	8-47	2 each of cut spikes for line and anchors. (Rubber anchor spike cushions were applied to the north 10 pine ties 12-49)
10	59	47	49	155	13	8-47	2 cut spikes for line and 2 round head cut spikes with single coil spring washers for anchors
11	59	47	47	153	13	8-47	2 cut spikes for line and 2 round head Dowel Studs with double coil helical spring washers for anchors
12	57	48	48	153	13	8-47	2 cut spikes for line and 2 Oliver Hold-Down Drive Spikes with double coil helical spring washers for anchors
12	2	0	0	2	13	8-47	2 cut spikes for line and 2 cone neck Oliver Hold-Down Drive Spikes without spring washers for anchors
13	47	47	47	141	13	8-47	2 cut spikes for line and 2 Elastic Spikes of design No. 93 for anchors
13	12	0	0	12	13	8-47	2 cut spikes for line and 2 Tie Plate Lock Spikes for anchors (North 12 ties)
14	47	24	24	95	13	8-47	2 cut spikes for line and 2 - 3/4 in thru bolts with single coil washers for anchors — Applied in the field
15	48	24	24	96	13	8-47	(same as 14) — Applied in shop under load
16(a)	60	47	48	155	13	8-47	2 cut spikes for line and 2 screw spikes with double coil washers for anchors
17	60	47	47	154	13	8-47	2 AAR spring rail clips and screw spikes for line and anchor spikes on tangent plus 2 cut spikes for line on the curve (PRR standard 14-3/4 in tie plates cut to a 13-in length with 1/4 in eccentricity)
18	58	48	48	154	13	8-47	No anchor spikes. Erie single shoulder tie plate with diamond bottom and zero eccentricity
19(a)	59	0	0	59	13	8-47	2 cut spikes for line and 2 screw spikes with double coil washers and above Erie RR. tie plate
21	0	47	47	94	13	8-47	Fabco tie pade, 1/4 in thick, uncoated, no anchor spikes
21	47	0	0	47	13	8-48	Fabco tie pads, 1/4 in thick, uncoated, no anchor spikes

(Continued on next page)

TABLE 1. (CONCL.) DESCRIPTION OF TEST SECTIONS SHOWN IN FIG. 1

Section No.	No. of Test Ties: Creo. Oak Curve	Creo. Oak Tang.	Pine Tang.	Total	Tie Plate Length in.	Date Built	Number and Type of Hold-Down Fastenings per Tie Plate, Tie Pads and Coatings (131-lb RE Rail)
22	0	48	48	96	13	8-47	2 cut spikes for line and 2 Oliver Tie Plate Drive Spikes with single coil spring washers for anchors
23	24	24	23	71	14	9-47	L.& N. standard construction with 2 each of cut spikes for line and anchors
24	24	24	24	72	14	9-47	Same as section 23, except a Rails Co. compression clip was applied to alternate tie plates
25	47	0	0	47	13	8-48	Johns-Manville, uncoated, laminated rubber-asbestos tie pads; 1/8 in thick in north panel, 1/4 in thick in south panel, no anchor spikes
26	49	0	0	49	13	8-48	DL&W D.S. diamond bottom tie plate with 1/2 in eccentricity, 2 cut spikes for line and 1 anchor only
27	48	0	0	48	SH 13	10-48	Burkart fiber pads, no anchor spikes
28	48	0	0	48	SH 13	9-49	Western Felt Works wool felt pads, 1/4 in thick, no anchor spikes
29	48	0	0	48	SH 13	9-49	Bird fiber-rubber pads, 1/4 in thick, coated, no anchor spikes
30	48	0	0	48	SH 11	9-49	Bird 5-ply duck-burlap pads. SH 11 in. plates were cut from 13 in Plan 5B plates, no anchor spikes
31	0	48	0	48	14	8-49	G&H Controls No-Creep rail anchors on alternate tie plates. 2 cut line spikes on unanchored ties, 1 cut line spike and 2 Oliver Tie Plate Drive Spikes for anchors on anchored ties
32	0	12	0	12	14	9-49	Farbertite. Paddle coat applied to adzed surface and bottom of tie plate, no anchor spikes
33	0	5	0	5	14	9-49	Tie plates cemented to ties as in section 1.5 but under ideal conditions, no anchor spikes
34	0	48	0	48	14	9-49	2 cut spikes for line and 2 Tie Plate Lock Spikes for anchors. Asphalt roofing paint brushed on adzed surfaces of south 24 ties
35	0	120	0	120	SH 13	7-50	Coating of Koppers No. 16 Sealing Compound with covering of 1/4 in washed gravel on alternate new ties, 2 each of cut line and anchor spikes
36	0	118	0	118	SH 13	7-50	Coating of Koppers No. 16 Sealing Compound with covering of 1/4 in washed gravel on existing ties, 2 each of cut line and anchor spikes
44	0	48	0	48	12 7/16	11-50	Dayton Rubber Co's. cast steel tie plates with raised rubber insert pads on new ties, 2 each of cut line and anchor spikes
45	0	47	0	47	12 7/16	11-50	Same as section 44 except that existing ties in track were used
48	58	0	0	58	14	8-52	Racor coated tie pads with 2 cut line spikes and 2 Racor studs for anchors
49	60	0	0	60	14	8-52	2 cut spikes for line. 3 Racor studs as anchors on N. 30 ties and 4 on S. 30 ties
	1,353	1,283	854	3,490			Totals

Notes: All of the new 13-in tie plates, except as noted above, were of the AREA Plan 5B (Modified) design with flat rail seat. Second hand (SH) 13-in tie plates were of the Plan 5B Design with rolled circular crown. All of the 14-in tie plates placed prior to 1949 were of the AREA Plan 6B design and subsequent installations were of the current design, AREA Plan 12.
All tie plates have flat bottom except as noted above.
In the sections on the two 4-deg 30 min curves where no anchor spikes were provided, 4 cut spikes were used.
(a). In the north half of each portion of the test sections the double coil Helical (experimental) spring washer was used and in the south half the double coil Thackery washer was used.
Prior to 1952, all of the above tie pads were placed without anchor spikes, except in sections 44 and 45. (b). These pads have 2 each of cut line and anchor spikes.
Section 20 with 2 Thompson rail and tie plate clamps has been excluded from this table and discontinued upon request by the sponsor.
Each portion of each test section has an oval tag on the north tie showing the section number, and every tenth tie from the north has a smaller tag showing the tie number.

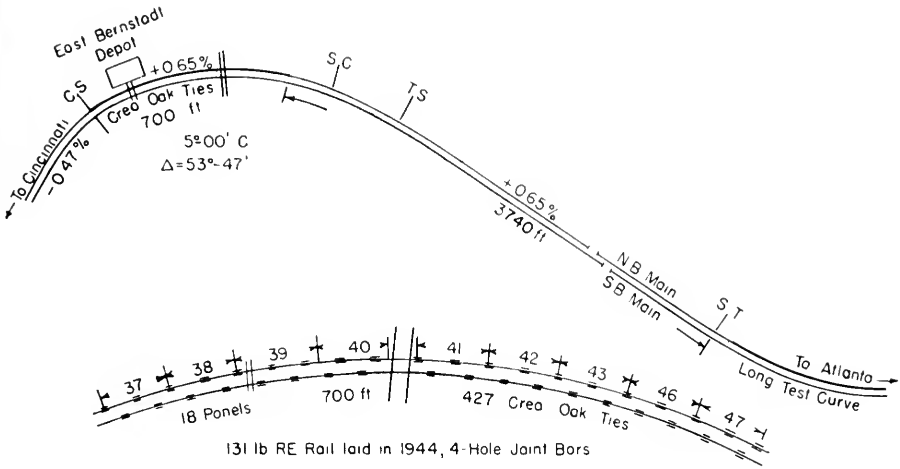


Fig. 2—Plan of Test Track

TABLE 2. DESCRIPTION OF TEST SECTIONS SHOWN IN FIG. 2.

Section No.	No. of Creo. Oak Ties	Date Built	Number and Type of Hold-Down Fastenings per Tie Plate and Tie Pad AREA Flat Bottom 14-in Tie Plates, 131-lb RE Rail
37	48	7-50	2 each of cut spikes for line and anchors
38	48	6-52	Achuff sisal fiber pads, uncoated (Original pads placed 7-50.third set installed 6-52)
39	22	7-50	Johns-Manville rubber-vegetable and asbestos fiber pads, uncoated (North 22 ties)
39	22	11-51	Johns-Manville rubber-comp. pads with coating on the bottom side, replacing original J.M. pads placed 7-50
40	48	7-50	Taylor Fibre Co's. rubber-vulcanized fiber laminated pads
41	23	7-50	Fabco pads, uncoated (North 23 ties)
41	12	7-51	Fabco pads with an oxidized asphalt coating compound on the bottom side. (These pads replaced pads placed in 7-50 with Baker's K-2 cement on the bottom side.)
41	12	7-50	Fabco pads coated on both sides with Baker's S-72 cement (South 12 ties)
42	48	7-50	Dunne Rubber Co's. molded rubber pad, 1/8 in thick, uncoated
43	47	7-50	2 each of cut spikes for line and Racor Studs for anchors
46	24	11-51	Racor rubber-fiber pad, uncoated
46	25	11-51	Racor rubber-fiber pad with asphaltic coating on both sides
47	48	6-52	Burkart fiber pads, coated on bottom side
	427		Total

Notes: All pad sections have 2 each of cut line and anchor spikes. All sections, except Nos. 46 and 47, were installed with new AREA Plan 12 tie plates. Sections 46 and 47 have SH 14-in AREA Plan 6B tie plates. Plan 6B was withdrawn from the Manual in 1948.
Each test section has an oval tag on the north tie showing the section number, and every tenth tie from the north has a smaller tag showing the tie number.

13-in tie plates. Section 7 with 4 Racor Drive Tight spikes (Sandberg design) and section 8 with 2 Racor spikes as anchors were damaged to the extent of having 31 and 42 tie plates bent sufficiently to require renewal. About one-third of the special fastenings also required renewal. Because the sponsor no longer manufactures the Racor Drive Tight spikes and the Racor stud is considered better and more economical, a request was made to discontinue damaged sections 7 and 8 and to rebuild them. Both sections were rebuilt with new creosoted oak ties and 14-in AREA Plan No. 12 tie plates because the 13-in length is no longer standard on the L&N. Section 7 was rebuilt with Racor tie pads (coated) and 2 each of cut line spikes and Racor Studs as anchors. This section has 58 ties and is now designated as section 48. Section 8 was renumbered section 49 and contains 60 ties. The north 30 ties have 3 Racor Studs as anchors and the south 30 ties have 4 studs for anchors. Through an oversight, the pads in section 48 were not punched. It was intended to have the pads punched with ½-in diameter holes for 2 staggered studs as anchors. All of the Racor Studs were first partially driven by hand and later driven home with a pneumatic hammer. These two sections were completed August 29, 1952.

Sections 01, 02 and 03

During the last five years each of two manufacturers has developed a new application of a compound which, when added to the spike holes in ties, will restore the withdrawal power of cut spikes to values exceeding those obtained with new spikes in new ties. It was decided to make a service test with these compounds to determine if their use would be beneficial in holding gage on a sharp curve.

Accordingly, the second curve north of the test curve opposite the depot at East Bernstadt was selected for these installations. This curve is in the northward main immediately north of Mile Post L–152. It is a 5-deg 36-min curve to the left for northward traffic and has approximately 4½-in elevation. Equilibrium speed is 35 mph, and 3-in unbalanced speed is 45 mph. The curve is located near the summit of Crooked Hill and is on a descending grade of 1.26 percent. Authorized speeds are restricted to 35 mph for passenger trains and 25 mph for freight trains because of the long descending grade. The curve is built with 1944—131 RE rail, 6-hole joint bars, 13-in tie plates with 2 each of cut line and anchor spikes, creosoted oak ties and stone ballast. The track was in good condition. Unfortunately, the tie plates had a pattern on the bottom designed to aid in holding gage. Most of the tie plates had longitudinal fluting on the bottom. The fluting was omitted for a 1-in width across the width of the plate at each shoulder. After the plates become fully seated, the two unfluted strips assume the function of two transverse ribs, except for being flush with the bottom plane of the tie plate. Each of the three test sections was made three rail lengths long on the body of the curve.

Section 01, on the north, will be used for controls. No work was done except to remove the seven gage rods. This section contains 72 ties with an average date of 1941.5.

Section 02, containing 71 ties having an average date of 1942.7, was assigned to the Wood-Treating Corporation, Cleveland, Ohio, for the application of Compound 8 in the spike holes. Compound 8 consists of a Bakelite resin with a catalyst to cause it to harden. Generally, the spike holes were sealed at the bottom with a glass marble for the purpose of forcing the compound into the wood around the spike when the spike was driven. Creosoted oak grooved plugs were used in all of the spike holes, except in the 1952 ties. The work was started on June 25, 1952, with a twin-tank, pneumatic dispenser for filling the spike holes with the compound. After completing two-thirds of the outer rail (2 out of every 3 tie plates) the dispenser developed mechanical trouble.

Completion of the installation was deferred until August 27, at which time the compound was applied in capsule form. The capsules were placed in the grooves of the creosoted oak plugs and set in the spike holes. The plastic capsule had two compartments. The upper inch contained the catalyst while the lower 3-in portion was filled with the resin. The two fluids were mixed as the spike was driven. Application of the compound by the capsule method was more convenient and rapid than by using the pneumatic dispenser. Excess compound flowed on top of the tie plates when using the dispenser, while with the capsules there was no waste of the compound. On both days representatives of the sponsor supervised the application of the compound, etc. Views of the two methods of application of Compound 8 are shown in Fig. 3. The left view of the pneumatic dispenser excludes the two tanks for the liquids and the hand pump. The right view shows the capsules and grooved plugs in place ready to be tapped down.

Section 03, immediately south of the last described section, included 69 ties with an average date of 1941.9. The sponsor of this section is The Master Builders Company, Cleveland, Ohio. Rust Joint Iron was furnished by that company for filling all of the spike holes before redriving the released spikes. Rust Joint Iron is a combination of finely ground iron, sal ammoniac and sulphur. It has been widely used for grouting bridge seats. A representative of the sponsor supervised installation of the compound with a simply constructed dispenser made of 2-in pipe and fittings, as shown in the left view of Fig. 4. The addition of water is required to cause the compound to harden, and this operation was performed in the manner illustrated in the right view of the figure. Because the spike holes in the ties were not enlarged by the lateral forces on the rails, it was not necessary to tamp the compound with the small rod attached to the lower end of the dispenser. Approximately 80 lb of Rust Joint Iron were used, or 0.145 lb per spike. Most of the spikes in all 3 sections were $\frac{9}{16}$ in square. The technique developed by the sponsor for applying the compound and adding the water was ideal for a small installation, and the work progressed rapidly. This installation was completed June 25, 1952. All gage rods were also removed from sections 02 and 03.

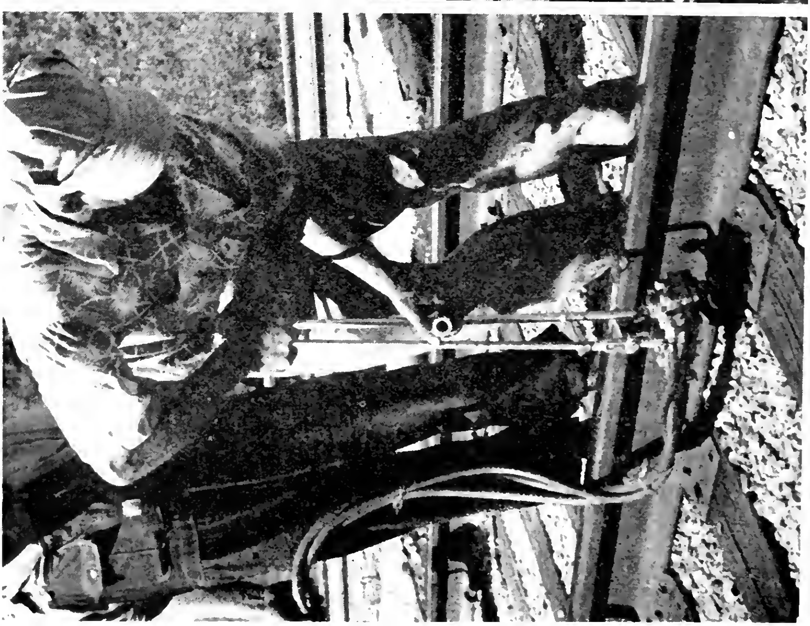
The performance of the two compounds will be judged principally from the annual measurements of the track gage taken at six points in each track panel. A record of the track gage was made prior to removing the gage rods from the nine test panels and after the installations were completed. In addition, measurements will be taken annually of the elevation and the middle ordinates of the outer rail.

Alterations in 1952

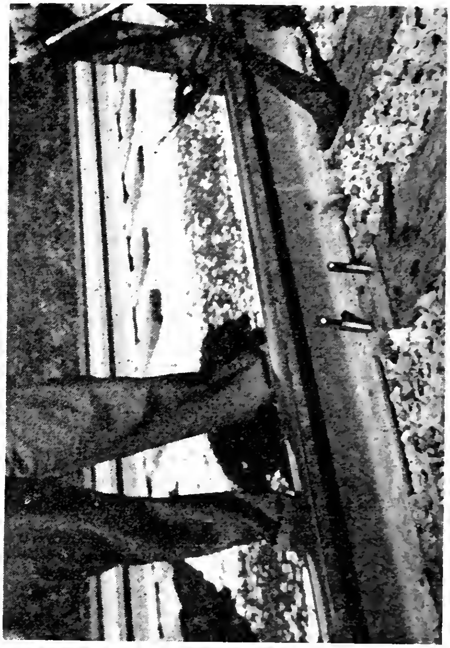
The following changes were made on July 18, 1952. The existing tie plates, ties and spikes were retained in the test, except as noted.

Section 38

The original installation of Achuff sisal fiber pads, 14-in. in length, was made in the 5-deg test curve, July 1950. Because of excessive mashing of the pads, a second set of pads was used to replace the first set in July 1951. Subsequently, the sponsor had a laboratory investigation made of several formulations of the adhesive-type of impregnant and the manufacture of the pads, which resulted in an improved pad which is said to eliminate about 80 percent of the mashing. At the request of the sponsor, the third set of pads was used to replace the second set. The pads were punched with $\frac{3}{8}$-in diameter holes for 2 staggered line spikes. There were no splits in the pads at the anchor spikes when installed. Several of the released pads had stretched more than 1 in. in length, but were in better general condition than when the first lot of pads was removed, July 1951.

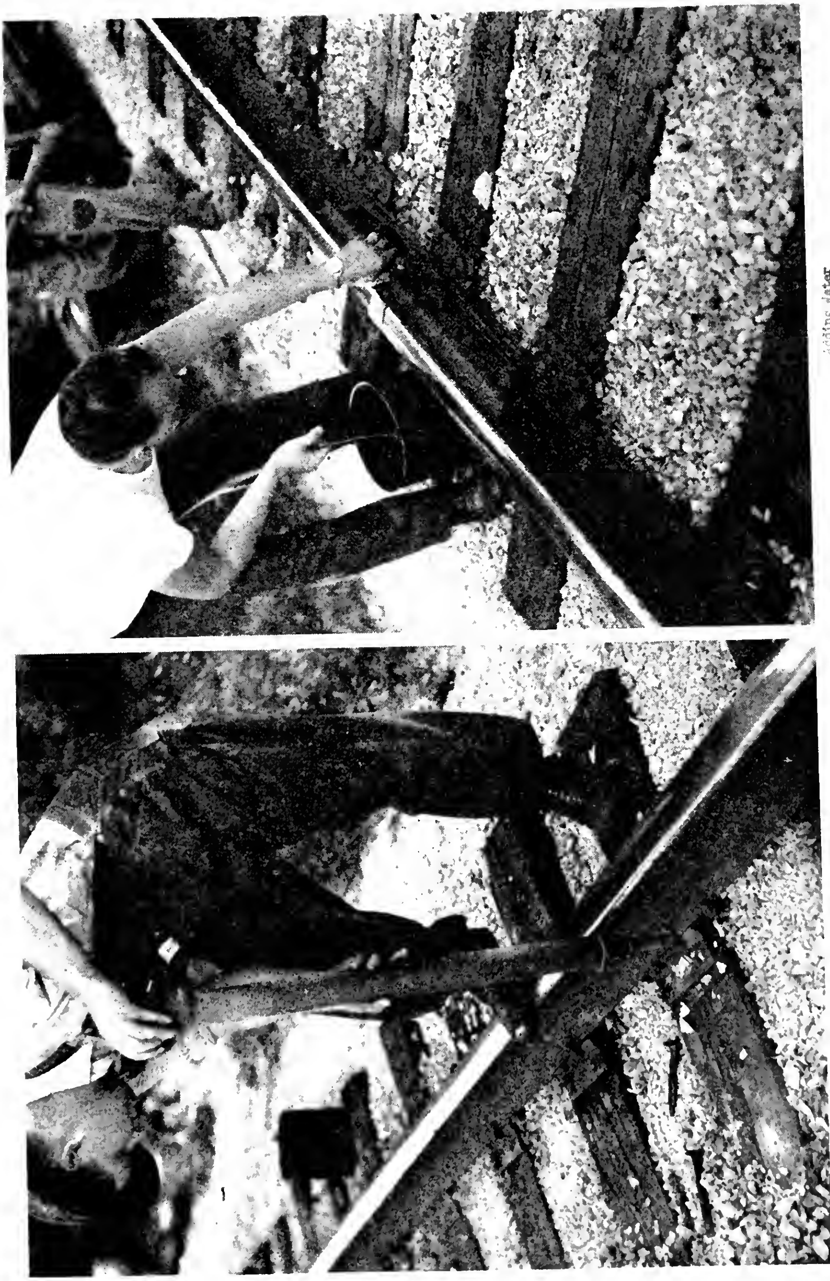


Pneumatic Dispenser



Capsule Method

Fig. 3. Section 02, Application of Compound 8 in Spike Holes.



Adding Water

Filling Spike Holes with Rust Joint Iron

Fig. 4. Section 63, Applying Rust Joint Iron in Spike Holes.

Section 3

The part of this section on the long 4-deg 30-min test had 1-ply duck pads, coated. These were placed in service August 1947, and have not performed well because of ripping at the spikes and becoming dislocated. Several of the 1-ply pads have worked out of place in the tangent test sections where only 2 spikes per plate were used. To provide a location for testing the Bird Improved Fiber–Rubber pads, it was decided to remove the 1-ply duck pads on the 24 ties in the long test curve and install the improved fiber-rubber pads. The improved fiber-rubber pads are similar in construction to the original lot placed in section 29, September 1949, except for a change in the pad surface to improve the bond between the pad and its asphalt coating. The original pads had a serrated finish, while the new ones had a shredded finish made of the fiber. New ⅝-in by 6-in cut spikes were used to replace the old $\frac{9}{16}$-in spikes. The new pads were spiked with two spikes each for line and anchors. There was only one split at the anchor spikes five weeks after the installation was made. The pads were not punched for the spikes. It was observed that the 1-ply pads that were not damaged or dislocated had protected the ties from abrasion.

Section 4

The north 27 ties of the part of this section on the long 4-deg 30-min test curve originally had 5-ply duck-felt pads placed in August 1947. Since the duck-felt pads are now obsolete, it was decided to replace them with a new pad developed by Bird and Son, Inc. The new pad is known as the Bird Vinyl pad, and is made of sisal fiber, vinyl resin impregnant and an inert filler. It has an asphalt coating on both sides. The pads were not punched and were spiked with 2 each of new ⅝-in by 6-in cut spikes for line and anchors, replacing the original $\frac{9}{16}$-in spikes. None of the pads split at the anchor spikes. Even though several of the 5-ply duck-felt pads had been damaged, there was no evidence of tie abrasion where the plate did not contact the tie.

Damage by Derailment

As a result of the derailment previously mentioned, 191 of the bent 13-in tie plates were replaced with used plates of the same pattern in the sections located north of old section 7 on the north part of the long 4-deg 30-min test curve, except in section 30 where the short 11-in plates were not bent to the extent of requiring replacement. The damage occurred July 3 and the bent tie plates were replaced July 24, 1952. Practically all of the damaged $\frac{9}{16}$-in cut spikes were renewed with new ⅝-in spikes. When the plates were changed in section 3 and on the north 27 ties of section 4, where new pads had been placed June 18, new pads of the same kind were also installed. This work involved replacing 23 Bird Improved Fiber-Rubber pads in section 3 and 18 Bird Vinyl pads in the north portion of section 4. No pads were replaced in any of the other sections damaged. If in future inspections the older pads develop premature failure attributable to the derailment, they will be omitted from the test results.

Discontinued Sections 7 and 8 in Long 4-deg 30-min Curve

Final tie plate penetration measurements were taken in these two sections before they were retired. For comparison, similar measurements were taken for section 9 in the same curve, which also has 13-in plates. This section has two each of cut spikes for line and anchors, and was not damaged by the derailment, except for some flange marks on a few of the ties at the north end of the section where the wheels did not strike the tie plates. The following tie abrasion measurements are shown in inches and cover the 57-month period from November 1947 to August 1952.

Sec. No.	*Total Traffic—Approx. 100 Million G.T.* Description of Anchor Spikes	*Tie Plate Penetration* Outer Rail	Inner Rail	Avg. Both Rails
7	2 each of Racor Drive Tight Spikes for line and anchors	0.040	0.044	0.042
8	2 cut line spikes and 2 Racor Drive Tight Spikes for anchors	0.052	0.052	0.052
9	2 each of cut line and anchor spikes	0.084	0.074	0.079

Using section 9 as a basis of comparison, the special fastenings in section 7 reduced the plate cutting about one-half, and for section 8 the corresponding reduction was one-third.

Anchor Spikes Retightened

Table 3 gives a summary of the maintenance work performed on the special fastenings as determined from the general inspection made in June 1952. This year it was necessary to retighten 17 percent of the screw spikes in section 17 with the AAR spring rail clips. Eighteen of the 96 screw spikes retightened were stripped. Last year in the

TABLE NO 3 - HOLD-DOWN FASTENINGS TAPPED DOWN OR RETIGHTENED ON THE L. & N. R.R. NEAR LONDON, KENTUCKY - JUNE 1952

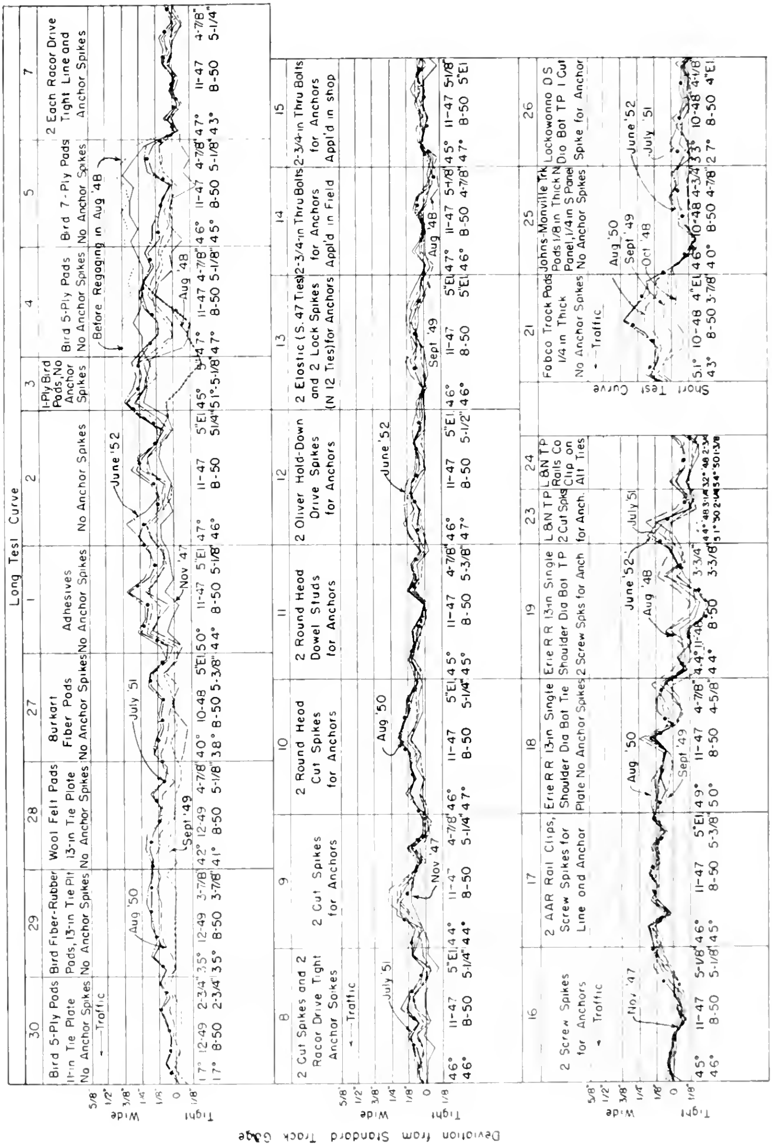
Sec. No.	Hold-Down Fastenings	Date Built	Long 4°-30' Curve (1)	(2)	Tangent Creo. Oak Ties (1)	(2)	Tangent Creo. Pine Ties (1)	(2)	Total For Each Construction (1)	(2)
10	2-R.F. Cut Spikes with Single Coil Spring Washers.	8-47	48	20	0	0	0	0	48	7
12	2-Oliver Hold-Down Drive Spikes with Double Coil Helical Spring Washers	8-47	6	3	0	0	0	0	6	1
13	2-Elastic Spikes of Design No. 93	8-47	0	0	0	0	(a)10	5	10	2
17	2-AAR Spring Rail Clips and 2-Screw Spikes	8-47	(b)36	16	(c)28	16	(d)32	19	96	17
	Totals		90	10	28	4	42	6	160	7

Notes: Col. (1) - Number of anchor spikes retightened or tapped down. Col. (2) - Percentage of anchor spikes retightened or tapped down. All tie plates have flat bottom. (a) Three elastic spikes lost holding power in the ties. (b) Three screw spikes stripped. (c) Nine screw spikes stripped. (d) Six screw spikes stripped.

same section only 1 screw spike out of 60 was found stripped. Prior to taking measurements of the tie plate penetration of all sections next year, a general retightening of the special fastenings will be made where necessary.

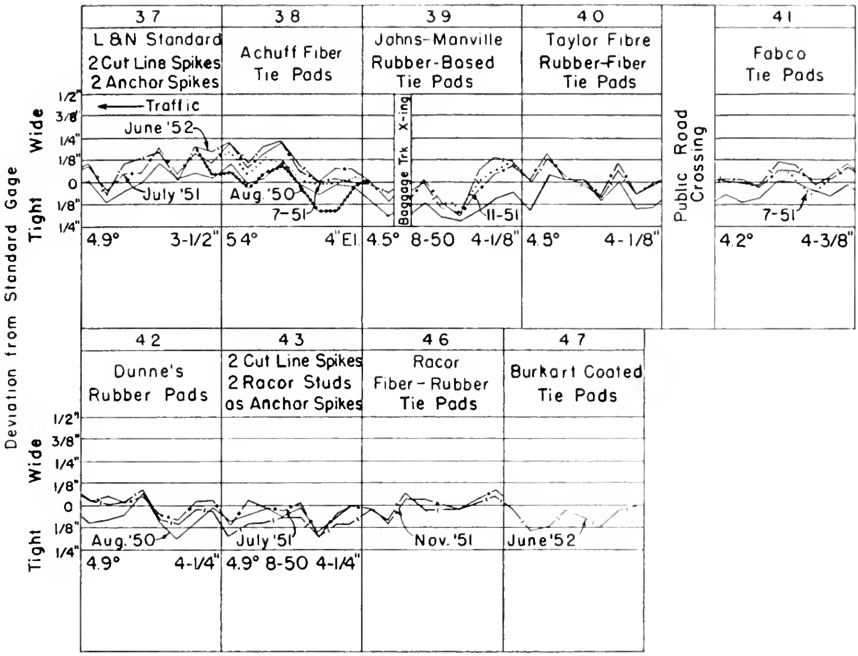
Track Gage on Curves

A record of the track gage for the two 4-deg 30-min curves is shown in Fig. 5. In most of the sections with special anchor spikes the gage has changed little in five years. There has been a moderate increase in the irregularity of gage in some of the cut spike sections with and without pads. It appears that the gage has ceased widening in section 21 with Fabco pads. In section 3 and the north portion of section 4 where the pads were replaced, the L&N standard track gage (made ⅛ in tight) was used. It would have provided a more uniform gage if the gage had been spiked wider. Most of the track on the test curves has been held to less than ¼-in wide gage. This is the final report for those portions of sections 7 and 8 which have been discontinued. Fig. 6 gives information on the gage of track for the 5-deg test curve. The weather was hot for the



Note All test sections have 13-in Plan 5B (Modified) tie plates with flat rail seat except those shown otherwise and as follows Sec 17, Penn R R 14-3/4 in tie plate sheared to a 13 in length; Sections 23 and 24, 14 in AREA tie plate, Sec 26, 13 in Lackawana double shoulder diamond bottom tie plate, Sections 27, 28 and 29, S H Plan 58 with rolled crown and also in Sec 30, except cut to 11 in length. All sections without anchor spikes have four line spikes and sections with anchor spikes have two line spikes. Sec 26 has 2 cut line spikes and 1 anchor spike
—— After replacing pads in 1952

Fig 5 - Gage, Curvature and Elevation of Each Section of Test Track on the 4°-30' Curves, Mile L-154, L&N R R, near London, Ky



Sections 37 thru 43 have AREA 14-in Plan 12 flat bottom tie plates.
Sections 46 and 47 have second hand AREA Plan 6B flat bottom tie plates.
All sections have two each of cut spikes for line and anchor except as noted. ···· After replacing pads in 1951 ---- After replacing pads in 1952

Fig. 6. Gage, Curvature and Elevation of Each Section of Test Track on the 5-deg Curve, Mile L-153, L.&N.R.R., at East Bernstadt, Ky.

June 1952 measurements. This caused tight rail, and in some cases the inner rail had moved inward of the track to give a gage a little tighter than the year before. There has been only a moderate increase in irregularity of the gage in some of the sections. When the Achuff pads were replaced in section 38, the inner rail was regaged.

General Inspection

Tie Pads and Coatings

The results of inspecting tie pads and coatings on the adzed surfaces of the ties by removal of tie plates have been summarized in Table 4. It will be of interest to observe the photographs in Figs. 7 to 11, incl., taken in conjunction with this inspection, which was made in June 1952.

In general, only a few types of the pads showed appreciably more damage from the past year's traffic. The wool felt pads, after less than three years' service, have started to fail from stretching, tearing and ripping at the spikes (Fig. 11). These pads lack the required strength to withstand the service conditions. The vulcanized fiber ply of the Taylor Fibre pads in section 40, after two years of service, have cracked and split extensively. The rubber ply evidently was not made of tough material because it showed

(Text continued on page 1063)

TABLE 4 — INSPECTION OF TIE PADS AND COATINGS BY REMOVAL OF TIE PLATES IN SERVICE TESTS ON THE LOUISVILLE & NASHVILLE R.R., NEAR LONDON, KY.—JUNE 1952

(Moisture content of ties was measured with a Delmhorst RC-1 Moisture Detector having 3/8-in electrodes. Readings over 30 percent are approximate. In Remarks column: P = percent average moisture under pad or tie plate. O = percent of moisture content outside of plate area. Rain fell two days before inspection.)

Section No.	Description of Pad or Coating	Date Built	Alinement and Kind of Ties	No. of Plates Removed	Condition of Pad and Tie	Remarks
2	4 line spikes, no pad	8-47	4½° Oak	1 (Inner rail)	Some tie abrasion	P = 57%, O = 11% Compare with pads.
				TIE PADS		
5	Bird 7-ply duck-felt	8-47	4½° Oak	1 (Inner rail)	Good seal, clean surface, no abrasion or compression.	Pad in good condition. See Fig. 7
4	Bird 5-ply duck-felt	8-47	Tan. Pine	1 (East rail)	Fair seal, clean surface, pad in good condition.	Compression of springwood: max. field end 0.03 in , gage end 0.06 in
4	Bird 5-ply duck-burlap	8-48	4½° Oak	1 (Inner rail)	Good seal, and clean surface, no abrasion.	Pad in good condition.
30	Bird 5-ply duck-burlap, 11 in	9-49	4½° Oak	1 (Inner rail)	Fair seal, clean surface, no abrasion.	P = 50%, O = 11% Pad in good condition.
29	Bird fiber-rubber	9-49	4½° Oak	1 (Inner rail) Joint Tie	75% pad area covered with asphalt, no abrasion.	P = 57%, O = 12%. Pad in good condition. Coating adheres to tie but breaks bond with pad. These pads have not stretched in length.
21	Fabco, uncoated	8-47	Tan. Pine	1 (East rail)	Sand under pad, some abrasion and compression of springwood.	Compression of springwood: max. field end 0.03 in , gage end 0.12 in. Pad stretched 1½ in and in fair condition, otherwise. See Fig. 8.
41	Fabco, oxidized asphalt coated on bottom side	7-51	5° Oak	1 (Inner rail)	Coating covered 80% of pad area, pad was sealed well, clean surface	Pad in good condition.
27	Burkart fiber, uncoated	10-48	4½° Oak	1 (Outer rail)	No compression or abrasion of tie. Sand under pad. Pad ripped slightly at spikes.	Field end being cut off and was thinner. Note: This plate had only 2 cut spikes instead of 4. See Fig. 9.
25	J-M. Asbestos-Rubber pads, uncoated, ¼" thick	6-48	4½° Oak	1 (Outer rail)	Sand and dampness under pad. Pad in good condition.	Max. tie abrasion: field end, 0.04 in , gage end, 0.02 in. Pad too hard. See Fig. 10.
39	J-M Rubber Corp. pads, coated on bottom side	11-51	5° Oak	1 (Inner rail)	Coating covered 80% of pad area, no tie abrasion, pad in good condition.	P = 60%, O = 12%
28	Wool felt pads, uncoated	9-49	4½° Oak	1 (Inner rail)	Pad in poor condition, some free water under pad.	P = 75%, O = 12%. See Fig. 11.
40	Taylor Fibre laminated rubber-vulcanized fiber pads, uncoated	7-50	5° Oak	1 (Inner rail)	Pad is delaminating, sand under pad and between the two layers. Rubber ply is wearing thin on the field end, and the hard fiber layer was cracked and split, no tie abrasion.	(a). See notes for temperature readings.
42	Dunne's molded rubber pad, 1/8 in thick, uncoated	7-50	5° Oak	1 (Inner rail)	Sand under pad, slight wood compression between grooves in pad.	Pad in good condition.
44	Dayton Rubber Co's. raised rubber insert pads	11-50	Tang. New Oak	3 (East rail)	Pads were in good condition, but had abraded the ties. The pad area is only 38 sq in , or 34% of the plate area.	Approx. depth of tie abrasion and compression: Tie plate 24E, field end, 0.01 in , gage end, 0.06 in ; Tie plate 25E, field end, 0.01 in , gage end, 0.06 in ; Tie plate 18E, field end, 0.01 in , gage end, 0.03 in. Joint was swinging over ties 24 and 25.
45	Dayton Rubber Co's. raised rubber insert pads	11-50	Tang. Existing Oak Ties	1 (West rail)	Pad was in good condition, but had abraded the tie which was dated 1942. The rail base had contacted and polished the skeleton tie plate, but the plate was not broken.	Approx. depth of tie abrasion: Tie plate 33W, field end, 0.06 in , gage end, 0.03 in.
46	Pacor Tie Pads, formerly Ameba Pads	11-51	5° Oak	1 (Inner rail)	(Uncoated). Pad in good condition, surface was clean under pad, no abrasion.	P = 55%, O = 16%
	Pacor Tie Pads	11-51	5° Oak	1 (Inner rail)	(Coated). Well sealed, complete coverage by coating under pad, pad in good condition, no abrasion.	P = 32%, O = 16%
	Creo. oak ties removed from 5° curve the day before for installing section 47					Moisture content of bottom of tie 35%, indicating well drained ballast.
				COATINGS UNDER TIE PLATES		
4.10	Solvated Sealz Coating	8-48	4½° Oak	1 (Inner rail)	Coating had almost disappeared under the tie plate, some tie abrasion, some debris under plate. Material had filled a knot hole under plate.	Tie was not sealed by the coating outside of tie plate. This coating has now failed, but was in good condition in July 1950.
4.2	AREA Waterproofing Asphalt	9-47	4½° Oak	2 (Inner rail)	No asphalt was found under the tie plates, some tie abrasion.	Coating has failed completely.
4.1	Bocosol No. 40	9-47	4½° Oak	1 (Inner rail)	No coating left on tie and plate.	Complete failure, some tie abrasion.
34	Asphalt roofing paint on adzed surface	9-49	Tan. Oak	1 (East rail)	Only 20% of area under tie plate was coated. Coating outside of tie plate had weathered badly.	Not suitable for this application.
35	Koppers No. 16 Sealing Compound on adzed surface only	7-50	Tan. Oak	1 (East rail)	Coating was in good condition, and was not squeezed out from under the plate because the material was confined between the ribs of the diamond bottom pattern.	
32	Farbertite coating	9-49	Tan. Oak	None	Most of coating outside of tie plate area had weathered away.	

(a). The temperature readings in section 40 were measured with a Brown Portable Potentiometer, Model 126V2, with a thermocouple made of Iron-Constantan thermowire with fiber glass insulation. The temperatures in degrees Fahrenheit were as follows: Air 95°, rail head 129°, rail base 129°, tie plate 129°, exposed top of tie 136°, and top of tie under Taylor Fibre rubber-vulcanized fiber pad 119°.

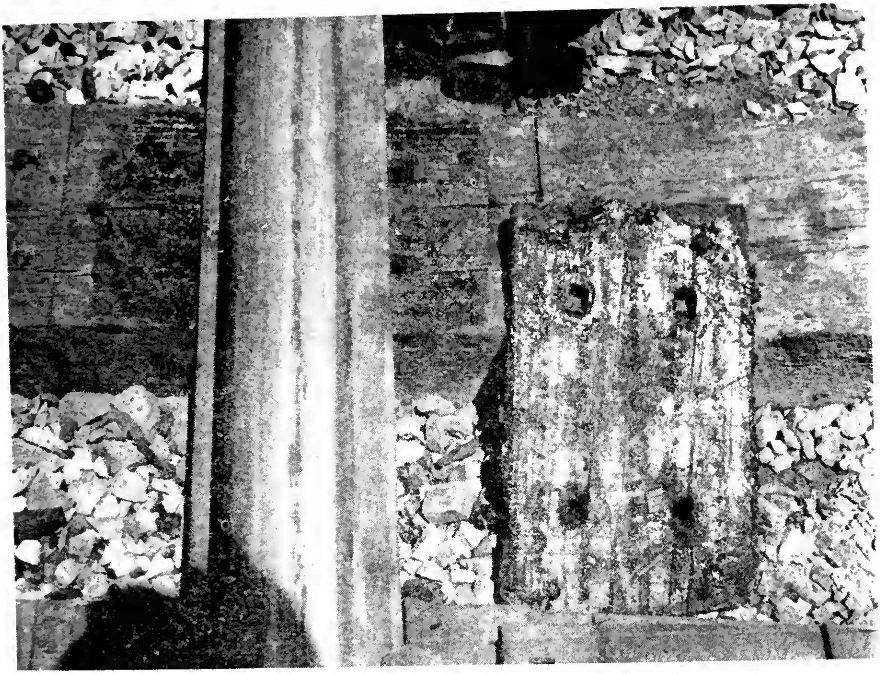


Fig. 7. Section 5, Bird 7-ply Lock-Felt Pad (Coated) After [illegible] Months' Service In Inner Rail of Long [illegible]-deg. [illegible]-in. Curve.

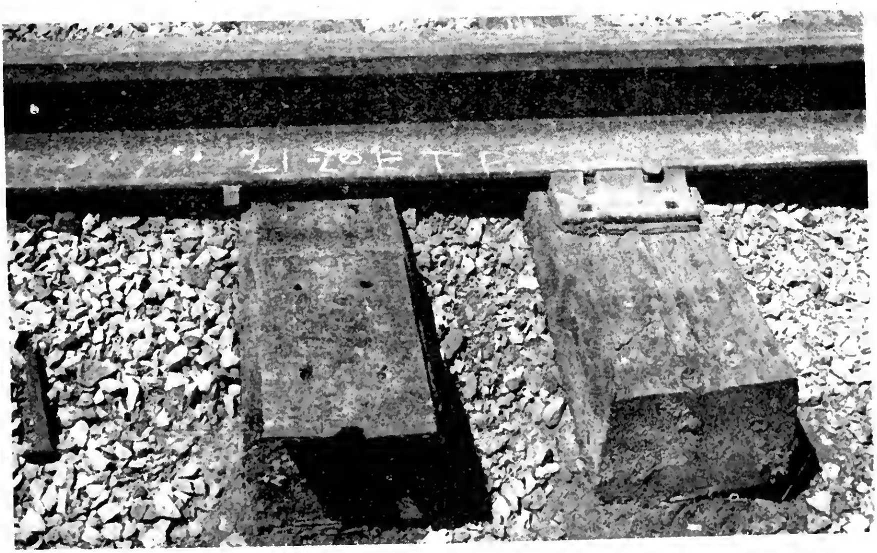


Fig. 8. Section 21, Fabco Pad (Uncoated) After 58-Months' Service In Tangent Track With Creo. Pine Ties.

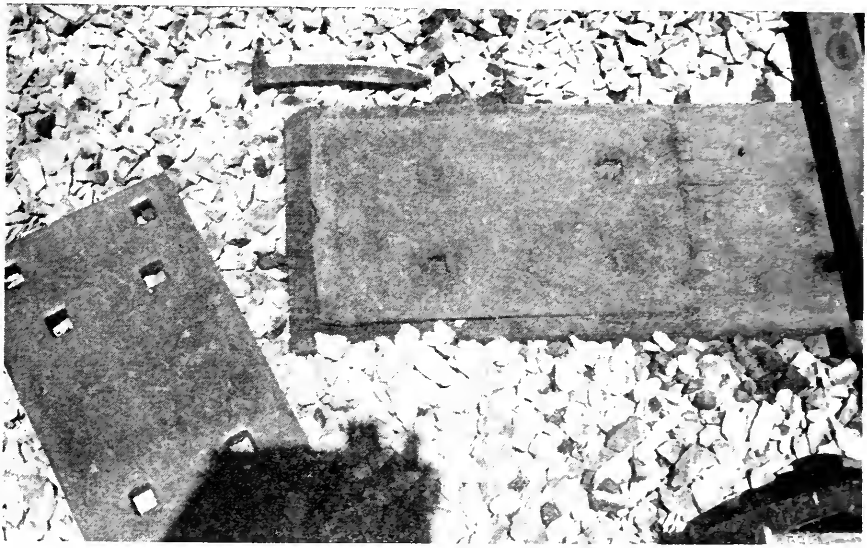


Fig. 9. Section [illegible] Treated After [illegible] Months' Servic[illegible] In Oute[illegible]

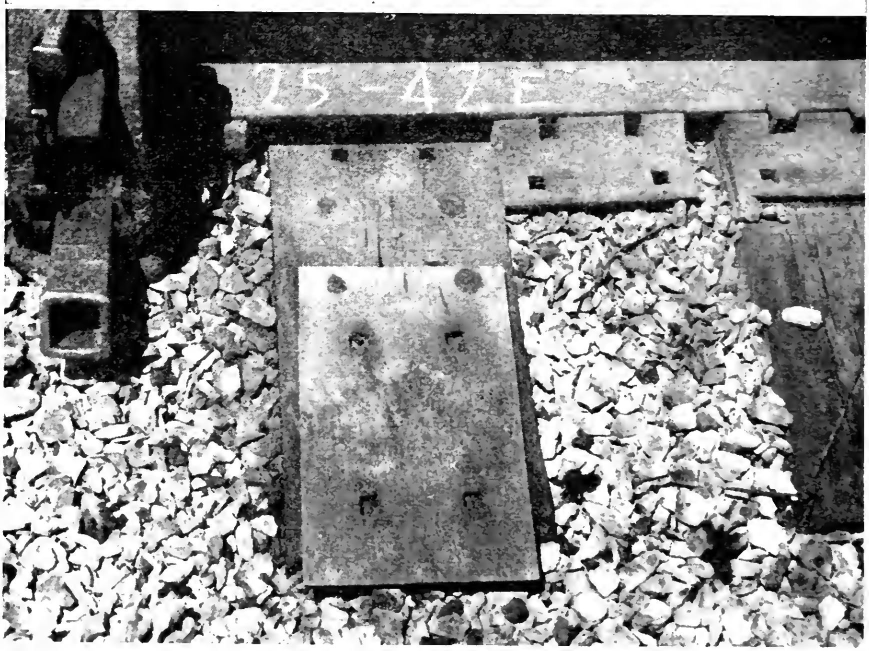


Fig. 10. Section 25, J-M Asbestos-Rubber Pad ¼-in. Thick (Uncoated) After 46-Months' Service In the Outer Rail of Short 4-deg. 30-min. Curve. (Note tie abrasion)

Fig. 11. Section 28, Wool Felt Pad (Uncoated) After 33-Months' Service in the Inner Rail of Long 4-deg. 30 min. Curve.

some abrasion. The pads are also delaminating. In less than two years' service there was evidence of abrasion and compression on the oak ties under the Dayton Rubber Company's raised rubber insert pads in sections 44 and 45. No other pads have abraded oak ties, except the hard J–M asbestos–rubber pads in section 25 (Fig. 10). Because some compression of the springwood of creosoted pine ties was found under the 1947 Bird fabric and Fabco pads, it seems particularly desirable to use sealed pads in order to keep out the sand and water to avoid a more rapid rate of abrasion of the softwood ties.

In November 1951 the J–M rubber composition pads were substituted for the J–M rubber–vegetable and asbestos fiber pads on the south 22 ties of section 39. At the time of installation the rubber composition pads gave little trouble from splitting at the anchor spikes. However, after 7 months of service, these pads had split at 40 percent of the anchor spikes, and some of the pad corners had torn out.

A limited number of tie moisture readings was taken under tie plates with and without tie pads. These are shown in the remarks column of Table 4. In section 46 with Racor tie pads after 7 months' service, the surface moisture of the tie under the coated pads was somewhat less than under the uncoated pads. It is interesting to observe in the footnotes of Table 4 the measurements of temperatures which showed that with a rail temperatures of 129 deg F, the top of tie was 136 deg F, while under the tie pad the temperature of the tie was 119 deg F.

The two best adzed surface coatings, Solvated Sealz and AREA Bridge Waterproofing Asphalt, have now practically disappeared from the under-plate area. In 1950 the two coatings were functioning reasonably well. It is estimated that the former was beneficial for about three years and the latter for about four years. During the effective periods the under-plate areas were protected from the effects of free water and sand, but tie abrasion was in evidence. The merits of the coatings cannot now be evaluated as to the extension of tie life. However, the life of the best coatings was relatively short when compared with the normal service life of ties.

The Dayton Rubber Company's raised rubber insert pad has not protected the ties from abrasion and compression of the wood. The area of this pad is inadequate. Two types of pads, wool felt and the Taylor Fibre rubber-vulcanized fiber pads, appear to lack the physical properties necessary to withstand the service conditions. The J–M rubber-laminated asbestos pads in section 25 were in good physical condition, but had abraded oak ties because of their hardness. So far, for the various service periods (as shown in years in the parenthesis next to each of the pads), the following pads have shown the better performance: Bird fiber-rubber (3); Fabco (5, 4 and 2); Bird 5 and 7-ply duck-burlap (4 and 3); Burkart fiber (4); Dunne's molded rubber (2); and Racor Fiber-rubber (0.6).

Hold-Down Fastenings

During 1951 and 1952 a limited amount of ordinary maintenance work was performed in retightening or tapping down the special fastenings. Sections having the largest percentage of fastenings retightened in the last two years are as follows: section 22, Oliver tie plate drive spikes, 69 percent; section 10, round head cut spikes with single-coil spring washers, 63 percent; section 17, AAR rail spring clips, 27 percent; and section 12, Oliver hold-down drive spikes, 20 percent. The following special anchor fastenings have required no tapping down since the year of installation (shown in the parentheses): Tie plate lock spikes in section 13 (1947) and section 34 (1949); Oliver tie plate drive spikes in section 31 (1949); Racor drive tight spikes in sections 7 and 8 (1947), except all of the anchor spikes were replaced in 1948 and 13 percent of the spikes in section 7 were driven home in 1951 with an air hammer; Racor studs in section 6 (1949) and in section 43 (1950), except for finishing the driving with an air hammer in 1951. The work of driving the Racor spikes with the air hammer was done after the sponsor had determined the best method for driving the special spikes to the proper depth. Evaluation of the special fastenings as to economy and effectiveness will require several additional years of service.

Tie Coating

Sections 35 and 36 were installed in July 1950, in tangent track, for making a test of Koppers No. 16 sealing compound, which is one of the coatings used on ties for the purpose of retarding the splitting and checking of hardwood ties. Section 35 was constructed with 120 new creosoted oak ties with only the odd numbered ties coated with the compound. In the north half of the section the coating was placed on only the tops of the ties, while in the south half the ends of the ties were also coated. The uncoated ties will serve as a basis of comparison. Section 36 consisted of 118 existing creosoted hardwood ties, all of which were coated on top. The south 58 ties were also coated on the ends. T. G. Gill, senior technologist, Timber Engineering Company, made the inspection of the checks, splits, etc., in company with two representatives of the Koppers Company in June 1952, when the track engineer, research staff, AAR, was making the annual inspection.

The condition of the coating after almost two years' service was good. It had a crust formed on top, but was soft and tacky after removing the crust. The coating had resisted the effects of the elements well. Checks and splits, ⅛ in wide or greater, on the top end surfaces of all ties were counted and recorded prior to the application of the sealing compound, and also rechecked after one and two years of service. In checking the splits and checks after the coating was applied, the count only included the defects where the seal coat failed to keep them fully covered. An efficiency index for the ability of the coating to keep the checks and splits covered was determined for each test condition. For the new ties, it was computed from the following formula:

$$\text{Efficiency, percent} = 100 - \frac{(\text{Number of checks in coated ties})}{(\text{Number of checks in uncoated ties})} \times 100$$

For the existing ties, since all were coated, the original number of checks in the ties before being coated was used as the base for the efficiency index.

Values of the efficiency of the coating for both new and existing ties for the years 1951 and 1952 are tabulated below:

	Section 35 New Ties Percent		*Section 36 Existing Ties Percent*	
	1951	*1952*	*1951*	*1952*
Efficiency of coated ties over uncoated ties	75	74	82	82
Efficiency of ties coated on top only	70	63	64	75
Efficiency of ties coated on top and ends	79	85	97	89

The efficiency of the coatings for all coated ties in each section (first line of values) was about the same for the one and two-year service periods. In each section the efficiency of the ties coated on the top and ends was greater than for the ties coated on the top only. This advantage in section 36 dropped from 97 to 89 percent. It is possible that over a period of several years this advantage will disappear. Generally, the ends of ties are not coated because of being buried in the ballast. The coating on the ends of the ties was thinner than on the top.

This year the moisture content of the tops of the ties was measured with the same moisture detector mentioned in Table 4. The meter had ⅜-in electrodes, and the values obtained were the maximum moisture content in the upper ⅜ in of the ties. These measurements were taken on June 19, 1952. The weather was hot and dry, except for a light rain that fell two days prior to the readings. Above the fiber saturation point of the ties (25–30 percent), the moisture readings are approximate, but the data obtained provides relative values that will serve the purpose. For section 35 with new ties, the moisture readings for the coated ties ranged from 17 to 32 percent, with an average of 20.6 percent; and for the uncoated ties the values ranged from 10 to 12 percent, averaging 10.9 percent. For the old ties in section 36, which were all coated, the values varied from 19 to 60 percent, averaging 29.8 percent. This compares with 20.6 percent for the new coated ties in section 35. For comparative purposes the moisture content was also measured in old ties, uncoated, immediately south of section 36. These values varied from 11 to 15 percent, averaging 12.3 percent.

If a tie can be kept at a fairly uniform moisture content, or above the fiber saturation point of the wood, shrinking and swelling stresses that cause checking and splitting can be held to the minimum. The top of the tie will generally have the lowest moisture content of 11 to 15 percent, and the highest moisture content is usually found in the center or bottom of tie, generally being above 45 percent. The moisture content of the top of the new coated ties was 21 percent as compared with 11 percent for new ties, uncoated. The corresponding figures for the old ties were 30 and 12 percent, respectively.

The sealing compound has been effective in maintaining a more uniform moisture content in the ties, which reduces the stresses in the tie that are caused by the tie seasoning in the track. Evaluation of the sealing compound as to its economy for extending the service life of ties will require a long test period unless the protective coating ceases to be effective.

Conclusions

Although several of the special fastenings and types of pads have been effective for periods of as much as five years, conclusions, which obviously must take into account the economic aspects, will require several more years of testing.

Acknowledgement

The Association is indebted to the L&N for its cooperation and assistance in the conduct of the field studies and extends its appreciation to the manufacturers for donating the test materials and for assisting in other ways.

Report on Assignment 7

Effect of Lubrication in Preventing Frozen Rail Joints and Retarding Corrosion of Rail and Fastenings

J. W. Hopkins (chairman, subcommittee), L. L. Adams, F. J. Bishop, Blair Blowers, H. F. Busch, E. D. Cowlin, R. G. Garland, W. E. Griffiths, T. R. Klingel, E. E. Martin, E. R. Murphy, W. N. Myers, M. P. Oviatt, J. S. Parsons, M. K. Ruppert, G. R. Sproles, R. E. Tew, J. B. Wilson.

Your committee offers the following recommendation with respect to the Manual:

Page 5–20

TRACK BOLT TENSION

Reapprove without change.

The following report, presented as information, includes the results of the second year of service of the rail joint lubrication tests on the Illinois Central Railroad and supplementary information concerning the discontinued service test on the Chicago, Burlington & Quincy Railroad.

The last progress report on this assignment, which covered the first years' service of the lubricants and rust preventives on the Illinois Central and the final results of the tests on the Burlington, was published in the Proceedings, Vol. 53, 1952, pages 800–837.

TESTS ON THE ILLINOIS CENTRAL

This installation, consisting of 10 test sections, was placed in the northward main track of the Illinois Central between Chebanse and Danforth, Ill., in connection with relaying the track with 132 RE rail and 6-hole headfree joint bars in June 1950. A location plan showing the profile and description of the test sections is presented in Fig. 1. During the second service period, extending from Aug. 1, 1951, through Sept. 10, 1952, the test track carried 37.5 million gross tons of traffic. The total traffic, since the initial test measurements were made in August 1950, amounted to 69.9 million gross tons.

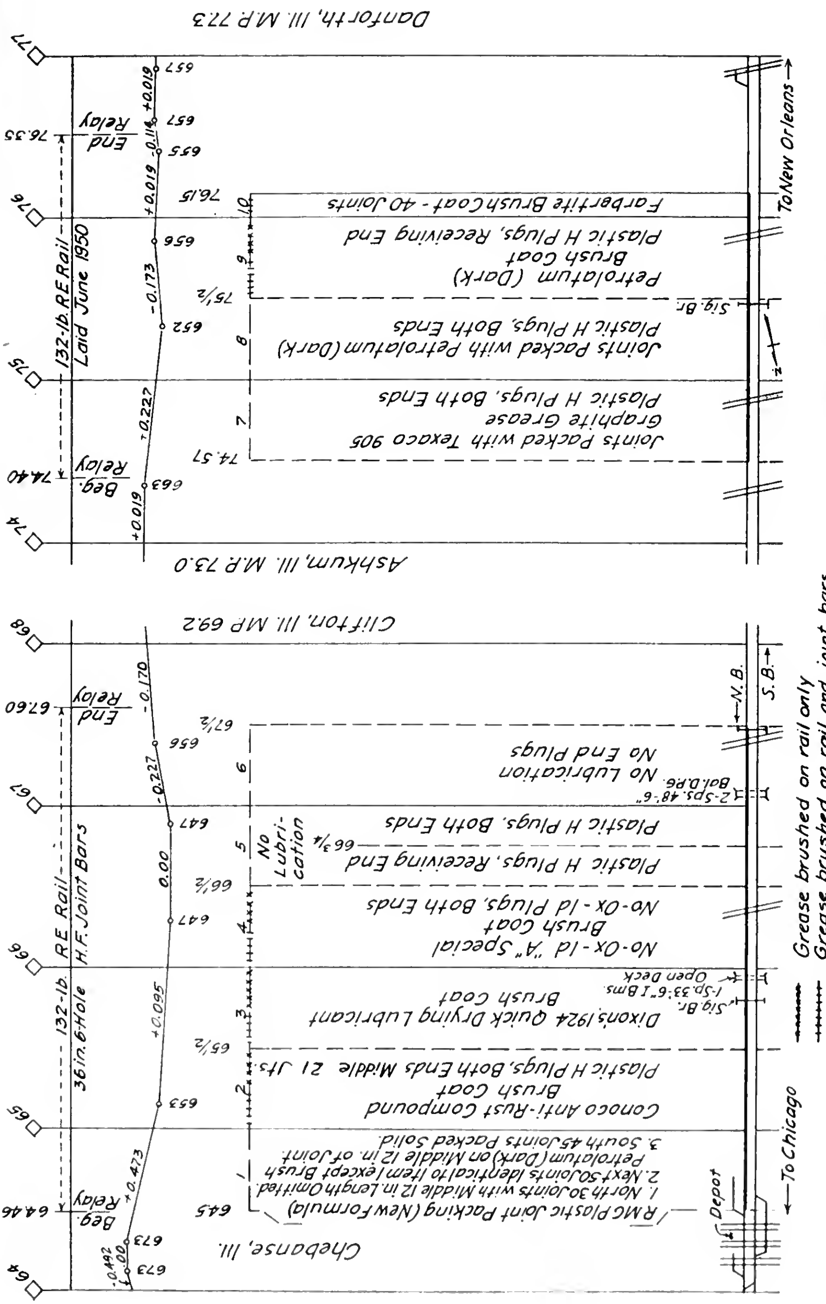


Fig. 1.—Rail Joint Lubrication Service Test in I.C.R.R. Northward Main Track Between Chebanse and Danforth, Ill.

Discussion of Test Data

Rail Joint Gap

The rail gap measurements were taken during the last winter and summer and are presented in graphical form in Figs. 2 and 3. The bar diagrams show percentages of the joints by increments of rail gap width of 0.05 in for each test section. From Fig. 2 for the winter measurements, it will be observed that no section had a good uniformity of rail gap width. The patterns of the bars in sections 5 and 6 without lubrication are not greatly different from some of the other sections with lubrication. Several of the test sections had more joints in the first bracket (0.00 in to 0.04 in) than for the previous winter. The average rail gap for the entire test was 0.24 in. in the first winter and 0.20 in for the second winter. This indicates that the slippage resistance of the joints has increased moderately for the second winter. In Fig. 3 for the measurements of September 1952, all sections, except Nos. 7, 8 and 9, had a smaller percentage of joints in the first bracket (0.00 in to 0.04 in) than in the previous summer. Generally, a greater percentage of the joints would be expected in the first bracket than shown in Fig. 3. The reduction of the joints in the first bracket for rail temperatures over 110 deg F indicates an increase in slippage resistance of the joints. The average rail gap for the summer readings increased from 0.07 in. in 1951 to 0.09 in for 1952. Section 10, with a brush coat of Farbertite, has all of the joints concentrated in the first three increments of rail gap width and is judged to have the best uniformity of rail gap. Because this section only has 40 joints, it is not comparable to the other sections, ½ mile in length.

Joint Bar Pull-In

Fig. 4 is included to show the pull-in of the joint bars, or joint wear, for the period from August 1950 to September 1952. There was more scatter in the pull-in values for the 10 sections in the two-year period than for the first year. Sections 3, 4 and 6 had the highest pull-in for the two-year period, while sections 1, 7, 8 and 9 had the lowest values. In section 1, with RMC plastic joint packing, the bars cocked sufficiently to offset the pull-in for the second test period. The top of the bars moved outward as much as the bottom of the bars moved inward. Other sections analyzed also showed the same tendency, but not to the extent of offsetting all of the pull-in for the second test period. No significance can be given to the differences in pull-in of the test sections until after the joint bars have become fully seated. The average pull-in for all of the test sections was 0.030 in for the first test period and 0.015 in for the second test period, making a total of 0.045 in for the 2-year test period.

Maintenance of Way Report

The Illinois Central reported for the second service period that there were no loose or broken bolts, or stripped joints. Each year after the summer measurements are made by the AAR research staff, the track bolts in the test sections are retightened out-of-face with power bolt machines.

Inspection of Dismantled Joints

This inspection was made July 15, 1952, and the party included six representatives of four manufacturers, one AREA member representing the Illinois Central, the photographer of the Burlington, and the track engineer of the research staff, AAR. Thirteen joints were dismantled and inspected. Photographic views of the joints are shown in

(Text continued on page 1072)

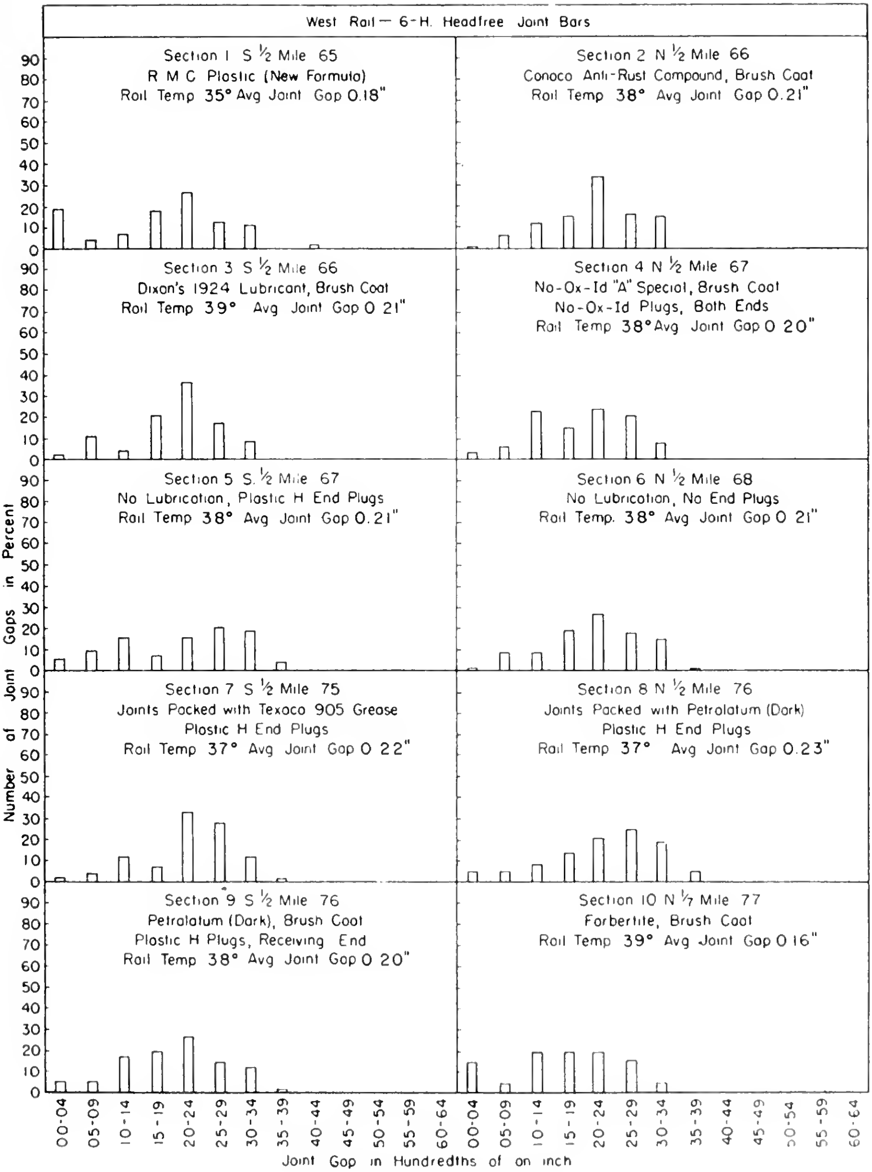


Fig 2 Joint Gap Measurements for Rail Joint Lubrication Test, Feb 29, 1952
I C R R Chebanse to Danforth, Ill

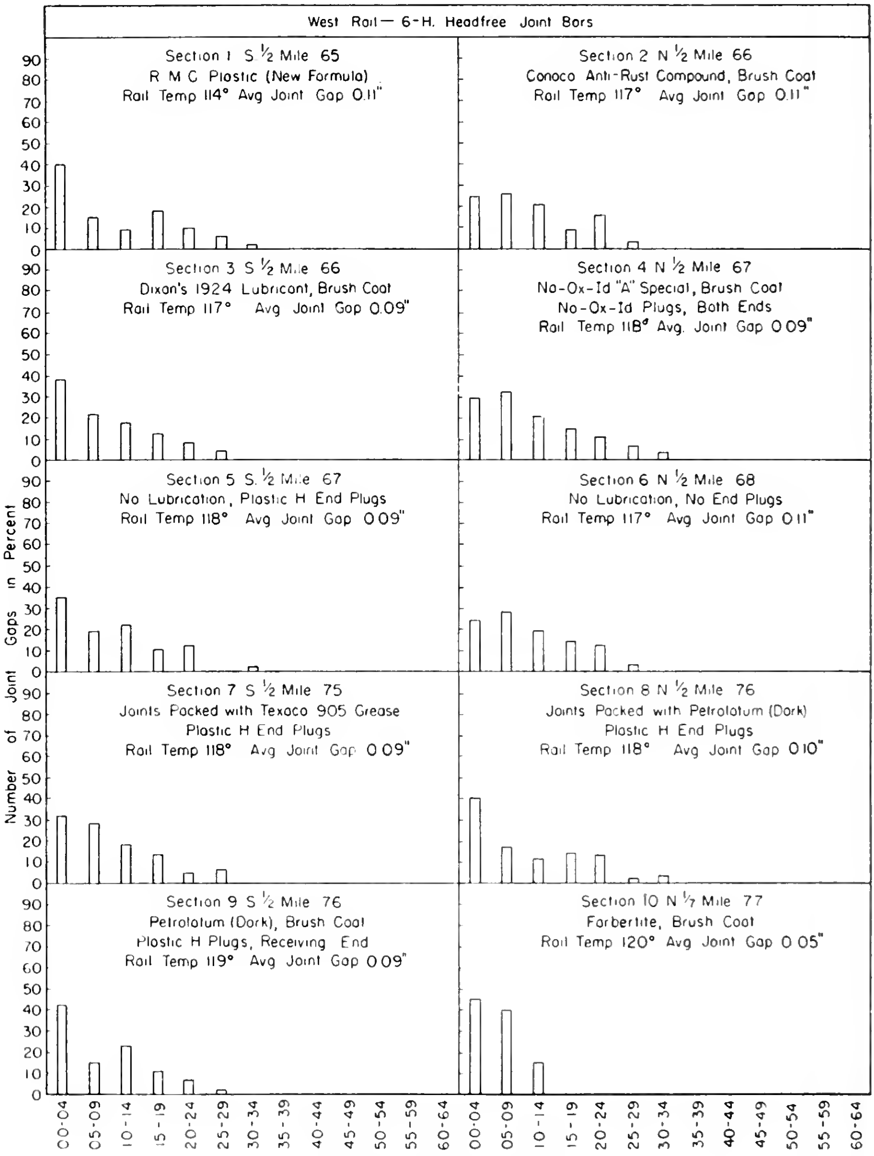
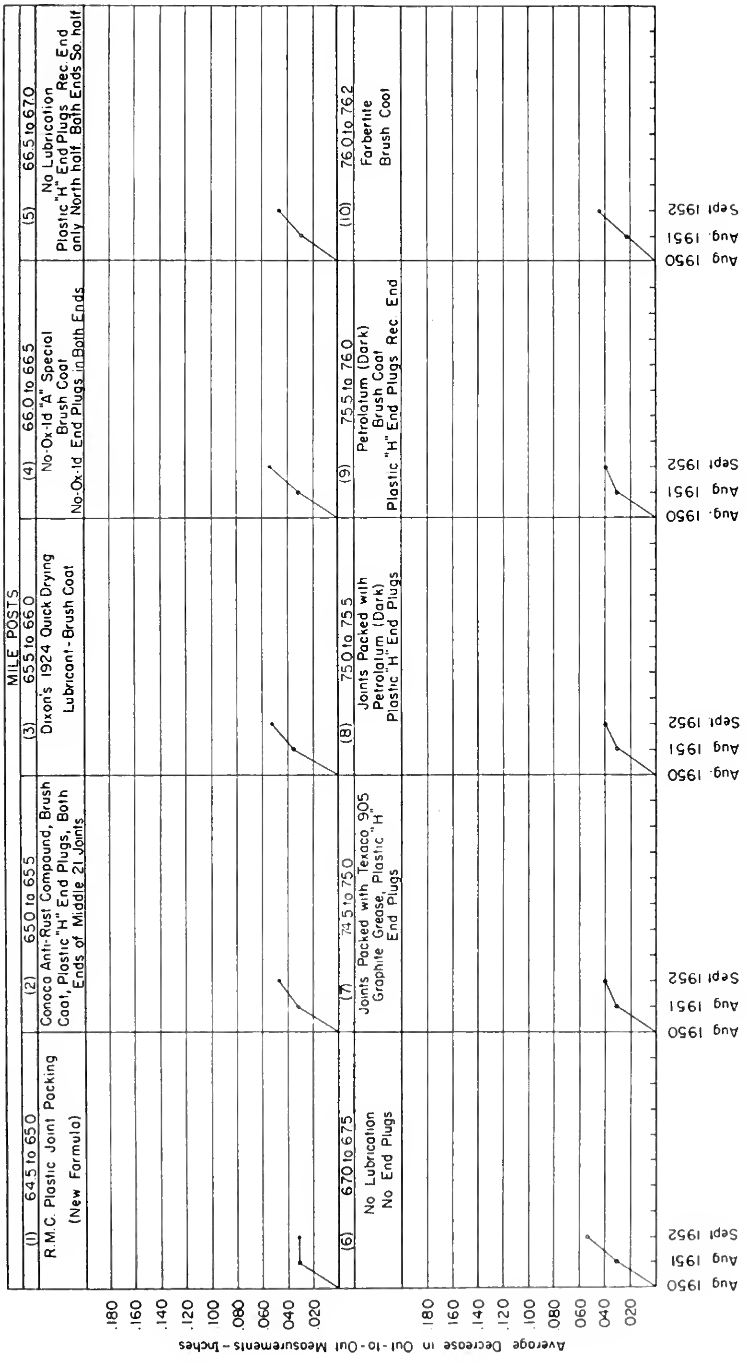


Fig. 3 Joint Gap Measurements for Rail Joint Lubrication Test, September 10, 1952
I.C.R.R. Chebanse to Danforth, Ill.



Note Out-to-Out measurements taken at top and bottom of ends and middle of all joint bars in west rail. Values shown are the mean of top and bottom of bars

Fig 4 Average Pull-in of Joint Bars, I.C.R.R., Chebanse to Danforth, Illinois

Figs. 5 to 17, incl. The Association is indebted to the Burlington for permitting its photographer to assist the inspection party.

In each of the figures, the upper view shows the rail and top of the bars, and the lower view shows the bottom of the bars. Most of the traffic is to the right, or northward. The dark streaks on the rails in some of the photographs is the asphalt metal preservative sprayed on the joints last year by the spray car. The Illinois Central very kindly consented to discontinue spraying the joints while this test is underway. Each year a different joint is inspected in the test sections.

Figs. 5 and 6 show two of the joints dismantled in the middle and south portions of section 1 with the RMC plastic joint packing made of the new formula. In the joint with solid packing (Fig. 6), there was a generous amount of bleeding of the oil from the packing. The end cakes of the joint in Fig. 5 showed little evidence of bleeding, and the brush coat of Petrolatum on the rail ends was thin because of the heat left from the rail end hardening. The heat may have also melted down the cakes in the joint packed solid. There was more of the metal preservative on the fishings of the joint packed solid. The solid packed joint provided complete protection of the bolts.

In the joint (Fig. 7) with Conoco Anti-Rust Compound, the grease had protected the rail and the bottoms of the bars better than on the tops of the bars where a portion of the areas was dry.

Fig. 8 shows a joint in section 3 with Dixon's 1924 Quick-Drying lubricant. The protective coating had hardened and flaked off. There was considerable corrosion on the rail and bars. The coating has failed and is not suitable for protecting rail joints.

Figs. 9 and 10 show the condition of two joints in section 4 having a brush coat of No-Ox-Id "A" Special and No-Ox-Id end plugs. Some debris was in the joint because the end plugs had melted down during the first summer. The coverage was better on the joint (Fig. 9) where the grease was brushed on the rail and bars. There was more rust on the back of the joint bars (Fig. 10) where the lubricant was only brushed on the rails.

Figs. 11 and 12 show two joints in sections 5 and 6, without a lubricant. The only difference in the two joints is that the one in Fig. 11 has plastic "H" plugs in both ends of the joint. The joint with end plugs was cleaner and had much less rust than the one without end plugs. There was no moisture in either joint. No rust slabs in the lower rail fillets near the ends of the bars had formed.

Fig. 13 shows a joint packed solid with Texaco 905 graphite grease and plastic "H" end plugs. Because of the whipping action of the joint under traffic, more lubrication was observed on the upper fishing surfaces than at the end of the first year. Some of the grease had pumped upward through the rail gap. There was a small amount of condensation in the joint, but the water was not in contact with the rail or bars. The joint and the bolts were well protected. Only a little corrosion was visible on the gage side of the receiving rail base. In some joints where the rail gap was not over a tie plate, only a moderate amount of the grease had whipped out on the ballast.

Fig. 14 covers one of the joints in section 8 packed solid with Petrolatum (dark) and plastic "H" end plugs. The top and bottom fishings were protected well. There was some moisture in the joint, but it was not on the rails or bars. In this section, the petrolatum melts in the summer and flows out regardless of whether the rail gap is over a tie plate or between ties. Over one-half of the lubricant had melted and run out of the joint inspected. In sections 13 and 14 the bolts were provided with complete protection from the elements.

(Text continued on page 1079)

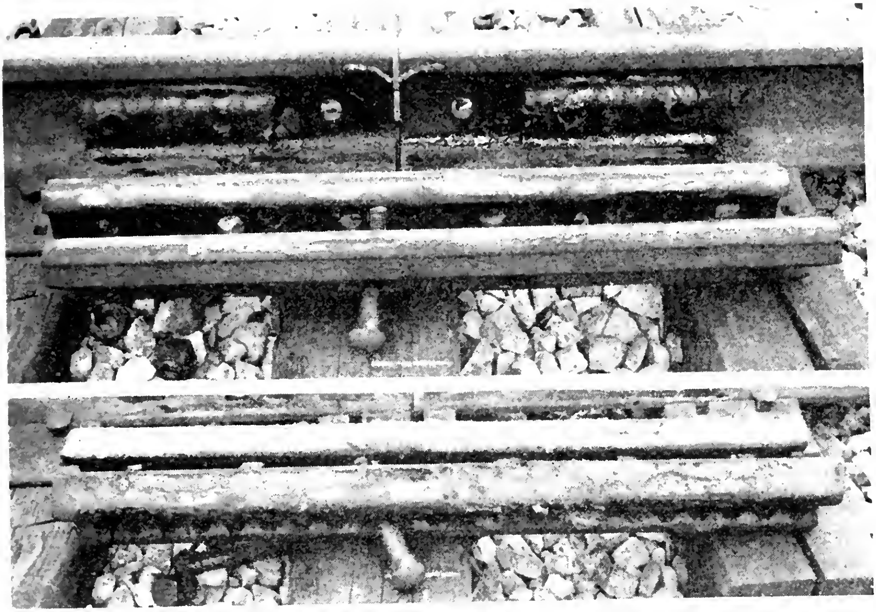


Fig. [illegible]. Middle Portion of Section 1, [illegible] Plastic Joint Packing (new formula) with [illegible] Coat of Petrolatum (Left) on Rail where Middle Boxes were omitted.

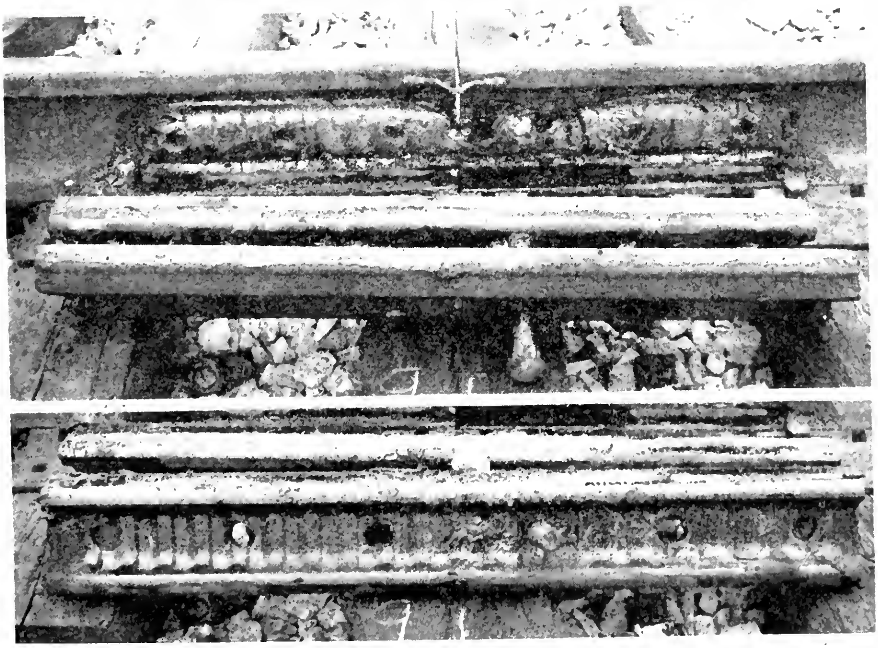


Fig. 6. South Portion Section 1, R.M.C. Plastic Joint Packing (new formula).

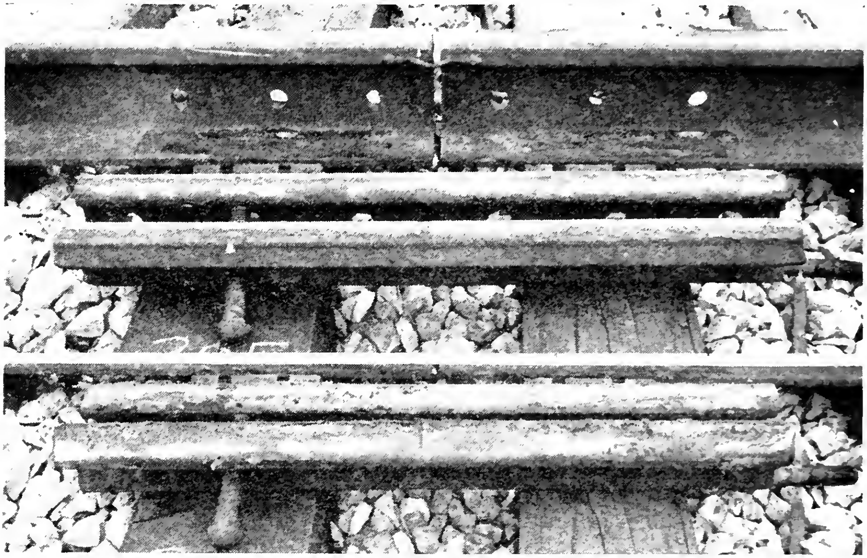


Fig. 7. North Portion Section 2, Conoco Anti-Rust Compound (Brush coat on rail and joint bars).

Fig. 8. South Portion of Section 3, Dixon's 1924 Quick Drying Lubricant (Brush coat on rail only).

Fig. 9. North Portion of Section 4, No-Ox-Id "A" Special (Brush coat on rail and joint bars with No-Ox-Id End Plugs).

Fig. 10. South Portion of Section 4, No-Ox-Id "A" Special (Brush coat on rail only with No-Ox-Id End Plugs).

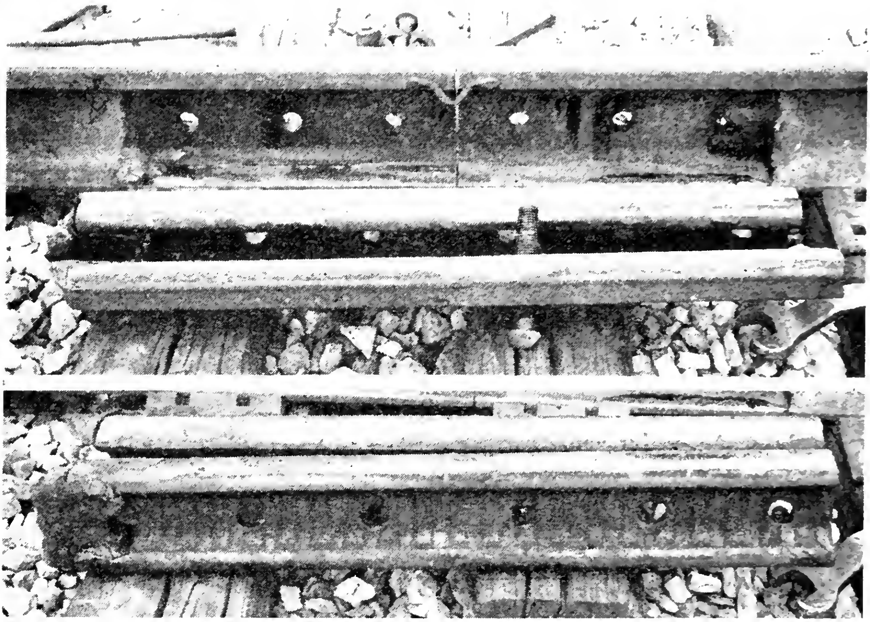


Fig. 11. [illegible]th portion of Section [illegible], No Lubrication ([illegible]lastic [illegible], [illegible] ends).

Fig. 12. Section 6, No Lubrication, No End Plugs.

Fig. 13, Section [illegible], [illegible] Grease and Plastic H End Plugs.

Fig. 14, Section 2, Packed with Petrolatum (Dark) and Plastic E End Plugs.

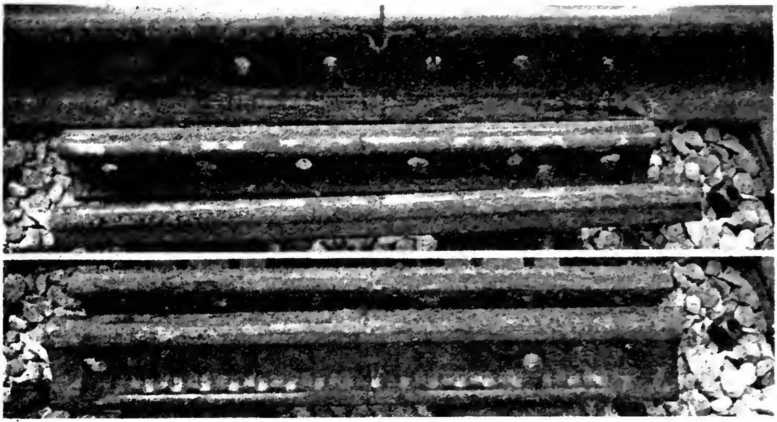


Fig. 15. North Portion, Section 9, Petrolatum (Dark). (Brush coat on rail and bars with Plastic H receiving end plugs on the left.)

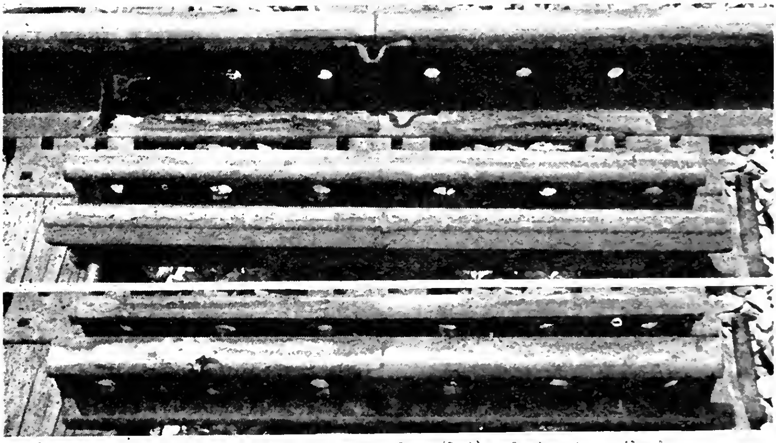


Fig. 16. South Portion of Section 9, Petrolatum (Dark). (Brush coat on rail only with Plastic H receiving end plugs on the left.)

Fig. 17. Section 10, Farbertite (Brush coat on rail and joint bars).

Figs. 15 and 16 show two joints in section 9 with a brush coat of Petrolatum (dark) and receiving end plugs. The joint in Fig. 15 had the rail and bars greased, and the other joint had only the rail greased. The joint in Fig. 15 had more grease left on the fishings, and the joint in Fig. 16 had more rust on the back of the bars and in the upper rail fillets near the rail gap. There was a small amount of debris in these joints which was attributed to the reverse movement of traffic.

The joint inspected in section 10 (Fig. 17), having a brush coat of Farbertite on the rail and bars, was in poor condition. The compound had formed a hard coating which had flaked off. This compound had failed completely and is not suitable for use on track joints.

General Remarks

In all of the test sections the bolt threads were greased initially, and they were well preserved after two years of service.

The adverse effect of the heat left from the rail end hardening on the rust preventives along the middle third of the joints, which had a brush coat, can be observed from the photographs for sections 1 (middle portion) 2, 4 and 9. This caused the protective coating on the critical stress areas of the rails to be inadequate. End hardening of rails at the mill would greatly facilitate securing a good brush coat of grease on new bars and rail.

In two sections it was shown that in joints which had the lubricants brushed on the rail and bars, there was more of the rust preventives left on the bars and rail than in joints where only the rail was coated.

The test results have shown that there has been no adverse effect from plugging both ends of a joint.

Texaco Plastic "H" material was used for the end plugs, except in section 4 where the Dearborn No-Ox-Id joint bar filler was used. In all sections having the plastic "H" end plugs, the plugs were beveled, except in sections 7 and 8 where they were finished square with the ends of the bars. Eleven of the beveled end plugs were found out of the joints. All of the square plugs were in place. Less material is required for the square plugs.

Two of the preservatives, Farbertite and Dixon's 1924 Quick-Drying lubricant, have failed by flaking off and are considered unsuitable for protecting rail joints.

In the sections having a brush application of a rust preventive, there was a deficiency of the material on the fishings. The service test on the Burlington showed that a protective coating could not be maintained on the fishings by the methods used.

Conclusions

A longer service period will be required before final appraisal can be made of the several rust preventives and methods of application.

TESTS ON THE BURLINGTON

This test in the westward main of the Burlington, near Earlville, Ill., extended over a six-year period, ended July 1951. The track was laid with 131 RE rail, 6-hole joint bars, 1-in track bolts, and Hubbard Super-Service spring washers. The joint bars in the north rail were the headfree type, and in the south rail the reformed head-contact type.

Joint Bar Pull-In

Final results of the measurements of joint bar pull-in, or joint wear, except for a supplementary test on the effect of relubrication, were published in last year's report.

In August 1950, 47 head-contact joints in the Petrolatum (dark) section were regreased with the same rust preventive by dismantling the joints. Application was made with a two-knot roofing brush, and the bars as well as rail ends were coated with petrolatum. In the first service period of the regreased joints, the joint bar pull-in for 9 months, ended July 1951, was 0.012 in. This is equivalent to 0.016 in for 12 months. Excluding the first year's service of the original petrolatum section to avoid the influence of the new bars becoming seated, the average annual pull-in of the head-contact joints for the next 4 years was 0.011 in. During the 12-month period ended July 1952, the pull-in for the regreased head-contact joints averaged 0.013 in. For the sixth service year (ended July 1951), the other sections with lubrication and head-contact bars had pull-in values of 0.014 in to 0.024 in, averaging 0.019 in. Regreasing the head-contact joints after five years of service was not effective in reducing the pull-in of the bars. It was developed in the laboratory test with the rail joint slippage machine that regreasing a head-contact joint greatly reduced its slippage resistance or force required to open and close the joint once a minute, and extended the period required to build up a large slippage resistance. It is possible that regreased joints in track open and close more freely due to daily rail temperature changes, and this greater movement may have offset the advantage of relubrication as to joint wear.

An investigation was made of the uniformity of the summer rail gap width of the same joints that were regreased in August 1950. The uniformity of the rail gap width two years after the joints were relubricated was about the same as it was in 1947, two years after the joints were initially greased.

Acknowledgement

The Association and the committee are indebted to the Illinois Central and the Burlington for their cooperation and assistance in the conduct of the field tests.

Report on Assignment 8

Field Measurement of Forces Resulting from Rail Anchorage

J. P. Hiltz (chairman, subcommittee), L. L. Adams, F. J. Bishop, D. B. Barge, Jr., L. E. Bates, H. B. Christianson, C. A. Colpitts, W. E. Cornell, K. E. Dunn, H. F. Fifield, J. W. Fulmer, R. G. Garland, A. B. Hillman, A. F. Huber, H. F. Kimball, T. R. Klingel, E. E. Martin, M. K. Ruppert, Troy West.

Your committee has reviewed the material in the Manual on rail anchorage and offers the following recommendation:

Pages 5–17 and 5–18

RAIL CREEPAGE—NUMBER AND POSITION OF RAIL ANCHORS

Reapprove without change.

Report on Assignment 9

Critical Review of the Subject of Speed on Curves as Affected by Present Day Design

J. W. Fulmer (chairman, subcommittee), L. L. Adams, D. B. Barge, Jr., L. E. Bates, M. C. Bitner, W. R. Bjorklund, T. Fred Burris, H. F. Busch, M. D. Carothers, E. W. Caruthers, H. W. Cox, Jr., H. F. Fifield, A. E. Haywood, E. R. Murphy, W. N. Myers, M. P. Oviatt, J. S. Parsons, C. E. Peterson, Troy West.

The general nature of this subject makes it desirable to present a complete report on the results of all the tests and all roads rather than to present the data in partial reports. The test program as originally outlined has been nearly completed, and unless further testing is found necessary, the program can be completed shortly and work started on a report to include all tests.

Progress of work since the report in Bulletin 500 (February 1952), Proceedings, Vol. 53, 1952, is as follows:

1. A Milwaukee car with a unique truck design has been tested on a round trip, Chicago to Minneapolis, on special high-speed runs, and lean measurements made statically on curves with elevations of 2, 4, and 6 in. This truck has no swing hangers or pedestal guides.

2. Lean tests were made on the Lackawanna cars with inboard and outboard swing hangers previously tested. Elevations of approximately 2, 4, and 6 in were used.

3. Lean tests were made with the outboard swing hanger car previously tested on the New Haven at elevations of 2, 4, and 6 in.

4. All records and data have been read and reduced to such form that analysis and preparation of a report can be started shortly.

5. Tests have been arranged involving a Pennsylvania Railroad car having a coil and leaf spring combination. It is expected these tests will be made about the middle of November, 1952. A lean test has also been arranged on the "dome" car tested on the Burlington and will be made shortly.

Completion of the tests scheduled above will leave only the Santa Fe car to be tested for static lean to complete the program. The railroad will be contacted shortly regarding this work. It probably will not be feasible to test this car both with and without the anti-roll device as the car was specially modified for the original riding tests. At that time the lean tests were not being made.

The railroads have all been exceedingly helpful in furnishing equipment and assistance for facilitating this program.

The program coincides with a similar assignment of the Joint Committee on Relation Between Track and Equipment and is being conducted jointly by the Engineering and Mechanical Divisions under that committee. The tests are under the general direction of G. M. Magee, director of engineering research, and William Keller, director of mechanical research. Randon Ferguson, electrical engineer, research staff, is in active charge of the program.

Your committee offers the following recommendations with respect to the Manual.

Pages 5–42 to 5–44, incl.

ELEVATIONS AND SPEEDS FOR CURVES

Reapprove with the following changes in table 507:

1. 1°—30′ curve, 3″ unbalanced elevation. Speed of 55 mph for ¼″ elevation has been eliminated. The equilibrium speed is 55 mph at 3″ elevation.
2. 2°—30′ curve, equilibrium speed. Change speed of 45 mph from 3½″ to 3¼″ elevation.
3. 2°—30′ curve, equilibrium speed. Insert speed of 65 mph at 7″ elevation.
4. 3°—30′ curve, 3″ unbalanced elevation. Change speed of 50 mph from 3″ to 2¾″ elevation.
5. 3°—30′ curve, equilibrium speed. Insert speed of 55 mph at 7″ elevation.
6. 4°—30′ curve, 3″ unbalanced elevation. Change speed of 45 mph from 3¼″ to 3″ elevation.
7. 5°—30′ curve, 3″ unbalanced elevation. Insert speed of 30 mph for ¼″ elevation.
8. 5°—30′ curve, 3″ unbalanced elevation. Change speed of 40 mph from 3″ to 2¾″ elevation.
9. 6°—0′ curve, 3″ unbalanced elevation. Change speed of 30 mph from ¼″ to ½″ elevation.
10. 6°—0′ curve, 3″ unbalanced elevation. Change speed of 40 mph from 3½″ to 3¼″ elevation.
11. 12°—0′ curve, equilibrium speed. Change speed of 20 mph from 3″ to 3¼″ elevation.

All these changes are minor, and if approved will correct some apparent inconsistencies and will make the recommended equilibrium speed and speed for 3-in unbalanced elevation 3 in apart in all cases.

Basis of calculations to remain the same as at present.

Page 5–37

SPEED OF TRAINS THROUGH TURNOUTS

Reapprove with the following changes:

Turnouts with straight switch points.

a. Lateral turnouts.
   Change speed through No. 7 turnout from 16 mph to 17 mph, and speed through Nos. 12 and 14 turnouts from 28 mph to 27 mph.
b. Equilateral turnouts.
   No change in present table.

Turnouts with curved switch points.

Speeds recalculated based on AREA Trackwork Plan 920–51. Delete present table from the Manual and substitute the following:

Lateral Turnouts With Curved Switch Points (AREA)
(Trackwork Plan 920-51)

Turnout No.	Length Switch Points	Speed in Miles Per Hour
5	13′—0″	12
6	13′—0″	15
7	13′—0″	18
8	13′—0″	21
9	19′—6″	22
10	19′—6″	25
11	19′—6″	28
12	19′—6″	29
14	26′—0″	35
15	26′—0″	39
16	26′—0″	41
18	39′—0″	46
20	39′—0″	51

Page 5-37

PERMANENT MONUMENTS

Reapprove without change.

Report on Assignment 10

Methods of Heat Treatment, Including Flame Hardening, of Bolted Rail Frogs and Split Switches, Together with Methods of Repair by Welding

S. H. Poore (chairman, subcommittee), L. L. Adams, F. J. Bishop, M. C. Bitner, T. F. Burris, P. H. Croft, K. E. Dunn, W. E. Griffiths, A. E. Haywood, A. B. Hillman, J. W. Hopkins, A. F. Huber, W. G. Hulbert, C. H. Johnson, C. Kuchel, R. E. Miller, E. R. Murphy, H. B. Orr, J. S. Parsons, G. A. Peabody, C. E. Peterson, J. A. Reed, R. D. Simpson, R. E. Tew, J. B. Wilson.

This is a new subject this year, and your committee feels that no report, other than progress, can be made.

Your committee has a program developed which includes certain test installations of heat treated, flame hardened, and "as rolled" crossing frogs, and is undertaking to secure service records of heat-treated and flame-hardened frogs, switches and special trackwork.

Report on Assignment 11

Means of Conserving Labor and Materials, Including the Adaptation of Substitute Noncritical Materials, and Specifications for the Reclamation of Released Materials, Tools and Equipment

Collaborating with Committee 3-A, General Reclamation, Purchases and Stores Division, AAR

Your committee has worked with the Board Emergency Committee on Track Problems and has obtained in writing the consensus of the Track committee on changes to be made in specifications and plans to conserve critical materials, should such become essential. We have also worked with Committee 3-A, General Reclamation, Purchases and Stores Division, on general reclamation affecting track items, these matters being referred to appropriate subcommittees for study.

Report of Committee 1—Roadway and Ballast

G. W. Miller, *Chairman,*	G. B. Harris	B. H. Crosland, *Vice Chairman,*
W. T. Adams	H. W. Jensen	A. W. Schroeder
E. W. Bauman	J. H. Jentoft	J. R. Scofield
R. H. Beeder	H. G. Johnson	R. J. Scott
C. R. Bergman	L. V. Johnson	L. D. Shelkey
F. W. Biltz	W. T. Johnston	L. R. Shellenbarger
J. M. Boles	H. S. Leard	W. C. Swartout
L. H. Bond	H. W. Legro	W. O. Trieshman
J. E. Chubb	R. R. Manion	C. D. Turley
M. W. Cox	F. H. McGuigan	G. C. Vaughan
A. P. Crosley	Paul McKay	Stanton Walker
J. P. Datesman	J. A. Noble	C. E. Webb
M. B. Davis	G. W. Payne	Charles Weiss
T. F. de Capiteau	J. W. Poulter	A. A. Winter
W. P. Eshbaugh	J. W. Purdy	J. C. Woods
J. G. Gilley	C. S. Robinson	R. C. Young
A. T. Goldbeck	L. S. Rose	W. L. Young
R. A. Gravelle	K. W. Schoeneberg	*Committee*

To the American Railway Engineering Association:

Your committee reports on the following subjects:

THE COMMITTEE ON ROADWAY AND BALLAST,

G. W. MILLER, *Chairman.*

AREA Bulletin 507, February 1953.

Report on Assignment 1

Revision of Manual

A. P. Crosley (chairman, subcommittee), R. H. Beeder, F. W. Biltz, L. H. Bond, B. H. Crosland, A. T. Goldbeck, L. H. Jentoft, L. V. Johnson, R. R. Manion, J. A. Noble, A. W. Schroeder, C. E. Webb.

Your committee has made a study of its chapter in the Manual and recommends the following changes:

Pages 1–6.1 to 1–6.63, incl.

PHYSICAL PROPERTIES OF EARTH MATERIALS STRUCTURAL FOUNDATION SOILS

Withdraw present material on these pages and substitute therefor the material appearing in the Proceedings, Vol. 53, 1952, pages 712 to 717, incl., which was submitted at the 1952 annual meeting for comment and criticism.

Pages 1–6.7 to 1–6.85, incl.

NATURAL WATERWAYS

201. GENERAL

202. DRAINAGE AREAS AND WATER RUNOFF

203. SIZE OF WATERWAY OPENINGS

Reapprove without change.

Pages 1–6.87 to 1–6.93, incl.

204. PREVENTION OF EROSION

Reapprove with the following revisions:

1–6.92. Delete first paragraph under "Check Dams".

1–6.93. Insert as a paragraph following the first complete paragraph:

The present condition of timber dams built 20 years ago clearly shows the need for careful selection as to kind and quality of timber to be used. There is also evidence that generally the use of treated timber is justifiable.

1–6.93. In the third complete paragraph after the first sentence, insert the following:

However, satisfactory service life where exposed to repeated freezing and thawing may be doubtful.

1–6.93. Change "Conclusions" to read:

Where maintenance costs and savings in operating costs justify the expenditure, and where conditions fall approximately within the limits described in the foregoing, this method of stream control is recommended.

Page 1–6.94

SPECIFICATIONS FOR RIPRAP STONE

Reapprove without change.

Pages 1–7 to 1–12, incl.

205. MEANS OF PROTECTING ROADBED AND BRIDGES FROM WASHOUTS AND FLOODS

Reapprove without change.

Pages 1–12.01 to 12.04, incl.

301. CULVERTS—LOCATION AND TYPE

Reapprove without change.

Pages 1–12.05 to 1–12.085, incl.

SPECIFICATIONS FOR EXTRA STRONG OR TRIPLE-STRENGTH VITRIFIED CLAY CULVERT PIPE

Withdraw the present material under this heading and substitute the following:

SPECIFICATIONS FOR EXTRA STRENGTH CLAY PIPE

Clay pipe intended to be used for the construction of culverts and other projects where conditions require that extra strength pipe be used shall conform to current ASTM specifications, designation C 200.

Pages 1–12.1 to 12.7, incl.

SPECIFICATION FOR CAST IRON CULVERT PIPE

Withdraw the present material under this heading and substitute the following:

Cast iron pipe intended for use in the construction of culverts shall conform to current ASTM Specifications, designation A 142.

Pages 1–12.81 to 1–12.88, incl.

SPECIFICATIONS FOR CORRUGATED STRUCTURAL PLATE CULVERTS AND ARCHES

Reapprove without change.

Pages 1–13 to 1–17, incl.

SPECIFICATIONS FOR CORRUGATED METAL CULVERTS

Reapprove without change.

Pages 1–18.01 and 1–18.02

SPECIFICATIONS FOR CORRUGATED METAL PIPE FOR SUBDRAINAGE

Reapprove without change.

Pages 1–18.03 to 1–18.10, incl.

SPECIFICATIONS FOR BITUMINOUS COATED CORRUGATED METAL PIPE AND ARCHES

Reapprove with the following revisions:

1–18.07 to 1–18.10. Delete Art. 11. Adhesion Test, which will necessitate the following editorial changes:

1–18.03. Art. 3. Bituminous Material. In second line change "Arts. 6 to 12" to read "Arts. 6 to 11".

1–18.03. Art. 5. Test Specimens. In the first line change "Arts. 6 to 12" to read "Arts. 6 to 11."

1–18.04. Art. 5. Test Specimens. Delete the first six lines, beginning with "From any two lengths, etc."

1–18.04. Art. 5. Test Specimens. In the first line of the second paragraph change "For the other tests hereinafter described" to read "For the tests hereinafter described."

1–18.07. Delete Fig. 3. Aging Tank.

1–18.08. Delete Fig. 4. Adhesion Anchor.

1–18.09. Delete Fig. 5. Adhesion Test Apparatus.

1–18.10. Art. 12. Imperviousness Test. Change to read "Art. 11. Imperviousness Test."

Pages 1–18.11 and 1–18.12

INSTALLATION OF PIPE CULVERTS

Reapprove without change.

Pages 1–19 to 1–24, incl.

JACKING CULVERT PIPE THROUGH FILLS

Reapprove with the following revision:

1–22. Art. 10. Jacking Procedure. Immediately prior to the last sentence of the first paragraph, beginning with "When jacking corrugated pipe, etc.", insert the sentence "Jacking should be continued, where practicable, until the installation is completed."

Pages 1–25 to 1–26.2, incl.

309. SPECIFICATIONS FOR PIPE LINE CROSSINGS UNDER RAILWAY TRACKS

Reapprove with the following revisions:

1–25. Art. 1. Scope. Delete the second sentence beginning with "Gas transmission and, etc."

1–25. Fig. 104. Change note reading, "Vent pipe at low end of casing to be connected to side or bottom of casing pipe", to read "Vent pipe at low end of casing to be connected to bottom of casing pipe."

1–26.2. Art. 6. Depth of Casing. In the first line change "The top of the carrier pipe shall, etc.", to read "The top of the casing shall, etc."

Pages 1–27 to 1–36.1, incl.

SPECIFICATIONS FOR THE FORMATION OF THE ROADWAY

Reapprove without change.

Pages 1–36.1 to 1–40, incl.

ECONOMICS OF FILLING BRIDGE OPENINGS

Withdraw from Manual.

Pages 1–43 to 1–66, incl.

ROADWAY DRAINAGE

Reapprove without change.

Pages 1–66.085 to 1–66.090, incl.

STABILIZATION BY PRESSURE GROUTING

Reapprove without change.

Pages 1-66.1 to 1-66.4, incl.

TUNNELS

Reapprove without change.

Page 1-66.1

701. ALINEMENT AND GRADE

Reapprove without change.

702. SPECIFICATIONS FOR CONSTRUCTION, EXCAVATION AND TEMPORARY LINING OF TUNNELS

Reapprove without change Secs. 1 to 3. incl., and Secs. 5, 7, 9, 12, 13, 14, and 18, and revise other sections as indicated below:

1-66.1. Sec. 4. Delete the two paragraphs under this section on page 1-66.2 and substitute the following:

The method of payment for tunnel excavation may be on the basis of linear feet or cubic yards, depending upon the practice prevalent in the locality where work is to be performed.

The price for tunnel excavation, under both methods of payment, shall cover all expenses incident thereto, and embrace the removal of all materials within the limits of tunnel excavation as hereinbefore defined, and the doing of everything to complete the work not included in other items priced on the form of proposal, and without limiting the meaning of the foregoing, shall be deemed to include the loosening, loading, transportation, placing and removing of all materials as directed, the furnishing of all necessary materials, plant and labor for temporary timbering, supports and scaffolding for the safe prosecution of the work, and keeping the tunnel free from water, oil and gas.

Except in ground where lining is required, the contractor must take out all loose or shattered rock or material of any kind which, in the opinion of the engineer, is dangerous or may become so in the future, which will be paid for under the same provisions as outlined under Sec. 6.

1-66.2. Sec. 6. Slides and Falls

Revise to read as follows:

Every precaution must be taken against slides or falls in blasting or other operations. Should such falls or slides be due to the operations of the contractor, the material must be removed at his own expense, but if they come from the nature and character of the ground so as to be beyond his power to prevent them, the railway company will pay a price for the removal to be determined by the conditions attached to such falls or slides if payment is on a linear foot basis. If the method of payment is on a cubic yardage basis, one-half the price per cubic yard for excavation will be paid. The chief engineer to be the sole judge as to cause of slide or fall.

1-66.2. Refuge Niches, Sec. 8

Revise to read as follows:

Refuge niches shall be constructed where shown and in accordance with plans. When payment is on a linear foot basis, refuge niches are to be included in the contractor's price per linear foot of tunnel.

1-66.3. Classification, Sec. 10

Revise to read as follows:

When payment is on a linear foot basis, there shall be no classification for tunnel excavation. When payment is on a cubic yard basis, all excavation shall be classified in accordance with the classification specified in the AREA Specifications for the Formation of the Roadway.

1–66.3. Disposition of Material and Overhaul, Sec. 11

Revise to read as follows:

The specified price per linear foot as well as the price per cubic yard for tunnel excavation, and for any other excavation, including shafts, shall cover the whole cost of labor and material incident thereto, and the depositing of the material in embankments at the end of the tunnel or as otherwise directed, and there shall be no allowance for any so-called "overhaul".

1–66.3. Drainage, Sec. 15.

Revise to read as follows:

Pipe for roadbed drainage shall be installed as shown on plans and properly laid on the established grade. Drainage facilities in accordance with plans are to be provided in rear of both temporary and permanent lining with outlets through the lining located not less than 12 in above the bottom of the ditch.

1–66.3. Timber Lining, Sec. 16.

Revise to read as follows:

Lining where required, must conform to standard or special plans. Timber to be left in place as lining or in portals shall be Douglas fir, larch, Southern pine or other approved wood and of the grade and treatment specified in AREA specifications. The lagging shall be in pieces 4 in thick and 6 in wide. Timber left in place as lining shall be paid for at a price per thousand fbm. This price shall include the cost of necessary hardware and total cost of all labor incidental to putting the timber and hardware in place. Timber to be left in place should as far as possible be cut to length framed and bored before treatment. All field sawed joints, framing and holes bored in field should be treated with an acceptable preservative. All hardware used with timber to be left in place shall be galvanized.

1–66.4. Packing, Sec. 17.

Revise to read as follows:

The contractor shall pack all cavities behind lining so that the total area of roof and sides will have a firm bearing on lining or lagging. This packing may consist of treated timber or stone. Should the cavities have been caused by blasting or other operations of the contractor, the packing shall be done at the contractor's expense. If the cavities result from natural causes and character of the ground so as to be beyond the contractor's power to prevent them, the railway company will pay a price to be determined by the engineer for the packing done.

Page 1–66.4

703. VENTILATION

Reapprove without change.

Page 1–66.4

704. LIGHTING

Reapprove without change.

Pages 1–66.5 to 1.66.7, incl.

SPECIFICATIONS FOR WOOD FENCE POSTS

Reapprove without change.

Pages 1–67 to 1–69, incl.

CONCRETE FENCE POSTS—SPECIFICATIONS

Reapprove without change.

Pages 1–71 and 1–72

METAL FENCE POSTS—SPECIFICATIONS

Withdraw present specification and substitute material as presented in the report on Assignment 8.

Pages 1–73 to 1–77, incl.

SPECIFICATIONS FOR RIGHT-OF-WAY FENCES

Reapprove without change.

Page 1–77

STOCK GUARDS

Reapprove without change.

Pages 1–79 to 1–85, incl.

METHODS OF PROTECTING AGAINST DRIFTING SNOW AND OPENING SNOW BLOCKADES

Withdraw the present material under this heading.

Page 1–85

METHODS OF PROTECTION AGAINST DRIFTING SAND

Withdraw the present material under this heading.

Pages 1–87 to 1–89, incl.

SIGNS

Reapprove without change.

Pages 1–91 to 1–96, incl.

SPECIFICATIONS FOR ONE, TWO, THREE AND FOUR-TRACK OVERHEAD METAL WARNING AND METAL SIDE WARNING

Reapprove without change.

Pages 1–97 to 1–99, incl.

SPECIFICATIONS FOR ONE AND TWO-TRACK OVERHEAD WOOD WARNING AND WOOD SIDE WARNING

Reapprove without change.

Pages 2–1 to 2–3, incl.

SPECIFICATIONS FOR PREPARED STONE, SLAG AND GRAVEL BALLAST

Reapprove with the following revisions:

Under Art. 4. Grading Requirements for crushed stone and slag and for size 3 substitute 95–100 instead of 90–100 passing 2-in sieve. Size 57, substitute 95–100 for 90–100 passing the 1-in sieve. Rest of table to remain. Under "Note", change R 163–39 to 163–48.

Under Art. 8. Methods of Test, under Para. (d), substitute the following:

(d) The percentage of soft particles shall be determined in accordance with the current ASTM Specification, designation C 235.

Page 2–4

Standard Method of Test for Quality of Soft Pebbles in Gravel

Withdraw the present material under this heading and substitute:

Refer to ASTM, method C 235–49T.

Page 2–11

SPECIFICATIONS FOR PIT-RUN GRAVEL BALLAST

Reapprove without change.

Page 2–15

CINDER BALLAST

Drop the heading and include the material thereunder as a part of "Types of Ballast", changing "Choice of Ballast" to "Types of Ballast."

Page 2–15

SHRINKAGE ALLOWANCE

Reapprove without change.

Page 2–15

CLEANING FOUL BALLAST

Reapprove without change.

Pages 2–16.1 to 2–22, incl.

BALLAST SECTIONS FOR SINGLE AND MULTIPLE TRACK ON TANGENT AND CURVES

Reapprove without change.

Report on Assignment 2

Physical Properties of Earth Materials

(a) Roadbed. Load Capacity. Relation to Ballast. Allowable Pressures

(b) Structural foundation beds, collaborating with committees 6 and 8

R. R. Manion (chairman, subcommittee), J. P. Datesman, J. G. Gilley, L. H. Jentoft, J. W. Poulter, R. J. Scott.

Your committee reports this year on both of its assignments. One report, designated Part 1, comes under Assignment (a) only. It is the 1953 report on the results of the soil pressure cell installation under railroad tracks, prepared with the assistance of the Engineering Division research staff, AAR, under the direction of G. M. Magee, director of engineering research, and Rockwell Smith, research engineer roadway.

Part 2 relates to both Assignments (a) and (b) and consists of additions to the report on Physical Properties of Earth Materials, which was submitted last year as information and which is now offered for adoption and inclusion in the Manual in the report on Assignment 1. This additional material was prepared with the assistance of the Engineering Division research staff.

A first draft of specifications for soil test borings has been prepared in collaboration with Committee 8. These specifications will be discussed and presented as information in the 1954 report of Committee 1, with the expectation that they will be proposed as Manual material in 1955.

Part 1

(a) Roadbed. Load Capacity. Relation to Ballast. Allowable Pressure

Fifth Progress Report on Soil Pressure Cells—1953

Synopsis

This is the fifth progress report on the measurement and study of soil pressures under normal rail traffic by means of soil pressure cells. The test installation, which consists of 12 cells, is described in detail in the "Third Progress Report on Soil Pressure Cells", which can be found in the Proceedings, Vol. 52, 1951, page 482. The pressure cells were installed on July 7, 1950. Readings were taken that year for 42 runs, 20 before grouting and 22 after grouting. In 1951 readings were taken for 27 runs, and in 1952 for 31 additional runs.

The present report includes an analysis of the data obtained in 1950, 1951, and 1952, and a comparison of the 1952 results with those of 1950 and 1951. In previous reports comparisons have been made between theoretical pressures and shears and recorded pressures and shears, and the apparent effect of pressure grouting on recorded pressures has been noted.

The pressure cells all functioned well in 1950, but at the time of the 1951 readings pressure cell 7, for measuring horizontal pressures on vertical planes 4 ft to the left of the track center line, and pressure cell 12, for measuring vertical pressures on horizontal planes 8 ft to the left of the center line, were out of order and consequently did not register. The reason for failure was thought to be somewhere in the electrical circuits, but cannot be definitely ascertained until the cells are removed from the ground.

Introduction

This is the fifth progress report on the measurement of subgrade soil pressures from rail traffic by means of pressure cells. The work was conducted with committee sponsorship under the general direction of G. M. Magee, director of engineering research of the Engineering Division, AAR, and under the guidance of Rockwell Smith, research engineer roadway, AAR, by G. L. Hinueber, assistant research engineer roadway, and M. F. Smucker, assistant electrical engineer, both members of the AAR Engineering Division research staff. The test installation is described in detail in the Proceedings, Vol. 52, 1951, page 485.

The pressure cell provides a means of determining directly the stress distribution within the earth structure which constitutes the roadbed subgrade of a railroad. This function is important because it furnishes a check on the theories of stress distribution. These theories require certain general assumptions as to the conditions which prevail in a soil mass. The actual conditions found in nature generally will vary from the assumed conditions to a greater or lesser degree, and the extent of errors introduced by these variations is usually unknown.

The data for this year's report were obtained between June 8 and June 17, 1952. Records were taken for 42 runs, 31 of which were usable.

As mentioned previously, pressure cell 7 and pressure cell 12 failed in 1951, and consequently did not register on either the 1951 or 1952 records. It has been the practice in previous reports to use average values from two cells for all pressures at the 4-ft off track center line and 8-ft off-center line positions since the pressure cell clusters at these positions, both to the left and to the right of the center line of the track, are duplicates. However, pressure cells 7 and 12 are not in working order, hence the values for horizontal pressures on vertical planes 4 ft off the track center line and vertical pressures on horizontal planes 8 ft off center line for 1951 and 1952 runs are of necessity not average values, but only the readings of single cells.

Discussion

As in previous reports, the theoretical pressures were determined from Newmark charts (Influence Charts for the Computation of Stresses in Elastic Foundations, Nathan M. Newmark, Bulletin Series 338, University of Illinois Engineering Experiment Station) for the tie loads involved. The theoretical and recorded vertical pressures were integrated graphically for the 16-ft width of the pressure cell installation, thus obtaining the average values of the equivalent vertical pressure. Curves of equivalent vertical pressure vs tie loads on five ties for theoretical pressures and recorded pressures for 1950 runs before and after grouting, 1951 runs, and 1952 runs, are shown in Fig. 1. The curve for 1952 runs appears as a dotted line. It can be seen that the 1951 and 1952 curves are in close agreement, the reduction of pressure brought about by grouting still being evident, although not as great as immediately after treatment in 1950.

Curves of lateral horizontal pressure vs tie loads on five ties for theoretical pressures and for recorded pressures for 1950, 1951, and 1952 runs are shown in Fig. 2. The 1952 curve appears as a dotted line. The 1951 and 1952 curves for recorded lateral horizontal pressures 8 ft off the track center line are almost identical, the decrease in pressure after grouting still being in evidence, although not to quite the extent as immediately after treatment.

The 1952 curve for lateral horizontal pressures 4 ft off the center line shows a decrease in pressures for corresponding tie loads over the corresponding curve for 1951. This brings the curve for recorded pressures somewhat closer to the theoretical curve. However, it must be kept in mind that the pressure cell recording horizontal pressures on vertical planes 4 ft to the left of the track center line was not in working order. The plotted values are, therefore, not an average of two cells, but rather representative of only one cell. Furthermore, in the 1952 runs the tie plates on the right hand side of the ties generally took a lesser portion of the load than did those on the left hand side, probably due to uneven tamping of the ties. Consequently, the pressure cells to the right of the track center line took a smaller portion of the total load than those on the left. This would offer a reasonable explanation for the decrease in recorded horizontal pressures for corresponding tie loads 4 ft off the center line of the track in 1952.

Fig. 3 shows curves of longitudinal horizontal pressure vs tie loads on five ties for 1950, 1951 and 1952 runs. The 1952 curve, which appears as a dotted line, indicates a slight decrease in pressure for corresponding tie loads from 1951 results. The deviation between theoretical and recorded pressure is still in evidence.

Figs. 4, 5, 6 and 7 show the distribution of vertical pressure over the 16-ft wide pressure cell installation for individual runs. Recorded pressures are indicated by solid lines and theoretical by broken lines. The pressure distribution for the 1952 runs is very similar to that of the 1951 runs. Close agreement exists for the most part between theoretical and recorded vertical pressures. The recorded vertical pressures at the position 8 ft to the left of the track center line are omitted for both the 1951 and 1952 runs because of the failure of the pressure cell recording vertical pressures at this position.

Figs. 8, 9, 10 and 11 show the distribution of lateral horizontal pressures over the 16-ft wide pressure cell installation for individual runs. The curves for 1952 runs are very similar to the 1951 curves. Because the pressure cell recording lateral horizontal pressures 4 ft to the left of the track center line was not functioning, the reading of the pressure cell located 4 ft to the right of the center line for measuring horizontal pressure on vertical planes was used in plotting the recorded pressure for both positions. Since there is no cell for recording lateral horizontal pressure on the center line, a straight line was used to connect the readings 4 ft to the left and 4 ft to the right of the center line.

Fig. 12 shows curves of theoretical and recorded maximum shears vs tie loads on five ties for 1950, 1951, and 1952 runs. Readings from the clusters of 3 cells 4 ft to the right and 4 ft to the left of the track center line supplied sufficient information from which the maximum shears at these positions could be computed. Theoretical maximum shear values 8 ft off the track center line are considerably less than theoretical maximum shears 4 ft off the center line. The pressure cell clusters 8 ft to the left and right of the track center line are not complete enough to permit the calculation of shears from pressure cell readings at these positions. Theoretical maximum shears were computed using the elastic theory with a Poisson's ratio of 0.5. The 1951 and 1952 results were again quite similar. A wide variation between theoretical maximum shears and shears computed from pressure cell readings still exists.

Summary of Conclusions

The results of the 1952 readings are in very close accord with the 1951 results. Recorded vertical pressures are in fairly close agreement with theoretical vertical pressures, but considerable divergence exists between theoretical maximum shear values and recorded maximum shear values.

From a complete analysis of all the data on this pressure cell installation it appears that the elastic theory can be used satisfactorily for computing vertical stresses. It would appear, however, that the elastic theory does not give sufficient accuracy for predicting lateral pressure intensities and shearing stresses in earth masses.

The 1952 readings give additional evidence that steam powered locomotives produce higher pressure intensities than diesel locomotives produce, and that the pressure increase is in greater proportion than the corresponding increase in axle loads. As further evidence of the above, reports have been received that some troublesome sections of roadbed have shown appreciable improvement when diesel power was substituted for steam.

Grout stabilization decreases the subgrade pressure intensities somewhat, but this effect seems to be most pronounced immediately after treatment. The amount of decrease is relatively small and does not appear to explain the excellent results attributed to pressure grouting. Other hypotheses, such as increase of internal friction along potential sliding planes, sealing of shrinkage cracks, waterproofing action, and increase of density, would seem to be of greater consequence.

Apparently the pressure cells are registering pressures and variation in pressure faithfully, showing impact and vibratory effects of traffic in detail.

This will be the last report on this particular pressure cell installation. Another more extensive and more complete installation is proposed for the near future.

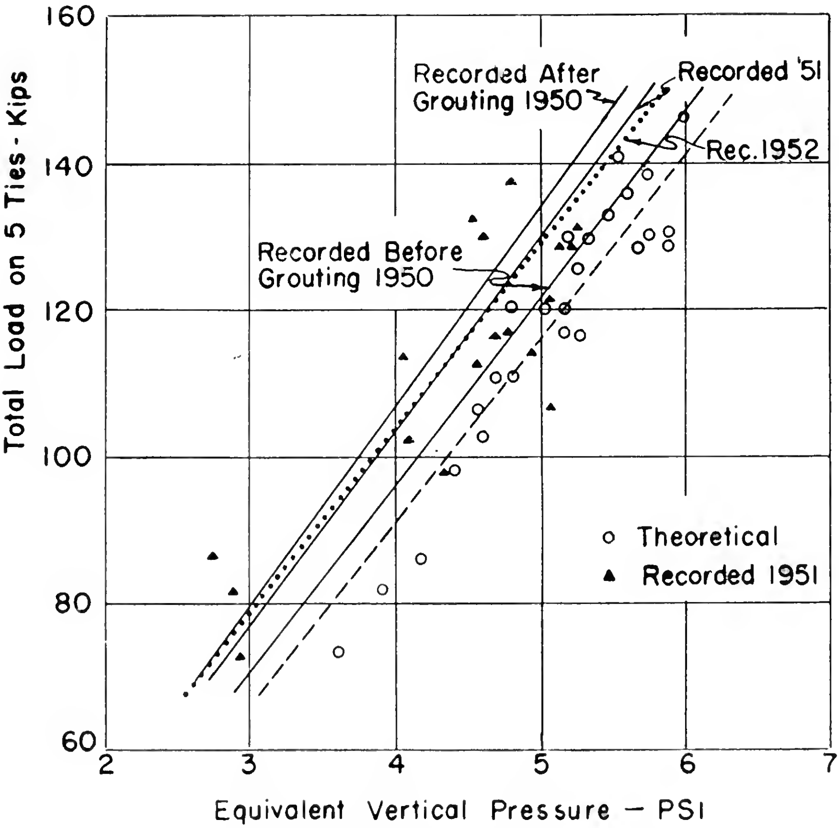


FIG. 1 — RELATIONSHIP OF VERTICAL PRESSURE TO LOAD

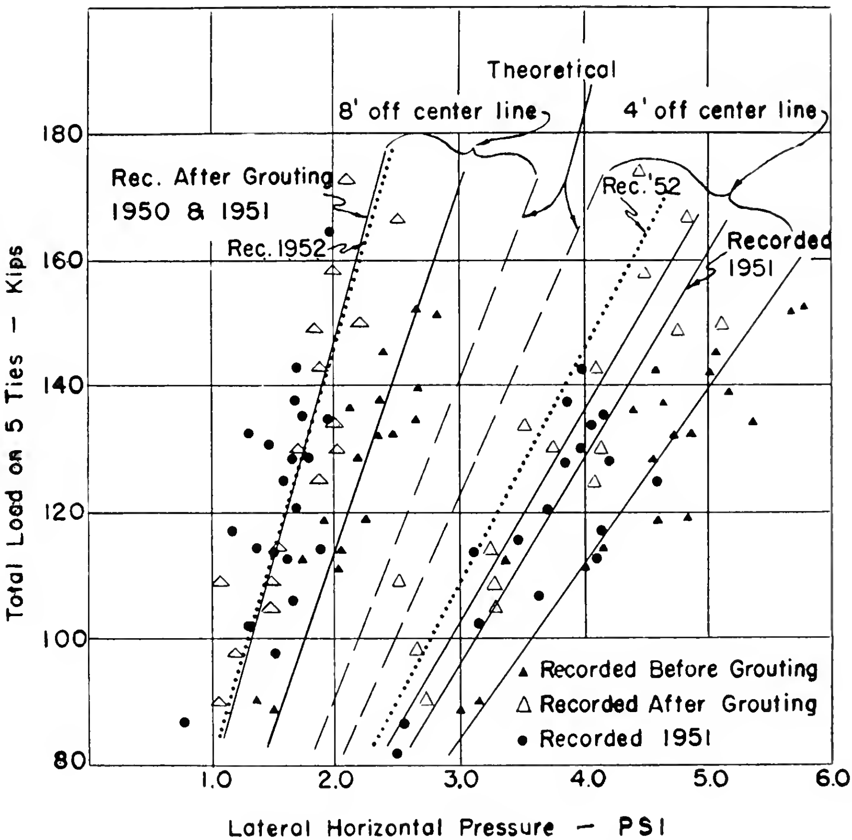


FIG.2 - RELATIONSHIP OF LATERAL HORIZONTAL PRESSURE TO LOAD

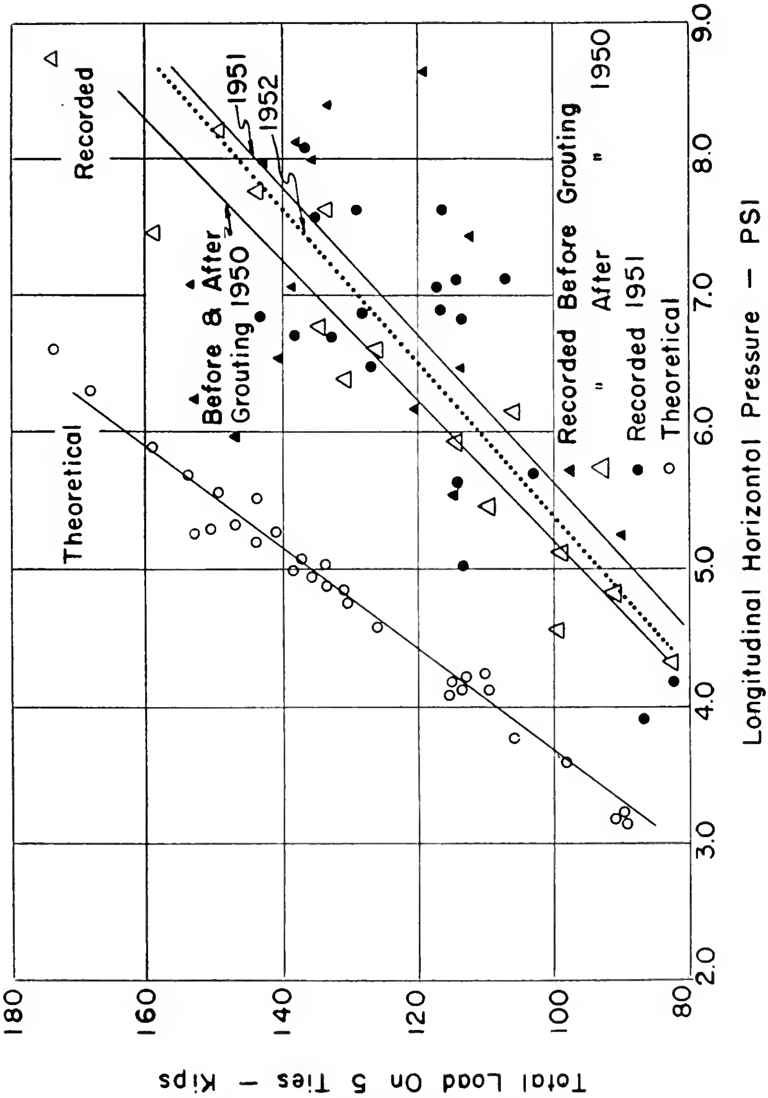


FIG.3 - RELATIONSHIP OF LONGITUDINAL HORIZONTAL PRESSURE TO LOAD

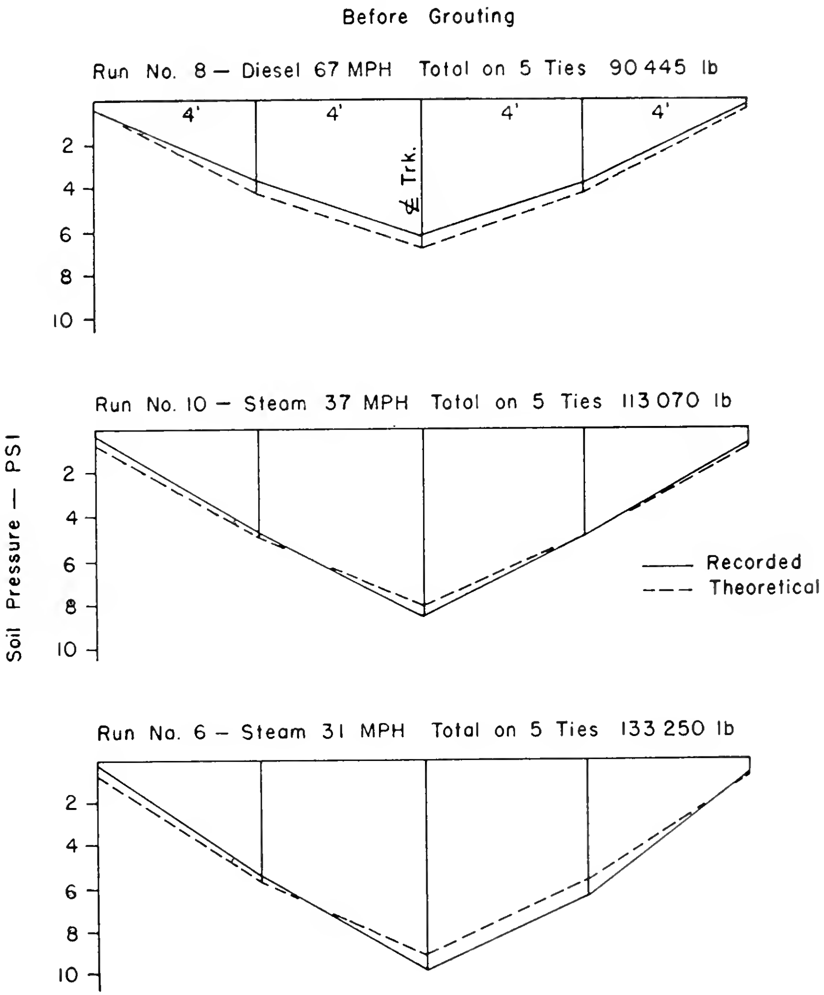


FIG. 4 - VERTICAL PRESSURE DISTRIBUTION AT SECTION THRU PRESSURE CELLS

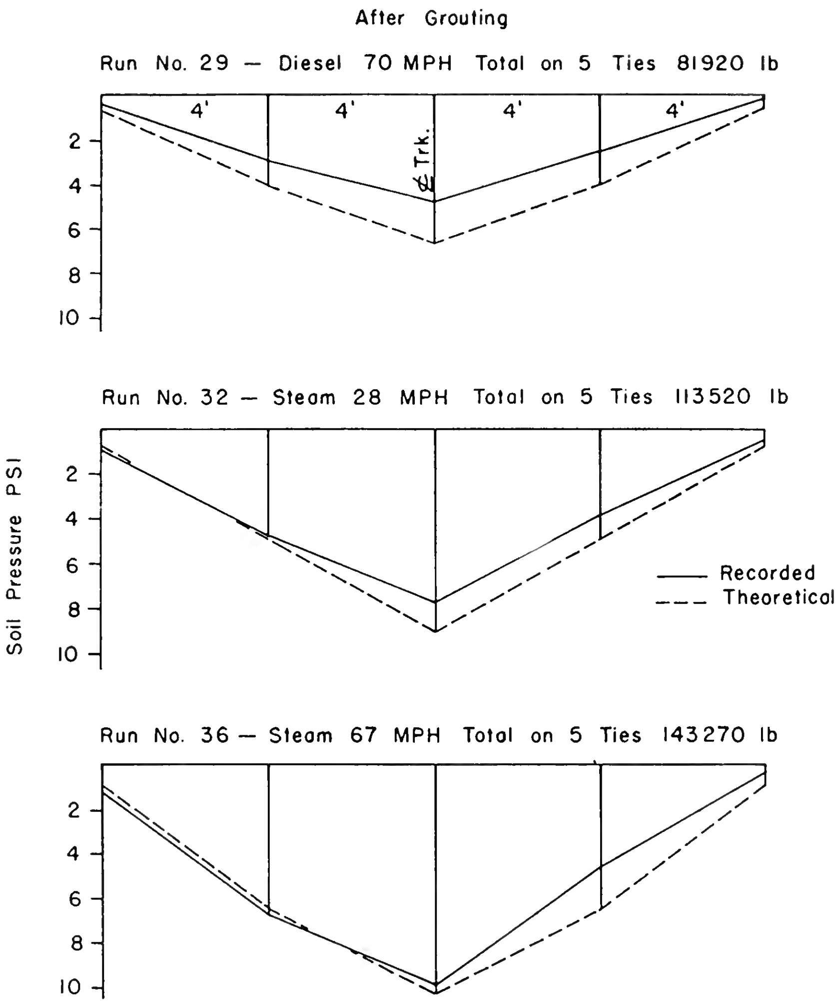


FIG. 5 - VERTICAL PRESSURE DISTRIBUTION AT SECTION THRU PRESSURE CELLS

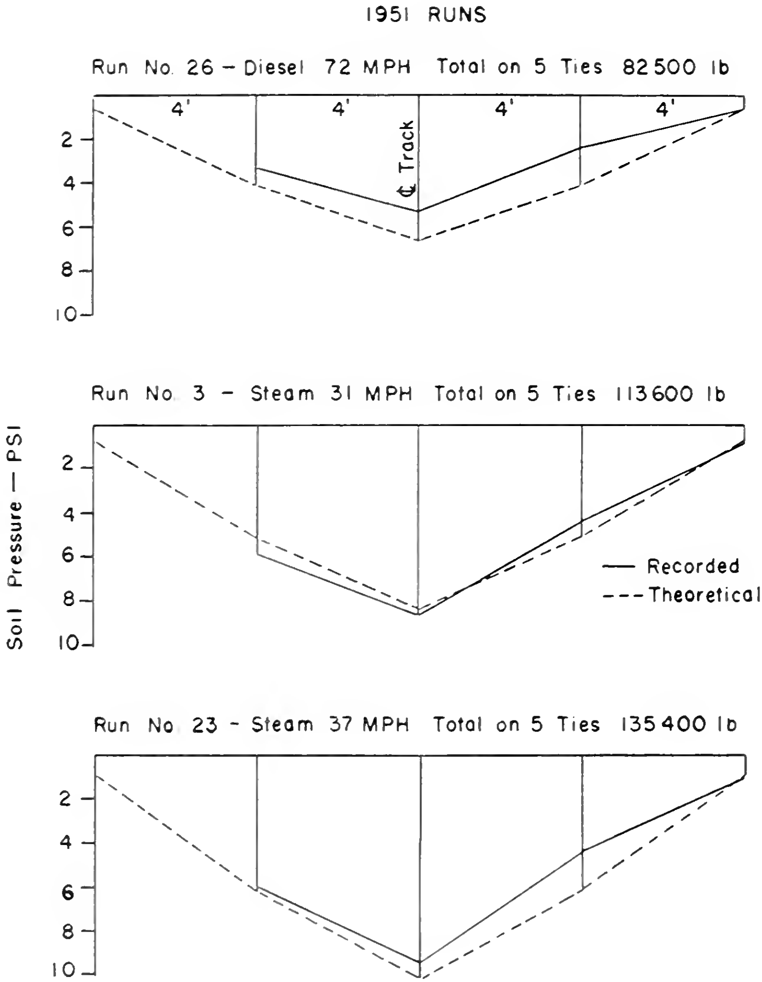


FIG. 6 - VERTICAL PRESSURE DISTRIBUTION AT SECTION THRU PRESSURE CELLS

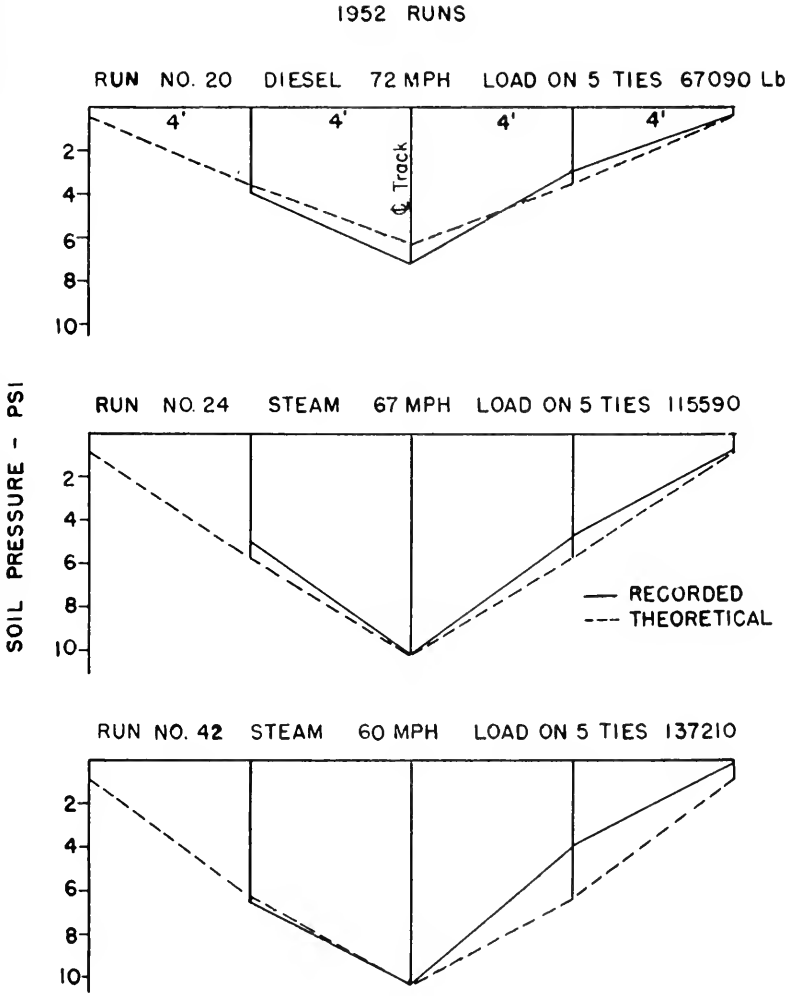


FIG. 7 - VERTICAL PRESSURE DISTRIBUTION AT SECTION THRU PRESSURE CELLS

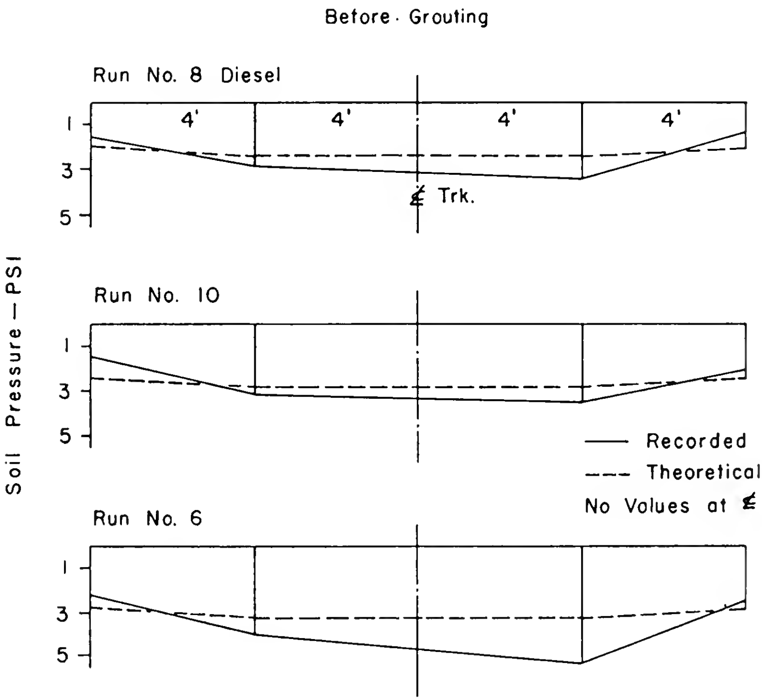


FIG. 8 – LATERAL HORIZONTAL PRESSURE DISTRIBUTION AT PRESSURE CELLS

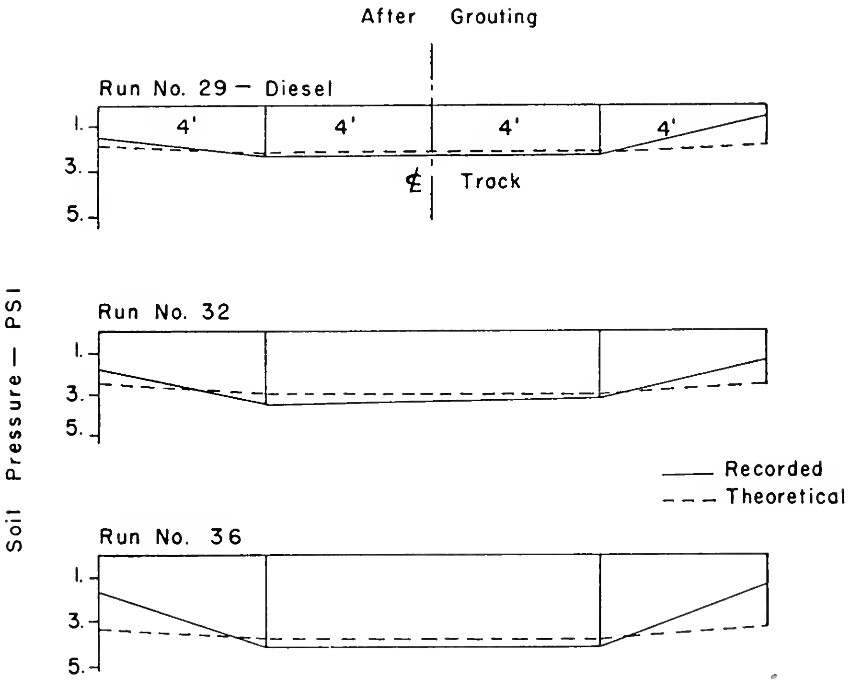


FIG. 9 - LATERAL HORIZONTAL PRESSURE DISTRIBUTION AT PRESSURE CELLS

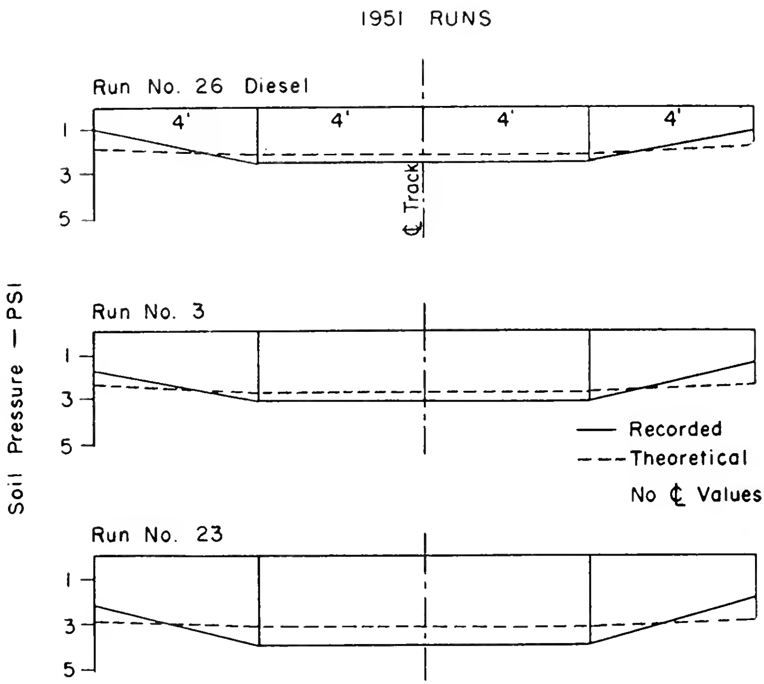


FIG. 10 - LATERAL HORIZONTAL PRESSURE DISTRIBUTION AT PRESSURE CELLS

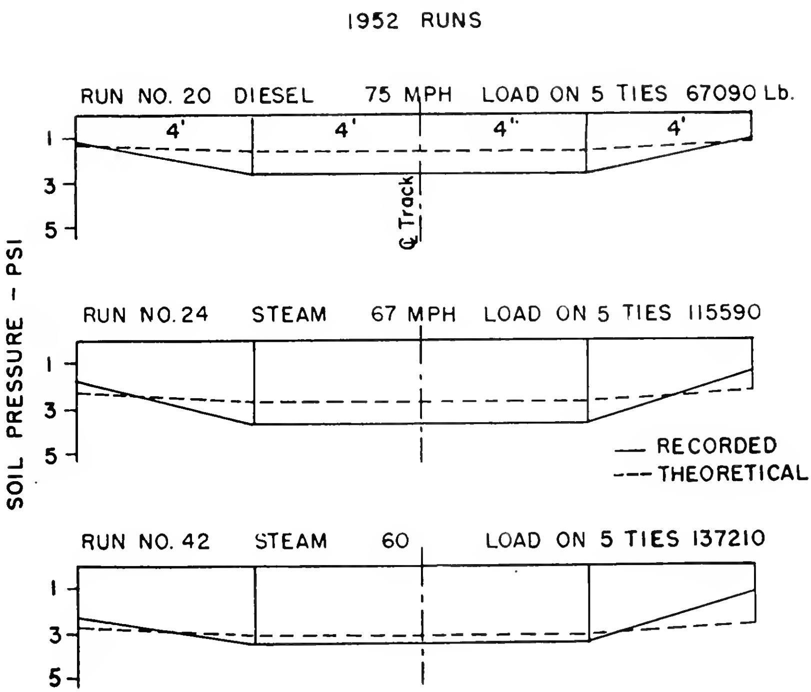


FIG. 11 - LATERAL HORIZONTAL PRESSURE DISTRIBUTION AT PRESSURE CELLS

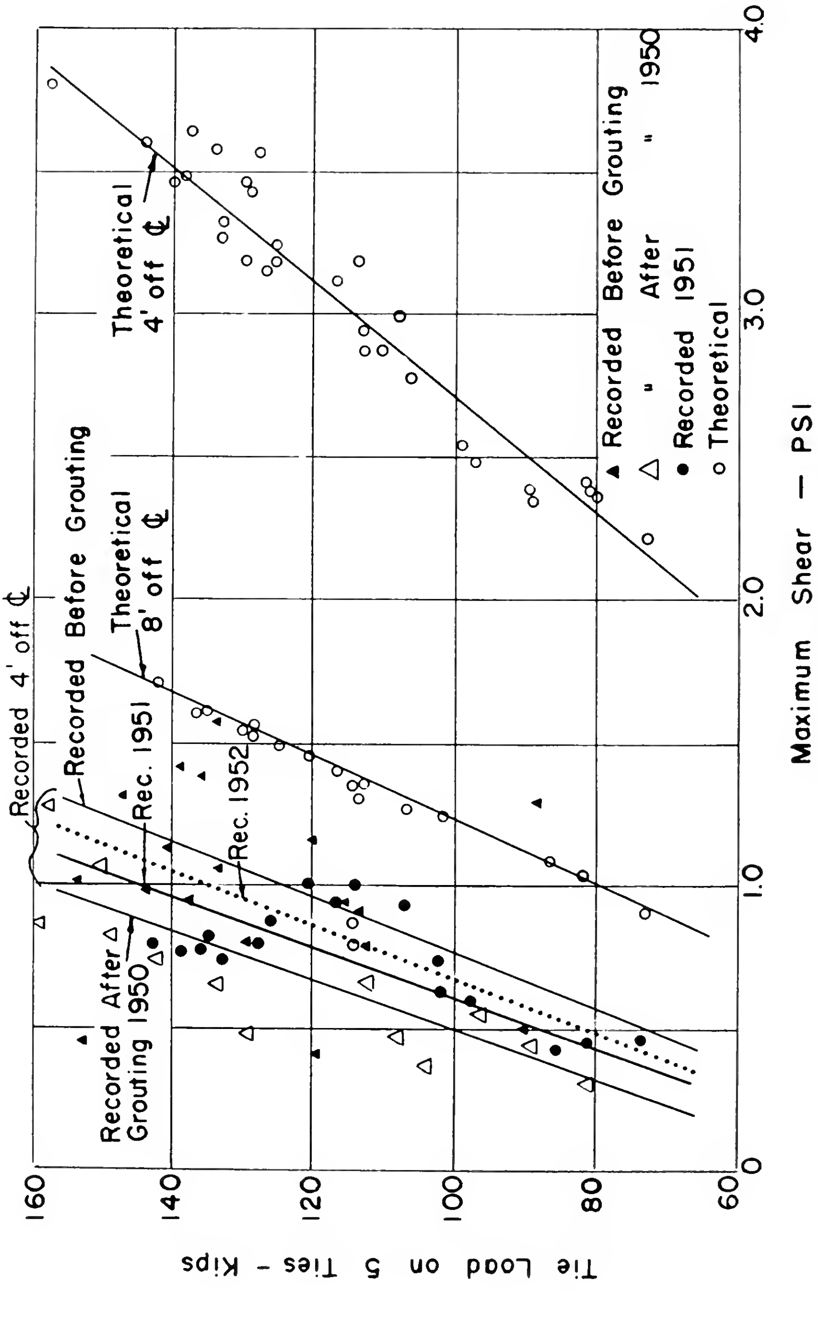


FIG. 12 - RELATIONSHIP OF MAXIMUM SHEAR TO LOAD

Part 2

Report on Assignments 2 (a) and 2 (b)

Physical Properties of Earth Materials

It is recommended that the following material be adopted for publication in the Manual, to be inserted after the first sentence, fourth paragraph under Sec. D. Exploration and Tests, of the material in the Proceedings, Vol. 53, 1952, page 715, which material is offered for publication in the Manual in the recommendations of the committee under Assignment 1. The second sentence of the fourth paragraph under Sec. D will follow as a separate paragraph.

Addition to Manual Recommendations with Respect to Physical Properties of Earth Materials

The character of a roadbed or foundation soil can be determined by means of test pits, wash borings, auger borings, or core borings of a type and extent consistent with the magnitude of the project.

Test pits are the best means of exploration where conditions are favorable for excavation, since they permit careful examination of the exact soil profile and make it possible to obtain larger and usually less disturbed soil samples. Soil exploration by means of test pits is usually carried to shallow depths of only 10 to 20 ft, and excavation is usually by hand. This type of exploration is generally considerably more expensive than other methods of subsurface exploration.

The cheapest and most adaptable methods of exploration are wash borings and auger borings.

Wash borings can be used in all common soils which do not contain numerous stones or boulders, but are not a suitable method for boring in hard or cemented soils or rock. Caution should be used in interpreting the results of wash borings unless suitable samples of the soil are obtained from the hole for each 5 ft of depth and at changes in strata as indicated by changes in appearance of the mixture of wash water and soil.

Shallow borings for railroad work may be performed with a hand-operated screw-type auger. Most soils above the water table, with the exception of clean dry sand, will permit borings to the depth of 20 ft or more without casing to support the walls of the hole. In order to obtain reliable information in sand strata it is necessary to test all parts of practically continuous cores. Because of the difficulty of extracting cohesionless soils in a relatively undisturbed state, it is preferable to determine the properties of these soils by a field test, such as the standard penetration test.

Auger borings generally give a better indication of the character of soil and limits of strata than do wash borings.

The machine-driven helical auger furnishes a rapid method of exploratory boring, but this method has several disadvantages. The helical auger brings up soil from the bottom of the hole and deposits it on the surfaces, and there is a tendency for the soil to get mixed with soils of other strata on its way to the surface. Consequently the soil discharged by the auger is not always truly representative of the strata from which it came. Then, too, it is difficult to determine the exact depth from which the soil discharged by the auger was excavated. The auger may be withdrawn and a sample taken at any point during the operation, however.

Report on Assignment 4

Culverts

(a) Conditions Requiring Head Walls, Wing Walls, Inverts and Aprons and Requisites Therefore

(b) Specifications for High-Pressure Gas Lines

G. B. Harris (chairman, subcommittee), W. T. Adams, T. F. de Capiteau, J. W. Purdy, C. S. Robinson, A. W. Schroeder, W. C. Swartout, A. A. Winter, W. L. Young.

This year your committee makes report on its assignment (b) only.

This report contains a Tentative Specification for Pipe Line Crossings Under Railway Tracks, for Inflammable Substances, which is presented as information for the purpose of soliciting comments and criticism prior to submission in 1954 for adoption and inclusion in the manual in place of the current specification. It is proposed to retain the present specifications in the Manual for non-inflammable substances as section "B" of these specifications.

SPECIFICATION FOR PIPE LINE CROSSINGS UNDER RAILWAY TRACKS

A. FOR INFLAMMABLE SUBSTANCES

1. Scope

Pipe lines included under these specifications are those installed to carry oil, gas, gasoline or other inflammable or highly volatile substances, under pressure.

2. Installation

Pipe lines under railway tracks and across railway right-of-way shall be encased in a larger pipe or conduit called the casing pipe in accordance with these specifications and as indicated in Fig. 1.

Pipe lines shall be installed under tracks by boring or jacking if practicable.

Any replacement of a carrier pipe or a casing pipe shall be considered a new installation, subject to the requirements of these specifications.

3. Carrier Pipe

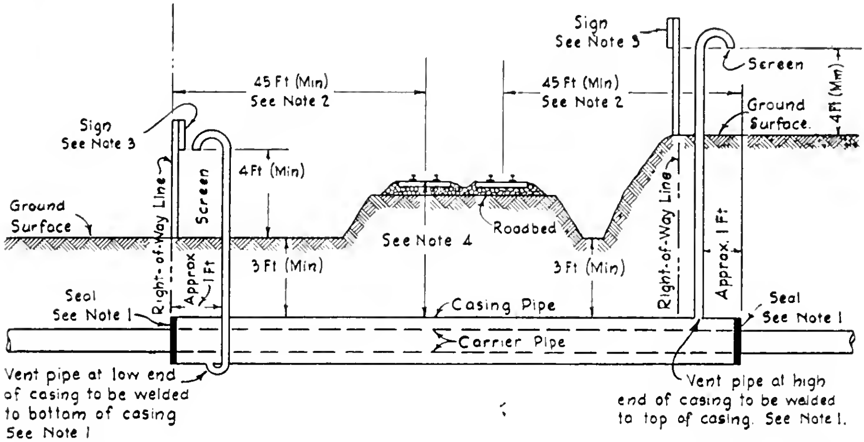
Carrier pipe line inside of casing shall conform to the requirements of ASA B31.1—1951 Code for Pressure Piping, except as revised below.

Gas lines shall be designed in accordance with Section 2, Division 1, and crude oil and liquid petroleum products lines in accordance with Section 3, Division A, except that the allowable working stresses for design shall be not more than 90 percent of those permitted by the ASA Code.

Pipe shall be laid with slack (no tension) in the line, or with expansion joint near point of railroad crossing.

4. Casing Pipe

Casing pipe and joints shall be of metal, and of a rigid, leakproof construction capable of withstanding railway loading.



NOTE: 1. Seal and vent pipe not required if casing ends above ground where drainage is available.
2. Casing pipe shall extend beyond limit of railway right-of-way if necessary to provide a minimum distance of 45 ft measured at right angles from center line of the outside track. For crossings carrying pressures of 200 psi or over the casing shall extend to the railway right-of-way line if this distance exceeds 45 ft.
3. Signs to indicate location of pipe line at right-of-way line are required for crossings carrying pressures of 200 psi or over. For crossings carrying pressures less than 200 psi signs are optional with the railway.
4. Depth from base of rail to top of casing at its closest point shall not be less than 5 ft 6 in for crossings carrying pressures of 200 psi or over and shall not be less than 4 ft 6 in for crossings carrying pressures less than 200 psi.

Fig. 1.

WALL THICKNESS FOR STEEL* CASING PIPE FOR E72 LOADING (INCLUDING IMPACT)

Minimum Thickness Inches	*Diameter of Pipe Inches*
1/4	6, 8, 10, 12, 14, 16
5/16	18 and 20
3/8	22 and 24
7/16	26 and 28
1/2	30, 32 and 34
9/16	36 and 38
5/8	40 and 42

Class 150 cast iron pipe may be used for 12 in and under. Over 12 in, Class 250 shall be used.

***Thickness is for pipe made of steel having a minimum yield strength of 35,000 psi. Adjust thickness as necessary for other grades of pipe, except that thickness of pipe shall not be less than 1/4 in.**

The inside diameter of the casing pipe shall be great enough to allow the carrier pipe to be subsequently removed without disturbing the casing pipe or roadbed, but shall be not less than 2 in greater than the largest outside diameter of the carrier pipe, joints or couplings, including coating.

All supports or centering devices for the carrier pipe shall be so designed and constructed that no loads from the roadbed, track, traffic or casing pipe itself are transmitted to the carrier pipe.

Casing pipe shall be so constructed as to prevent leakage of any matter from the casing or conduit throughout its length under track and railway right-of-way, except at ends of casing or conduit where ends are left open, or through vent pipes when ends are sealed to outside of carrier pipe. Casing shall be so installed as to prevent the formation of a waterway under the railway and with an even bearing throughout its length, and shall slope to one end.

5. Protection Against Corrosion

Both casing pipe and carrier pipe within the casing shall receive externally the same protective coating which is applied to the carrier pipe adjacent to the crossing, except that in no case shall the protective coating be less than a coal-tar primer coat, followed by a single application of hot coal-tar enamel 3/32 in thick $\pm \frac{1}{32}$ in, plus a bonded 15-lb asbestos felt wrap, or the coating shall be an approved equal of this combination protective coating.

Before installation, electrical detection methods shall be used to locate flaws or breaks in the coating. All damaged or broken coatings shall be repaired or replaced. Installation shall be made in such manner that the protective coating is undamaged.

If adjacent carrier pipe is cathodically protected, the casing shall also be cathodically protected.

6. Seals

Where ends of casing are below ground they shall be suitably sealed to outside of carrier pipe and properly vented above ground with vent pipes of sufficient diameter to permit free evaporation of water or moisture, but in no case shall they be less than 2 in. in diameter. Vent pipe shall, at low end of casing, be welded to the bottom of the casing and at the high end be welded to the top of the casing. Vent pipe shall extend not less than 4 ft above ground surface, with the top turned down and elbow properly screened.

Where ends of casing are at or above ground surface and above high water level they may be left open, provided drainage is afforded in such manner that leakage will be conducted away from railway tracks or structure. Where proper drainage is not provided, the ends of the casing shall be sealed.

7. Depth of Casing

Where practicable, the depth from base of railway rail to top of casing at its closest point shall not be less than 5½ ft for pipe lines carrying pressures of 200 psi or over, and shall not be less than 4½ ft for pipe lines carrying pressures less than 200 psi. On other portions of railway right-of-way where casing is not directly beneath any track, the depth from surface of right-of-way and from bottom of ditches to top of casing, shall not be less than 3 ft. Where it is not practicable to secure the above depths, special construction shall be used.

8. Length of Casing

Casing shall extend to a minimum distance of 45 ft each side from (measured at right angles to) center line of outside track. For pipe lines carrying pressures of 200 psi or over, the casing shall extend to the railway property line if this distance exceeds 45 ft. If additional tracks are constructed in the future, the casing shall be correspondingly extended.

9. Shut-Off Valves

Accessible emergency shut-off valves for pipe lines carrying pressures of 200 psi or over shall be installed within effective distances each side of the railway as mutually agreed to by the railroad company and the pipe line company. Where warranted by special local conditions, which are mutually agreed to by both companies, similar valves shall be installed for pipe lines carrying pressures of less than 200 psi.

10. Location

Pipe lines shall, where practicable, be located to cross tracks at approximately right angles thereto, and shall not be placed within a culvert nor closer than 45 ft to any portion of any railway bridge, building or other important structure which might be injured by leakage from or failure of the pipe line.

Pipe lines, casing pipe and vent pipes shall be at least 4 ft (vertically) from aerial electric wires and shall be suitably insulated from underground conduits carrying electric wires on railway right-of-way.

All crossings carrying pressures of 200 psi or over shall be prominently marked on both sides of track, at the railway right-of-way line, by signs substantially worded thus —"High Pressure Gas Main .... ft under." Crossings carrying pressures under 200 psi shall be so marked at the option of the railway company.

11. Approval of Plans

Plans for proposed crossing shall be submitted to and meet the approval of the chief engineer of the railway before installation is begun, and the execution of the work on railway right-of-way, including the supporting of track, shall be subject to his inspection and direction.

Report on Assignment 6

Roadway: Formation and Protection

(a) Roadbed Stabilization.

(b) Construction and Protection of Roadbed Across Reservoir Areas; Specifications.

B. H. Crosland (chairman, subcommittee), R. H. Beeder, W. P. Eshbaugh, R. A. Gravelle, G. B. Harris, W. T. Johnston, G. W. Payne, C. S. Robinson, C. E. Webb, W. L. Young.

Your committee makes report on only part (a) of its assignment, this report being submitted in four parts, as information.

Roadbed Stabilization

The following report consists of four parts. Part 1, recommended practice for tie and pole driving, is offered for publication in the Bulletin with the expectation that it will be presented for adoption as Manual material in 1954.

Part 2 is presented as information, and describes a number of investigations into rather extensive slides and possible corrective measures.

Part 3, also presented as information, contains a description of the provisions taken in new yard construction at two locations to increase the stability and service behavior of the track structure. It is not strictly a report on roadbed stabilization, but rather a record of preventive measures to eliminate the need of future stabilization. The committee recommends that similar studies and procedures, as needed, be adopted for all new construction. Much of the soil testing was performed by the roads. This is indicative of the increased consciousness of the value to be obtained from soil investigations.

Part 4, presented as information, is a record of pressure grouting projects, showing grout quantities, original costs and savings effected through reduced maintenance. The tabulation has been published annually for the past 5 years and is repeated with an additional year's record included. The data are strongly indicative that great benefits can be obtained through judicious stabilization.

This entire report was prepared under committee sponsorship by the research staff of the Engineering Division, AAR. The work is part of the cooperative investigation of the Engineering Division and the Engineering Experiment Station of the University of Illinois under the direction of G. M. Magee, director of engineering research, AAR, and R. B. Peck, research professor of soil mechanics of the university. Part 2 was prepared by R. B. Peck and H. O. Ireland—Parts 1, 3 and 4 by Rockwell Smith, research engineer roadway, of the research staff.

Part 1

Roadbed Stabilization

B. STABILIZATION BY POLE AND TIE DRIVING

1. General

This method of stabilization consists of driving ties or poles vertically along the track and closely adjacent to the ends of the cross ties. Lengths of 8 to 20 ft are most common. Where an 8-ft length is indicated, cull or reclaimed cross ties can be used if desired. Fig. 1.

Excellent results have been obtained economically in stabilization through this method on low fills over wet and swampy ground, and in wet cuts subject to subgrade displacement. These installations are usually for fills 6 ft or less in height. Each proposed installation should be subject to separate investigation to disclose the type and zone of instability, and to analysis to determine the length of pole required. Experience indicates that the pole or tie should penetrate undisturbed and stable material for a minimum of half its length, with a greater proportional penetration for the longer lengths. Large trackage has been driven in the Southwest, both under contract and with company forces.

2. Equipment

The driver is the only special equipment required for this work. A regular on-track pile driver may be used, but is cumbersome and expensive for use with short lengths. Crawler-type tractors equipped with leads and a drop hammer are easily capable of driving 30 poles or ties per hour, and reduce clearance time very appreciably. Similar small on-track drivers are also economical, and special equipment designed for pole lengths up to 20 ft has been developed capable of much greater production.

3. Materials

Cull and reclaimed ties are acceptable if they retain sufficient strength to stand driving. Poles should be of sound timber, unpeeled, with a minimum dip diameter of

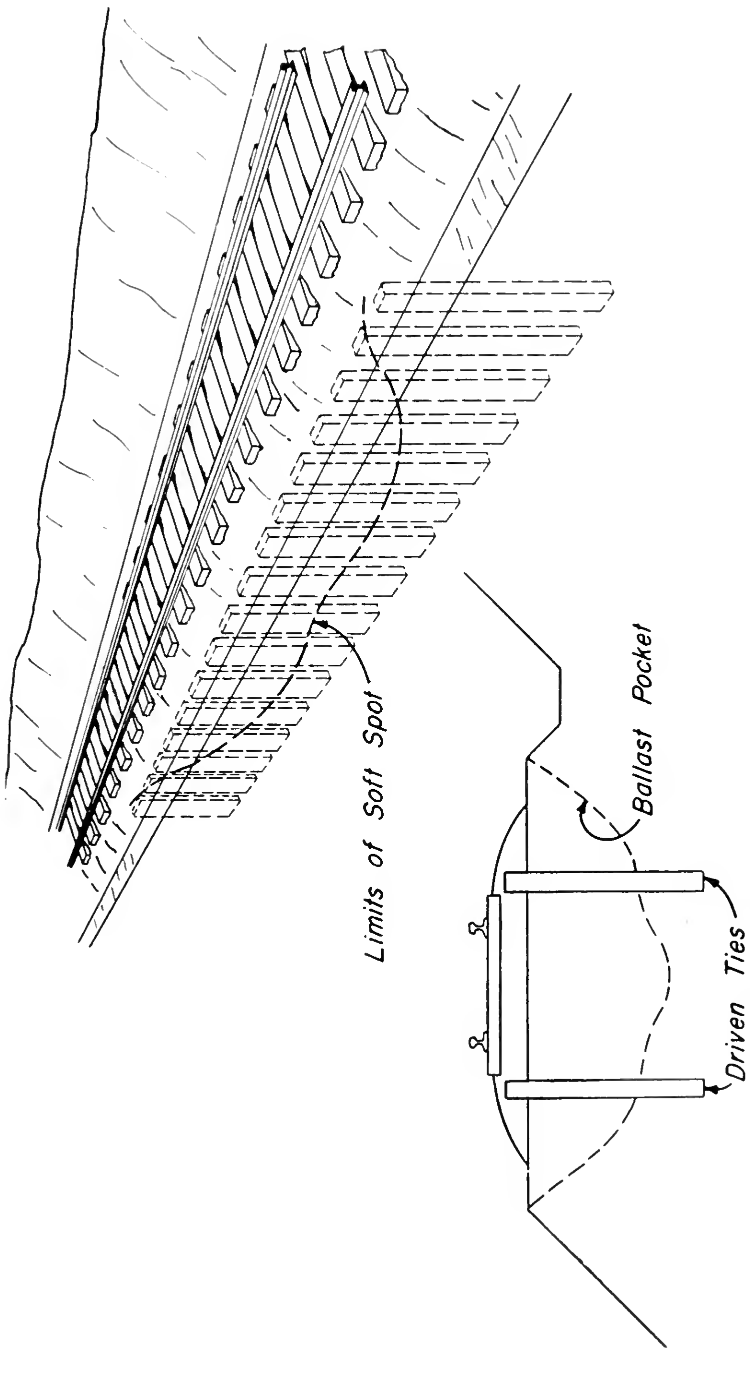


Fig. 1—Tie and pole driving, typical treatment for soft track.

6 in under the bark, cut from live trees, and with limbs and knots trimmed flush with the bark. Change in diameter is usually limited to a maximum of 4 in. Poles should be used as soon as possible after cutting.

4. Procedure

The poles and ties are driven close to the ends of the cross ties, usually within 1 ft, and often with only 4 in between the face of the pole and the end of the tie. Most installations call for one tie or pole at the end of every tie on both sides of the track, but this procedure may be varied as conditions dictate particularly in multiple-track territory. On some branch lines or secondary tracks, and for certain conditions of instability, the spacing may be doubled, or the installation made on only one side. This is not recommended for general use, even where instability is evident on one side only. The poles and ties are driven so their tops are below the bottoms of the ties, usually about 6 in. The installation should extend a minimum of 20 ft beyond the affected area. To insure this the ballast must be shoveled or bladed out prior to driving. Some surfacing may be required after installation.

Part 2

Investigation of Stability Problems

By R. B. Peck and H. O. Ireland[1]

During the course of the research program, numerous specific stability problems have been investigated. Each of these has contributed to better understanding of the nature of such problems on the railroads. Three have been selected for detailed presentation because of their unusual interest. These are (1) the Little Mistongo crossing of the Canadian National Railways, where investigation of a sliding embankment revealed the record of the remarkable failure of a fill some 45 years ago; (2) the Bismarck bridge approach of the Northern Pacific, where a detailed 60-year history of a very large slide in the river bluff was available, and where remedial measures have been carried out; and (3) the Cameo slide of the Denver & Rio Grande Western Railroad, which illustrates the factors leading to reactivation of an ancient slide area.

LITTLE MISTONGO CROSSING

The line of the Canadian National crosses the Little Mistongo River at a point about 28 miles east of Cochrane, Ont., on a deck plate girder span 102 ft long, supported by piled abutments (see Fig. 1). The west approach to this bridge is an embankment that for several years has experienced subsidences and small slides. In addition, the abutment has moved appreciably. To prevent erosion of the slopes, the small stream has been confined by means of a timber sluiceway. In 1949 consideration was given to replacing the sluiceway and girder span by a culvert and fill.

An investigation was undertaken to determine the adequacy of the subsoil to support the proposed fill. It was known that the east approach fill had failed during construction in 1909. In the belief that the details of this failure would be relevant to the current problem, its history was compiled and field studies were made. The results disclosed that the original slide had been a remarkable occurrence.

[1] Research professor of soil mechanics and research associate, respectively, University of Illinois.

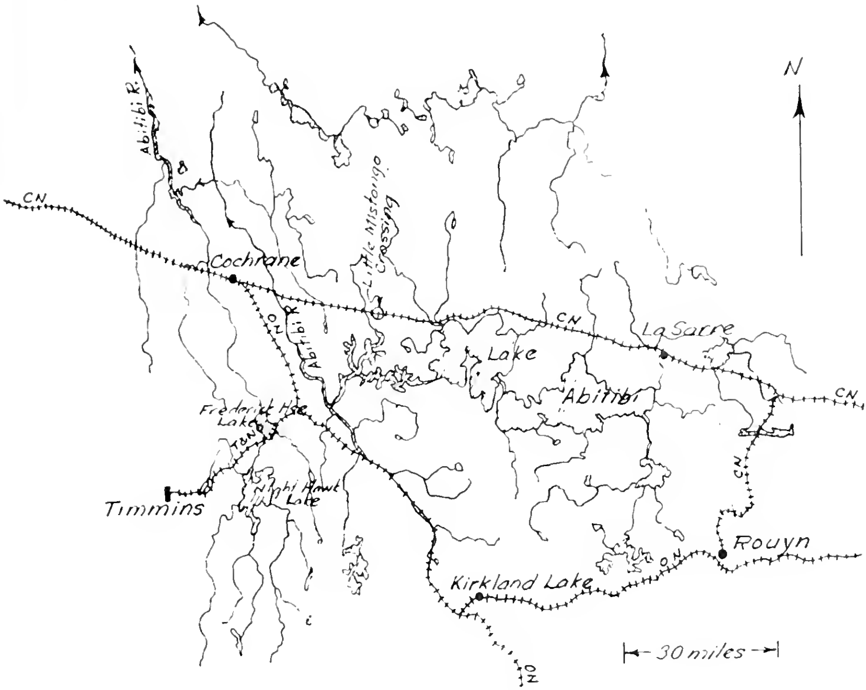


Fig. 1—Map of area.

Four successive stages in the history of the site are shown in Fig. 2. The original structure was an 8-ft concrete arch culvert founded on 43-ft piling as shown in (a). The river valley was to be filled above the culvert to a maximum height of about 50 ft from the original ground surface. When the fill was 90 percent complete, it slid to the south carrying the culvert with it. It is reported that no remnants of the fill, the temporary trestle, the culvert, or the piles on which it rested, were left at the location of the fill. After this failure a timber box culvert was installed 12 ft above the original stream bed and to the west of the original culvert, (b). The higher invert served to dam the Little Mistongo River and created a small lake north of the railroad. This culvert was destroyed by erosion in the spring of 1910. Between 1910 and 1912 a timber trestle was constructed across the river on mud sills, as shown in (c). Two 6-ft corrugated iron pipes were embedded in concrete and were located between two rows of Wakefield piling. These pipes were washed out in 1913, presumably as a result of erosion along the outside. In 1914 the deck plate girder (d) was established. A wooden sluiceway was constructed to replace the pipe culvert. The sluiceway was rebuilt in 1924 after it was damaged by erosion and minor slides.

The west abutment appears to have moved at various times since construction. By 1925 the southward movement became excessive and a considerable slump occurred in the track west of the abutment. By 1927 the abutment had settled as much as 6 in and had tilted. In 1944 the approach embankment on the west failed for a distance of 120 ft along the south side. A pile trestle was then constructed to carry the track, as shown in (d).

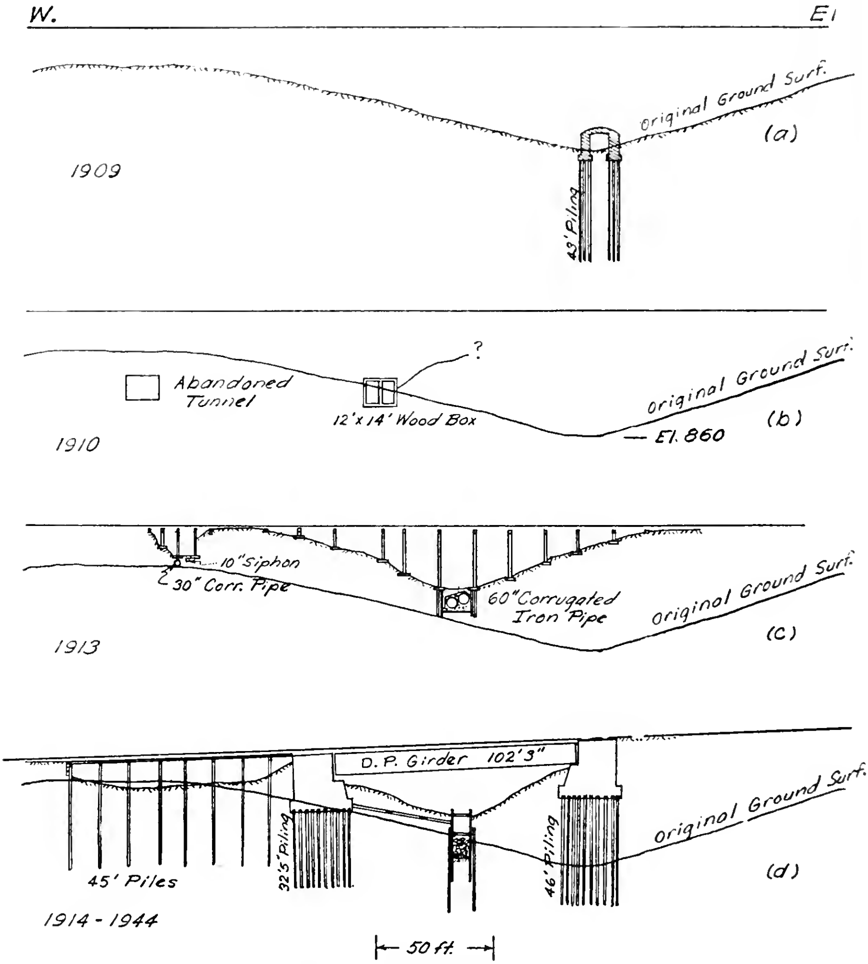


Fig. 2—Successive profiles.

The movements on the west side had the character of a base failure due to overstressing the foundation material. On the assumption that the history of the failure on the east side was similar to that on the west, and would provide pertinent information, an extensive investigation of the old failure was made. Contrary to expectation, it was found that the original failure involved a large movement of the fill itself and was not primarily a base failure.

According to the records of the company, some 250,000 cu yd of sand and gravel fill had been dumped at the Little Mistongo site up to 1944. On the other hand, the fill proper, as observed in 1949, contained no more than about 15,000 yd. A long hill was noted on the east side south of the location of the old culvert. Its surface had an extremely flat slope (about 1 vertical to 20 horizontal), as shown in Fig. 3 (a, b and c). Exploratory borings showed that the material in the shaded areas of these cross sections consisted of sand and gravel, and not of the extremely plastic clay characteristic of the natural soil of the locality. Furthermore, at distances of several hundred feet from the original center line of the track were found timbers, drift bolts, and other remains of the original construction trestle from which the fill was dumped.

The grain size of the natural clay soil in the vicinity is shown in Fig. 4. Also shown are limiting grain-size curves from the borrow pits from which the fill was originally taken, as well as the grain-size curves of two representative samples from the long ridge of material to the south of the original culvert. It may be seen that the ridge has a grain size corresponding to the borrow material and not to the natural local materials. Apparently the slide occurred in the form of a sudden rush of fill materials to the south for a distance of as much as 350 ft, and on a very flat slope. No evidence of mud waves exists at the site around the edges of the ridge. Thus, the flow must have been almost exclusively above the old land surface.

There is no record of the time of year at which the original slide occurred. However, rainfall is heavy in the locality and it appears evident that the fill must have been constructed of saturated or nearly saturated sand, which became practically fluid and flowed for very long distances. This is one of the few cases on record of an extensive flow slide in a railroad embankment.

Since the investigation disclosed that the slide on the east side of the bridge was not associated with the foundation materials, a thorough foundation investigation of the subsoil was needed to determine the stability of the foundation materials beneath the proposed fill. Subsurface information was obtained in part by means of a long test pile and by auger borings, combined with sampling and testing operations. The principal quantitative information, however, was determined by means of the vane auger.

Use of the vane auger was suggested by the fact that the subsoil was known to consist of soft plastic clays formed in a glacial lake representing a former southern extension of Hudson Bay. The test device consists of a two-bladed vane which is pushed into the ground and rotated while the torque of rotation is measured. The apparatus for jacking the vane and its casing into the ground is shown in Fig. 5, and the equipment for measuring the torque in Fig. 6. Typical stress-strain curves for the material are shown in Fig. 7. It may be noted that by means of the vane it was possible to obtain excellent stress-strain curves for the material in a completely undisturbed state without the necessity for taking samples.

The tests indicated that the average shearing resistance of the soil beneath the proposed fill was about 400 lb per sq ft. The tests also indicated that a somewhat stiffer stratum was located at elev. 890. Stability analyses were carried out in connection with the slope existing in 1949 as well as for various proposed flatter slopes. The factor of safety of the existing slope was found to be 0.82, a value indicating instability, in agreement with actual observed conditions. By flattening the slope to 2:1 from the top to Elev. 950, and by placing at Elev. 925 a berm 65 ft wide terminating with a slope of 3:1, a factor of safety of 1.1 could be attained for the proposed fill. Some of the stability analyses and the proposed slopes are indicated in Fig. 8.

The studies indicated that extremely flat slopes and wide berms would be required to replace the existing bridge by a fill. They also indicated that a large factor of safety

(Text continued on page 1125)

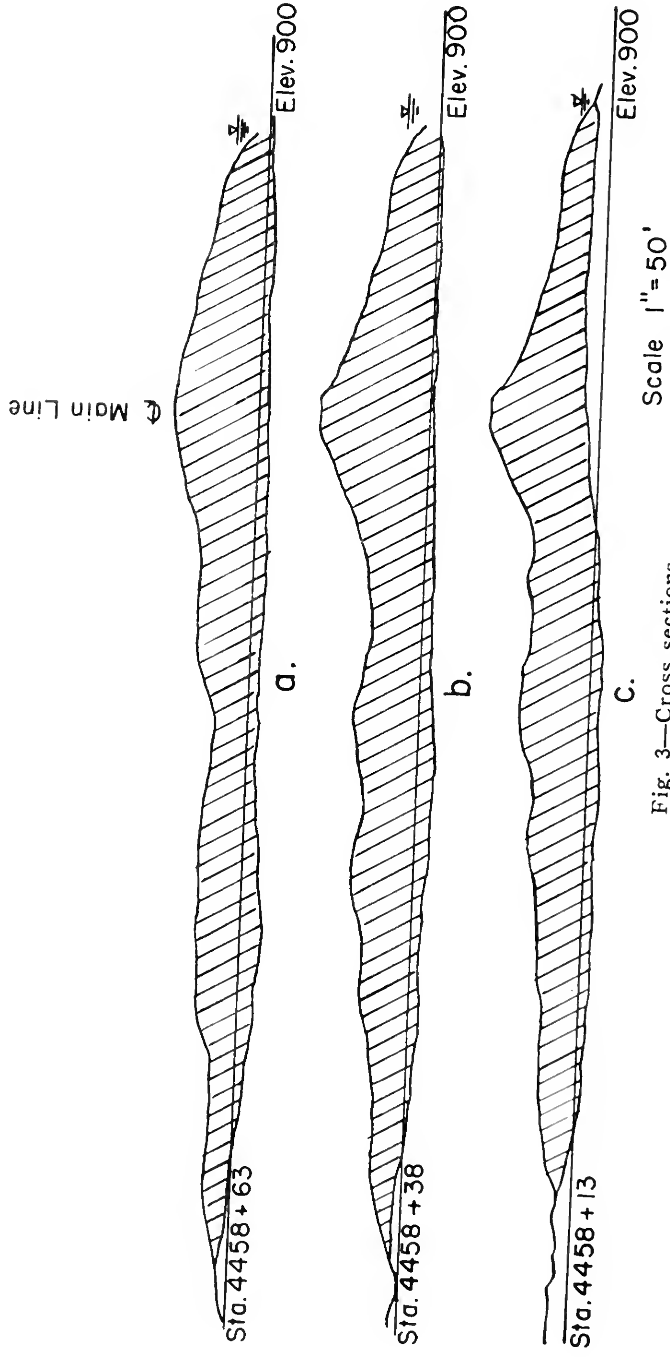


Fig. 3—Cross sections.

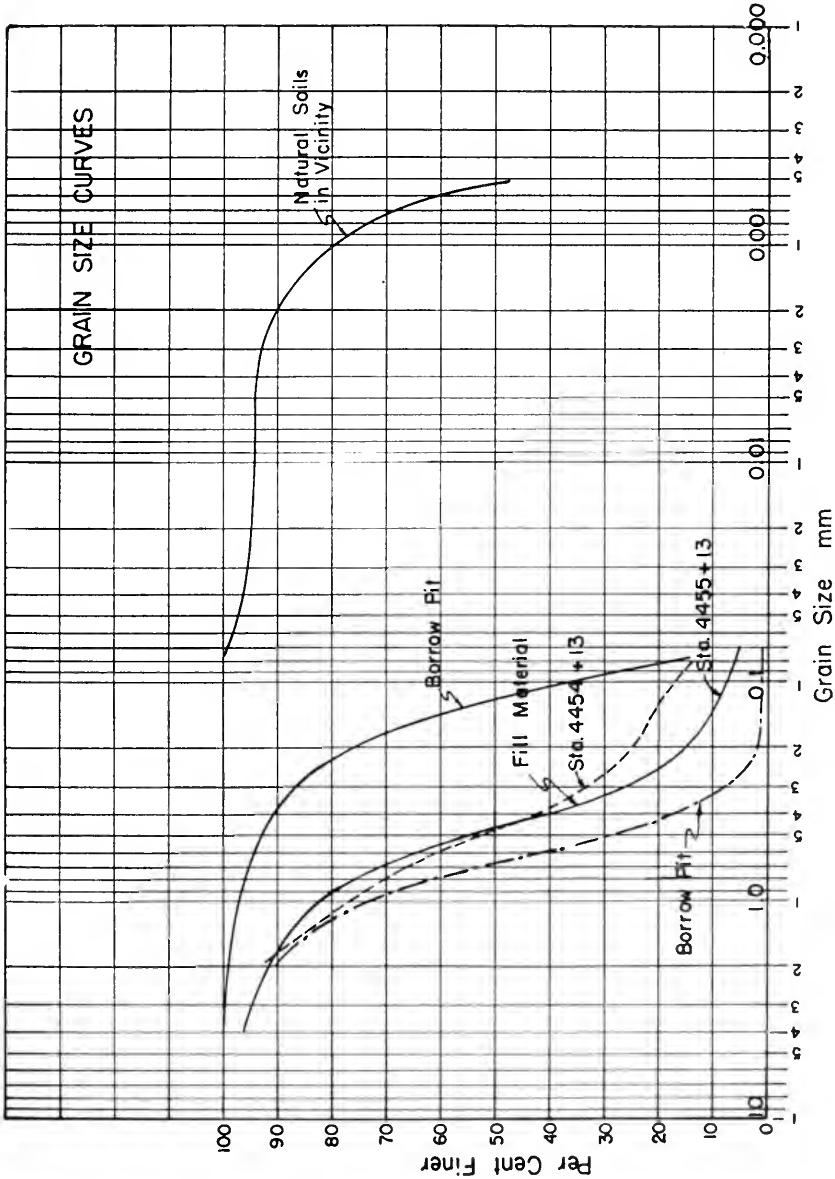

GRAIN SIZE CURVES
Natural Soils in Vicinity
Borrow Pit
Fill Material
Sta. 4454+13
Sta. 4455+13
Borrow Pit
Per Cent Finer
100
90
80
70
60
50
40
30
20
10
0
10
1.0
0.1
0.01
0.001
0.0001
Grain Size mm

Fig. 4.

Fig. 5—Jacking vane auger and its casing into the ground.

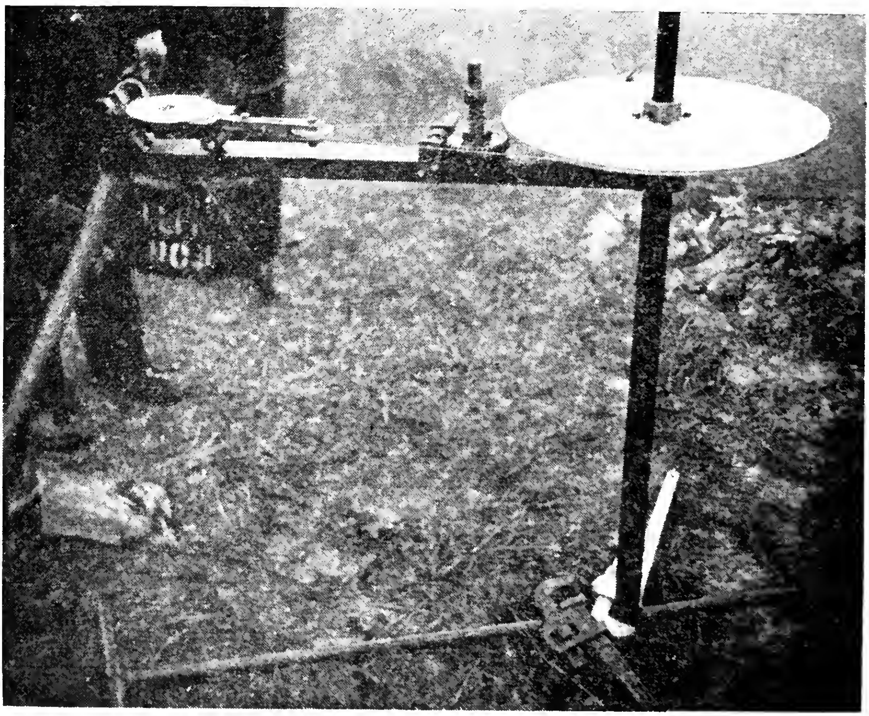
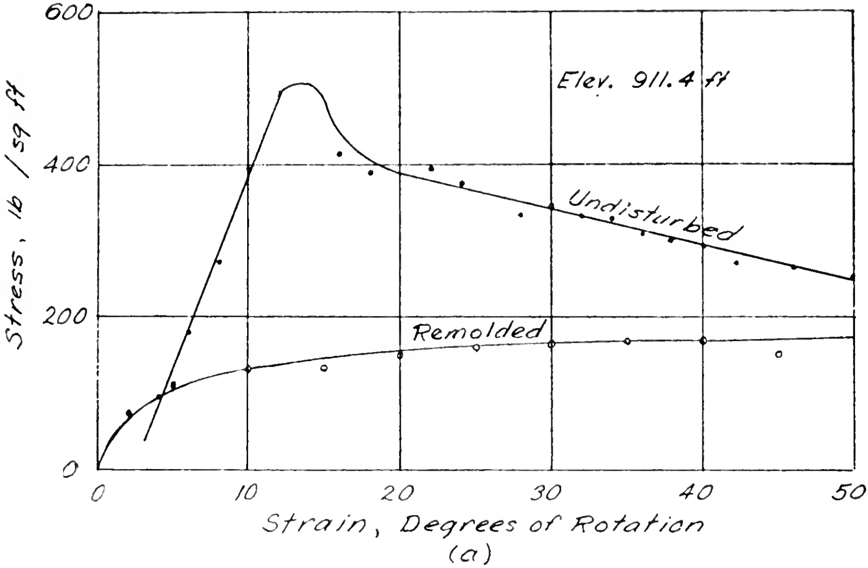


Fig. 6—Equipment for measuring torque on vane auger.



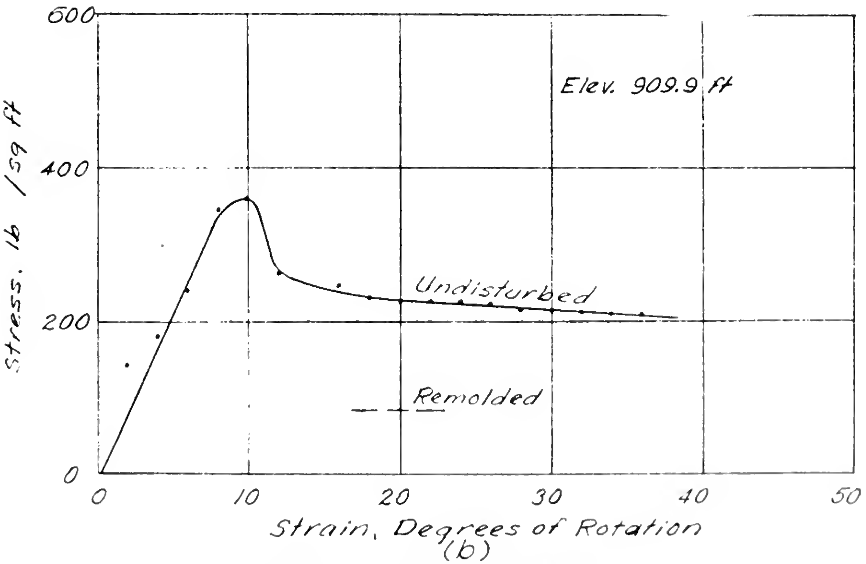


Fig. 7—Vane auger test results.

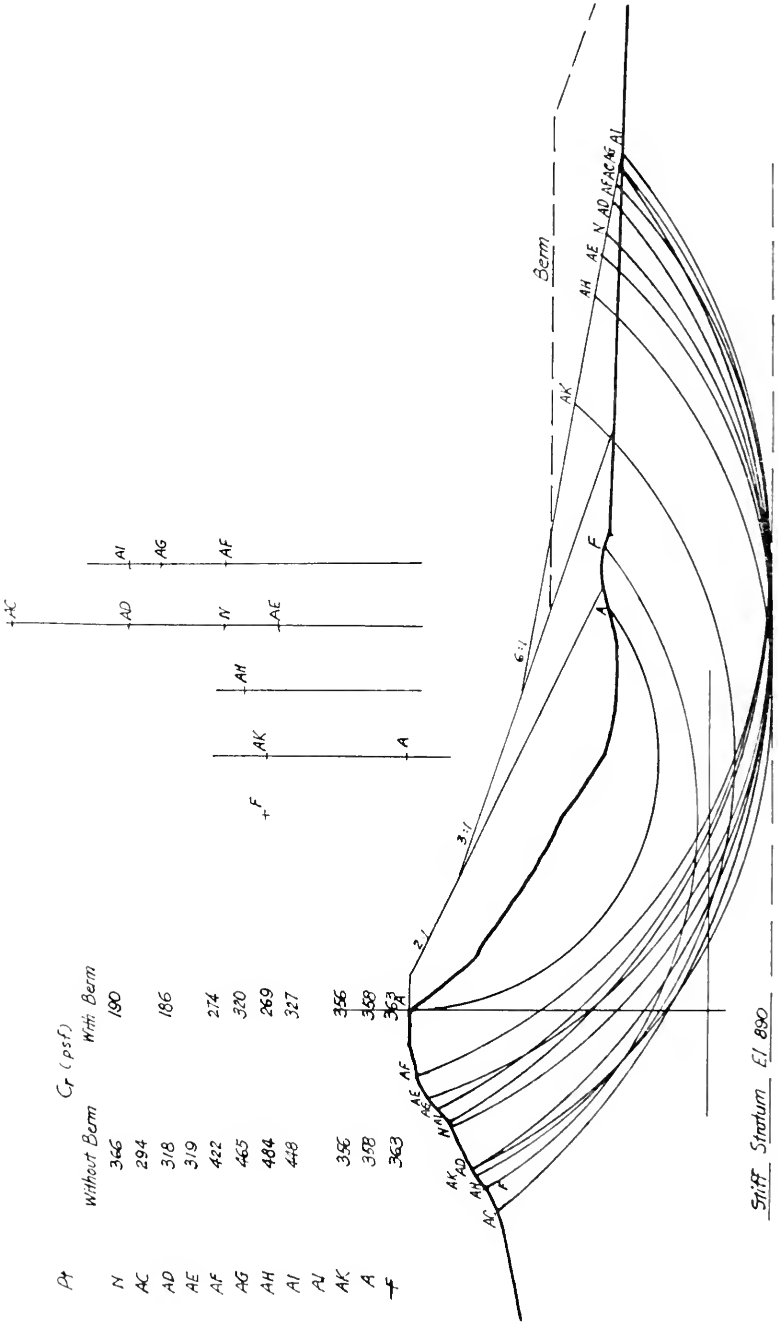


Fig. 8—Stability analysis.

could not be attained even by these measures. Therefore, the studies have provided the information for a satisfactory economic study regarding the desirability of filling the valley or of replacing the existing facilities with a larger bridge or trestle.

BISMARCK BRIDGE APPROACH

The Bismarck bridge on the Northern Pacific Railway was constructed between 1880 and 1882. On the east side of the river, steep bluffs of the Fort Union formation approach the water, Fig. 9, but on the west side is a long approach fill extending across the bottomlands of the Missouri. Almost as soon as the bridge was completed a crack was observed near the crest of the bluffs at a distance of about 500 ft from the first river pier. Sliding of the material between the crack and the pier began shortly thereafter and continued with few intermissions until 1951.

Fig. 9—General view of Bismark slide.

In 1882 the first river pier, designated as Pier 1, experienced small movements toward the river and observations of the movements were initiated. By 1888 the movements had amounted to 8 in and it was necessary to move the bridge span. At this time a large excavation was made northeast of the pier in the hope of relieving pressure of the slide which appeared to be approaching from that direction. In addition, two large concrete dowels 25 ft square by 15 ft in height were keyed into underlying firm formations in the hope of stabilizing the material. These measures did not prove successful, and in 1898 it was necessary to prepare new foundations for the pier and to roll the pier back approximately 4 ft to its original position. In 1902 it was found that the pier had again moved as much as 6 in. Therefore, in 1903 an area around the pier was excavated to the bottom of the slide in an effort to relieve the pressure. In 1918 a timber cofferdam was built around the pier to permit free movement of the sliding mass without damage to the structure. The cofferdam was repaired extensively in 1923 and was renewed in 1940. In 1950 the cofferdam was again in need of repair and consideration was given to stabilization of the slide. A line change was contemplated to reduce curvature at the east end of the bridge and it was considered possible that a combination of activities in connection with the line change and stabilization of the bank might be economically feasible. Therefore, a detailed and extensive field study was carried out.

A general cross section through the slide area, together with a general summary of the geological conditions is shown in Fig. 10. The entire bank is a part of the Fort Union formation, of Paleocene age. It consists of horizontally bedded deposits of soft shales and sandstones with occasional members of sand and hard organic clays. Test borings, indicated on the cross section, Fig. 10, furnished the number of blows in the standard penetration test when the borings were being made. The blows per foot are an indication of the relative density and firmness of the strata.

The penetration tests, as well as experience, demonstrated that the strength of the intact Fort Union formation is very great. The studies indicated that the original failure appears to have been caused only by erosion of the toe of the slope, caused by diversion of the river to the east bank for construction of the bridge, combined with the excavation for the bridge pier itself. However, the cause of the original failure is irrelevant insofar as studies of further movements are concerned, because the characteristics of the material involved in the sliding mass were significantly altered as a result of the movements and of the infiltration of groundwater through cracks caused by movements.

No definite correlation was found between precipitation and movement, either of the bridge pier itself or of various reference points established on the slope. Groundwater conditions at the time of the study are indicated in Fig. 10. The studies permitted location of the surface of sliding with considerable accuracy. In the lower part of the sliding mass hydrostatic uplift pressure existed, but the water pressure at levels below the surface of sliding corresponded approximately to river level. Thus, it appears that pockets of water were trapped in the sliding material. These pockets undoubtedly contributed to instability. Drainage of the area was not considered feasible. Drainage had been attempted previously by means of drainage tunnels and by vertical wells extending to the tunnels. Only small quantities of water could be removed. Undoubtedly, many pockets of trapped water were not touched by the drainage system and it is unlikely that any system of drains could be constructed to remove all of the significant water.

In lieu of drainage, it was considered preferable to unload the sliding mass to an extent that would result in a known and definite increase in the factor of safety. Several proposals were studied, indicated by A, B, and C, Fig. 10. Stability studies were made for various reasonable conditions of hydrostatic pressure and for various reasonable values of the shearing strength of the material. It was determined that proposal B would provide a factor of safety of not less than 1.4 under the worst hydrostatic pressure conditions that might arise. Proposal A would not provide sufficient increase in strength, whereas proposal C would be unduly conservative. Therefore, the slide was corrected by excavation of material as shown in proposal B. The slope of 1¾:1 was left against the existing escarpment to protect it from erosion, and the nearly vertical face near the upper edge was left inasmuch as it had stood for many years without weathering. The space around the pier within the cofferdam was filled with loose sand and all the slopes were trimmed to eliminate local steep slopes.

Approximately 800,000 cu yd of material were removed for the combined operations of line change and slide repair, of which about 250,000 cu yd could be directly chargeable to the improvement of the slide condition. The corrective work was completed early in 1952 and no significant movements have occurred since that date.

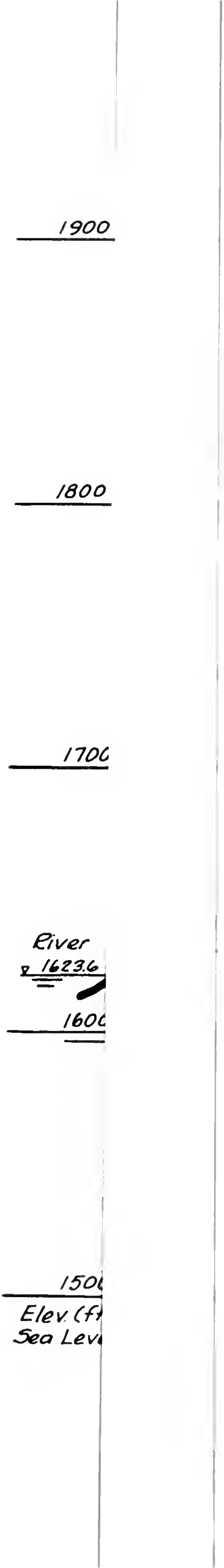
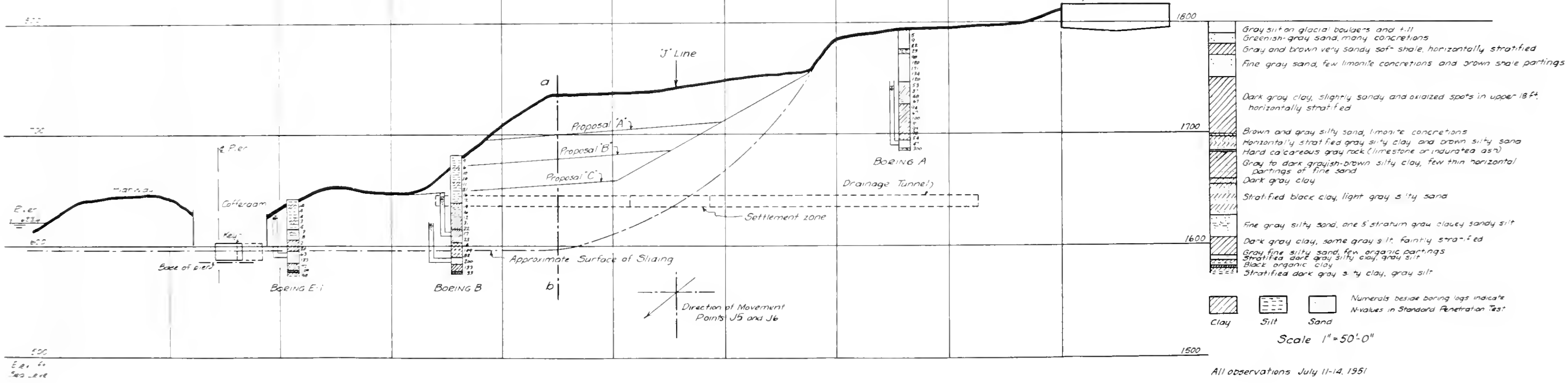

1900
1800
River
1623.6
Elev.
Sea

Fig. 10
Cross Section through Slide along Axis of Drainage Tunnel showing Principal Features and Soil Conditions 1951



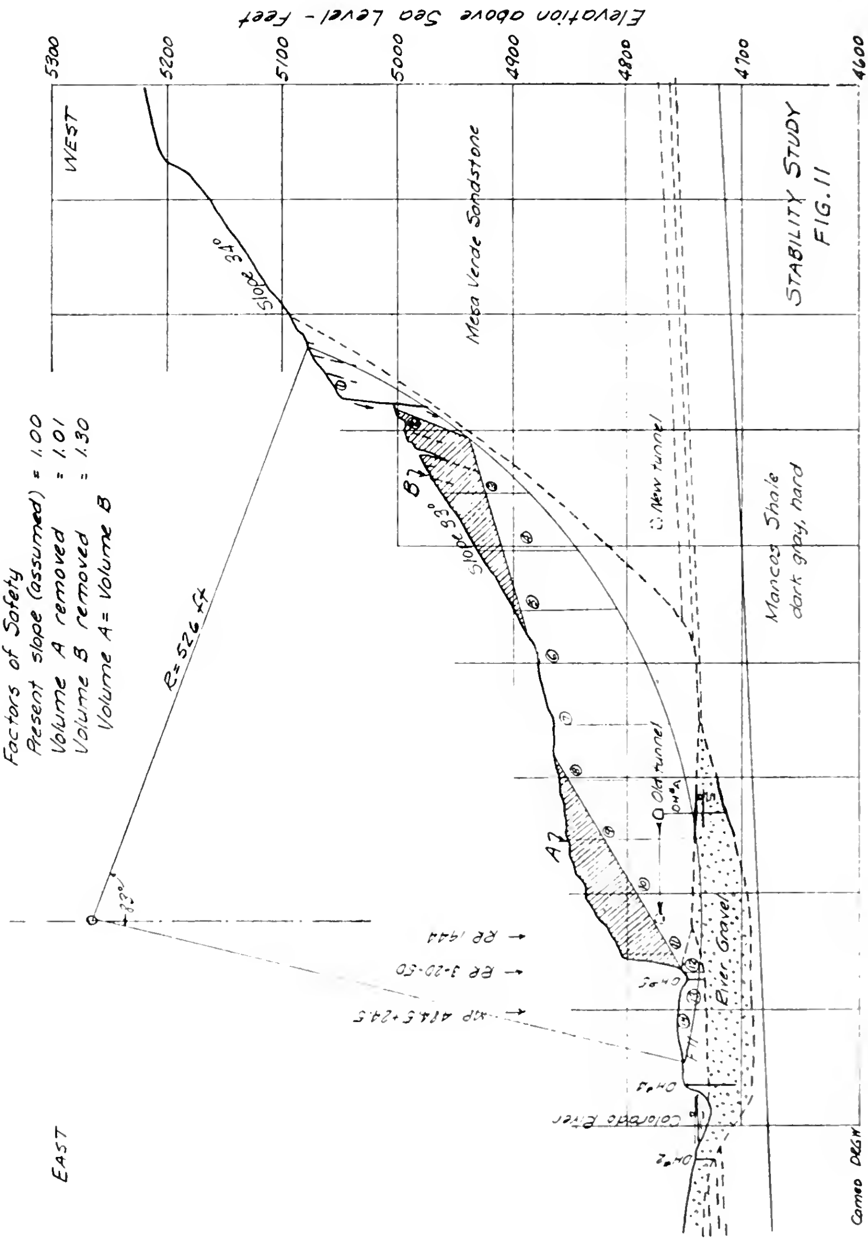
The Bismarck slide serves as an example of a slope continually on the verge of failure. This is usually the case of regions where masses of ancient slide material exist, inasmuch as the original slides undoubtedly continued to move until the factor of safety was approximately unity. Thereafter, slight variations in the strength of the sliding mass, in precipitation, or in hydrostatic conditions are commonly reflected in renewals or cessations of movements. However, the local variations in precipitation, water pressure, etc., serve merely as triggers for the movement, and the real seat of instability is the low strength of the sliding mass as compared to the forces of gravity that tend to produce failure. At the Bismarck slide, stabilization was achieved by reducing the driving weight by a predetermined amount, rather than by attempts at drainage, the efficacy of which could not be determined precisely in advance.

CAMEO SLIDE

The general features of a large slide along the Colorado River are shown in the cross section, Fig. 11. The sliding mass at this location was almost 300 ft in height. Inspection of the site indicated that the affected area was an ancient landslide on the face of cliffs of Mesa Verde sandstone. The sliding mass, however, had disintegrated into chunks of sandstone with some shale, surrounded by a matrix of clayey silt and sand. Isolated wet pockets were evident. The railroad, located at the toe of the slide, was displaced horizontally and the river temporarily diverted by a relatively general movement which occurred in March 1950. Borings at the site indicated the conditions shown on the diagram and the presence of hydrostatic excess pressures in the lower part of the sliding mass. However, the main portion of the sliding mass was underlain by river gravel in which the porewater pressures were not higher than those in the river itself. Thus, the slide may be said to have been provided with a natural underdrain.

Drainage of the slide did not appear feasible because of the erratic and pocketed nature of the sliding mass. The probability of being able to reach the trapped water by any system was relatively small. Therefore, recommendations were made that the upper part of the sliding mass be removed by excavation. The area to be removed is denoted by B, Fig. 11. The factor of safety would be increased by 30 percent if the volume shown by the shaded area were removed.

In contrast, if the same volume were removed from the shaded area A directly above the railroad track, the increase in the general factor of safety would be only 1 percent. It is obvious that the steep slope near the railroad track requires some local trimming to prevent slumps and rockfalls near the track ditch. The computations demonstrate, however, that no appreciable increase in the general factor of safety of a slope of this kind can be achieved by unloading the toe of the slide. A very much greater improvement is possible if a corresponding volume of earth is removed from the uppermost part of the slide area.


Elevation above Sea Level - Feet
5300
5200
5100
5000
4900
4800
4700
4600
WEST
EAST
Mesa Verde Sandstone
Slope 34°
Slope 33°
New tunnel
Old tunnel
Mancos Shale
dark gray, hard
River Gravel
Colorado River
STABILITY STUDY
FIG. 11
Factors of Safety
Present slope (assumed) = 1.00
Volume A removed = 1.01
Volume B removed = 1.30
Volume A = Volume B
R = 526 ft
33°
A
B
RR 1944
RR 3-20-50
MP 484.5+24.5
Fill
Comco DRGW

Part 3

Soil Engineering in Freight Yard Construction

Southern Railway, Ernest Norris Yard, Birmingham, Ala.

The industrial growth of Birmingham, Ala., the restricted area of its present yard installations, and the inherent inefficiency of operations over several locations, indicated to the Southern Railway the need for new yard facilities at Birmingham, complete at one location. Accordingly, a suitable location was established near Irondale on the northeast outskirts of Birmingham. This site was selected for availability and facility of operations. The soil, subgrade and drainage conditions were not ideal. The area in general is overlain with highly plastic residual clays and it is doubtful that a site with more favorable conditions was available. The nature of the soil material, well illustrated by action of the trackage in the vicinity and the experiences of the highway departments under similar conditions, led to construction measures to insure efficient operations without excess maintenance. It is with the character of the subgrade conditions and the corrective procedures that this report is concerned.

The soils at the site of the yard were all residual materials; that is, they were developed from the underlying rock. The greater portion of the area is over limestone and the soils developed from this material are clays of high plasticity and compressibility with low strengths when wet. In the area some micaceous soils were encountered, either developed from schists or crystalized limestone. The following table shows the test results from a number of samples taken during the preliminary soil survey.

Test Hole	*Depth Feet*	*Field Moisture Percent*	*Proctor Max Den Lb/Cu Ft*	*Control Opt. % Moisture*	*Liquid Limit*	*Plastic Limit*	*Plastic Index*
1	½–3½		90	28	90	32	58
1	3½–8	35	86	28	91	36	55
3	1–5		101	22	44	29	15
3	10–19	34	89	27	82	33	49
4	1–5		98	23	43	25	18
6	6		88	32	82	36	46
6	13	36	95	23	66	33	33

These results generally indicate rather unsatisfactory material for subgrades. Many highway department specifications prohibit the use of soils for embankments with liquid limits in excess of 65. Previous researches indicate that these characteristics also suggest subgrade material very subject to pocket development and lateral displacement under railroad tracks.

The northeast section of the yard over a relatively limited area contained soils developed from sandstones and shales. These soils were classified as silty sands, silts and clayey silts—soils with comparatively low plasticity and compressibility. Test results on a typical sample follows:

Liquid limit 35 percent; plastic limit 24 percent; plasticity index 11; proctor density 109 lb per cu ft; optimum moisture 18.5 percent.

The graph of Fig. 1 gives the moisture density curves of four other samples from the sandstone area, showing standard proctor dry densities of 105 to 113 lb per cu ft. A limited amount of this material was available for selected soil.

A

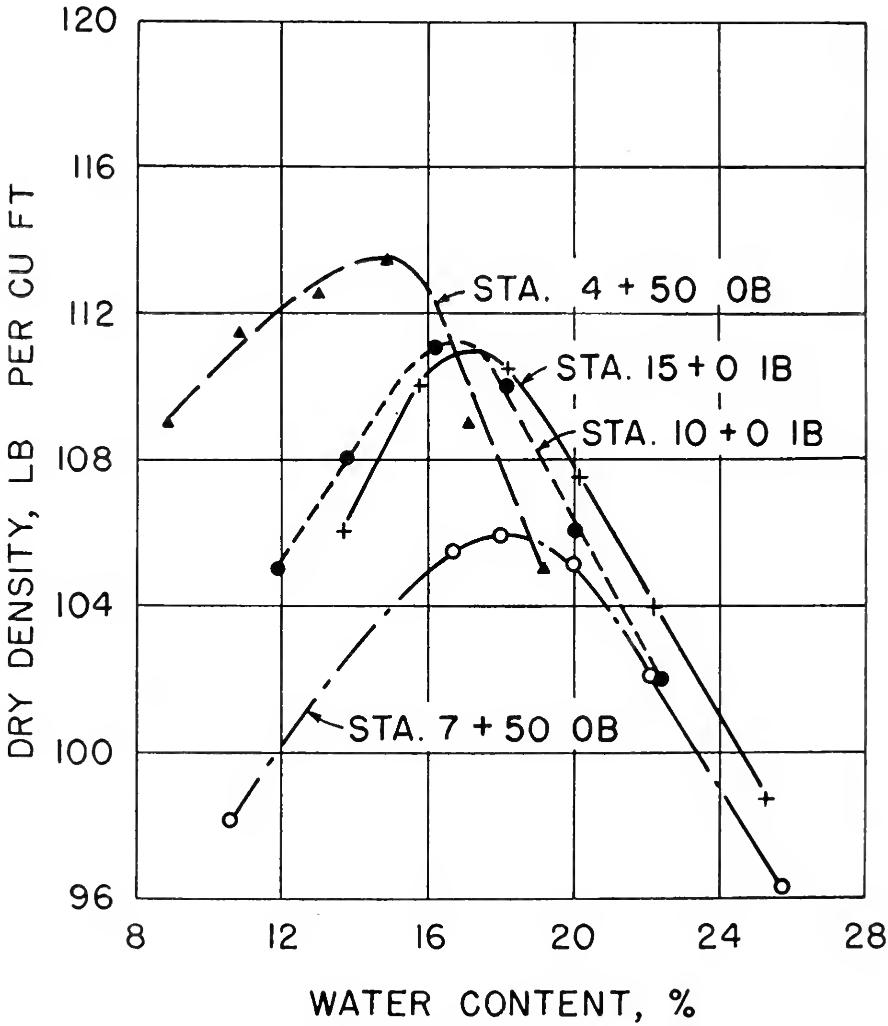


Fig. 1—Standard Proctor test results, Southern Railway, Birmingham, Ala.

The yard layout required cuts up to 30 ft in depth. The fills in general were less than 10 ft, except for the hump fill. More than 2,000,000 cu yd of dirt were moved and required excavation was less than the embankment requirements. Under such conditions, and with the lack of suitable material in the vicinity, it is evident that the soil material excavated had to be used in embankment construction. The borrow requirement, however, did provide some leeway in the selection of material, by judicious use of which a more stable subgrade could be produced.

As the heart of a classification yard is in the hump and retarder area, this area must stay in operation with the least possible interference from any cause, and particularly from subgrade failure or weakness. The typical plastic soils available under normal grading procedures would comprise the hump and retarder fill area. Special treatment to increase stability was needed. Controlled compaction and moisture contents were specified for the section with minimum slopes of 2½ to 1 for the fill heights in excess of 15 ft, 2 to 1 for the reach between 10 and 15 ft, and 1½ to 1 for the top 10 ft. In addition, the top 5 ft of the controlled area fill was made of selected soil of the general type noted above. Compaction of the lower fill was specified at a minimum of 90 percent of the standard derived from the proctor test. An average of 94 percent was obtained. Ninety-five percent was specified for the top 5 ft and obtained. To procure these requirements a sheepsfoot roller loaded to deliver over 400 lb per sq in on a single row of tamping feet was used. The soil was placed in lifts of not greater than 6 in compacted thickness over the hump area and 8 in over the remainder of the yard. Field moisture contents of the soils were generally at or near the optimum, so that additional watering was not usually necessary. Controlled routing of the work equipment also added to the compactive effort. For the remainder of the yard this method, without laboratory control of moisture and density, provided the compaction.

Drainage of the site presented a number of problems in itself, requiring considerable diversion and some drainage across the classification yard to provide for run-off from outside areas. In addition, the yard itself, with its layout of 56 or more tracks, required provision for rainfall run-off. This was made adequately by a system of 12 to 15-in transverse perforated metal pipe drains at intervals of 300 to 450 ft or at grade changes, discharging into drainage structures or channels outside the limits of the track area. The flow lines of these drains were approximately 2 ft below the bottom of the cross ties and the trenches were backfilled with granular material of a gradation similar to standard concrete sand or slightly finer. Such gradation is necessary in fine-grained soil areas to keep the soil from fouling the backfill and decreasing its permeability. In addition, several of the retarder foundations required separate drains. The importance of drainage is demonstrated by the annual rainfall of over 53 in and probable storm intensities of 4.5 in per hour for 10-min periods every 2 years. During construction, rainfall of 50-year expectancy, both in intensity and magnitude, was encountered. By control of grading operations semidrainage was maintained effectively and lost time was reduced appreciably. The clay soils involved are usually impermeable, but under the manipulation of construction equipment when wet easily become impassable.

With these factors well demonstrated during grading it was apparent that track laying and surfacing would require protection to prevent built-in soft track, incipient water pockets, and similar subgrade defects. A grade capping of granular material placed by truck on a dry subgrade prior to track laying was adopted as the most economical treatment to provide the desired results. Three types of material were available within reasonable haul limits. Sand-clay mixtures were present within 2 miles, but quantities were limited and removal from thin strata expensive and difficult. Large quantities of chert, (silica stone) and clay were also available. This material is much used by the highway departments in the vicinity for bases under bituminous roads. However, satisfactory results from this material depend on close control of the gradation, the clay content, and the plasticity. Often it requires an admixture of sand to obtain the necessary characteristics. The third material, and the one adopted for use, was slag screenings—the finer fractions of blast furnace slag after crushing and screening for use in concrete ballast and as road surfacing. This material is usually graded from a maximum size of ⅜ in to a small fraction passing the 100-mesh sieve. Large quantities were available at short rail haul on the Southern's lines.

Quantities of screenings were sufficiently large to justify the installation of a car ramp with a car shaker for unloading from the rails. It was then reloaded in trucks for hauling and spreading on the yard. The entire surface of the classification yard was covered. Over the hump and through the retarders and switch areas a minimum of 1 ft compacted thickness was placed. Over the general track area a minimum of 6 in was placed. The material was placed, only under conditions of firm subgrade support, in lifts not over 4 in. in compacted thickness, and was rolled with a multiple-wheel rubber-tired roller supplemented by the haul trucks. This procedure produced a yard area on which track laying could proceed with no interruptions caused by subgrade conditions. The slag screenings have a slow setting action which sometimes detracts from their value as ballast, but used in the manner described will serve as sub-ballast without detriment to surfacing operations. On all tracks coarse slag ballast was used in depth ranging from 12 in for the hump and retarder area to a minimum of 6 in for the yard tracks. Additional thickness was provided under the retaıders themselves in accord with manufacturer's recommendation.

This yard is now in operation, but without sufficient operating record to determine or assess the full value of the subgrade treatments. However, indications are favorable that the performance record will fully justify the additional expenditures made. These expenditures include a slight increase in grading costs incurred through the over-haul of selected material, an additional cost of approximately 3.5 cents a cubic yard for the embankment in the controlled compaction area, and the additional cost of the slab base material over that of conventional sub-ballast.

Many other features of the complete installation are extremely interesting and instructive but are not within the scope of this report.

Denver & Rio Grande Western Railroad, Grand Junction, Colo., Yard

Traffic requirements also necessitated new yard facilities on the D&RGW at Grand Junction, Colo. The new installation will provide a complete modern hump yard. Prior to construction, soil investigations were made to determine the soil characteristics on which to base the design of the earth structures. This design was directed toward producing trouble-free operation and low maintenance.

Little or no choice was possible in the selection of the site as regards subgrade conditions. Unfavorable soil conditions are general in the vicinity. The location is in the Colorado River valley near the junction with the Gunnison, on flood plains and terraces. The soils consist predominately of alluvial silts and clayey silts with a bad performance record under both railroads and highways. The following tabulation shows the physical characteristics of representative samples from the area.

Sample	*Moisture Content Percent*	*Liquid Limit Percent*	*Plastic Limit Percent*	*Plastic Index*
B	31	40	21	19
C	19	30	18	12
D	4	24	18	6
E	16	34	19	15

These soils have relatively low plasticity compared to the fatter clays, but are relatively low in bearing power and lose stability readily under adverse moisture conditions. They are particularly subject to deleterious frost action. The yard site is on flat terrain and the earthwork is almost completely borrow material. No selection of soil to increase stability of the embankments is possible within economic haul limits. The graph of Fig. 2 shows the moisture density relationship for sample E. The soil, at a density of 110 lb per cu ft, has sufficient strength with low moisture contents to provide adequate support, but protection is necessary to keep the contact loads within the bearing power of the material when moisture contents are high.

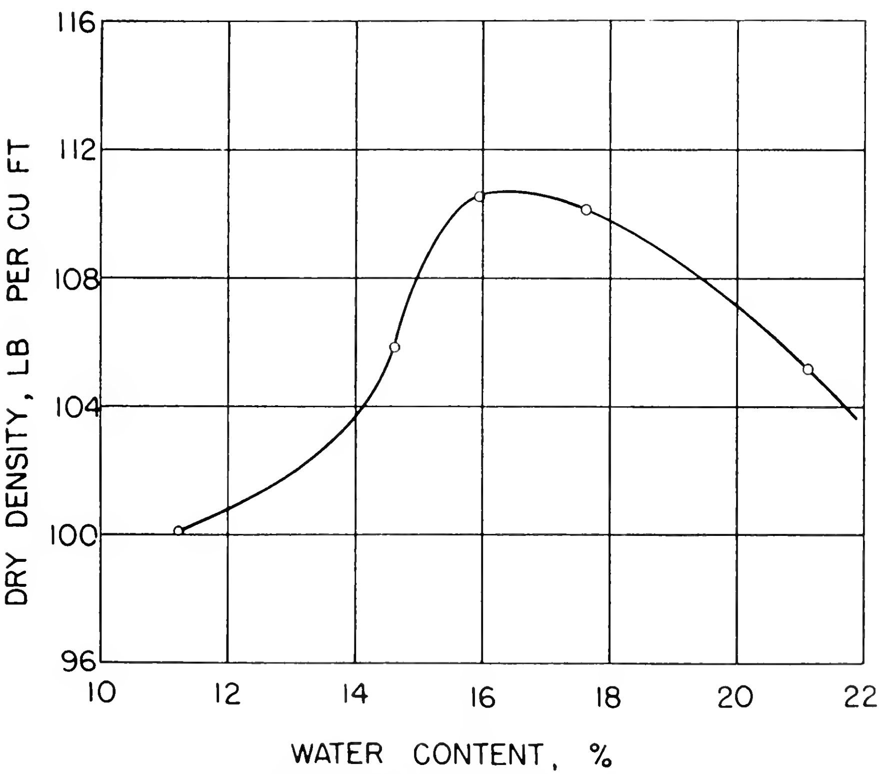


Fig. 2—Standard Proctor test results, Denver & Rio Grande Western Railway, Grand Junction, Colo.

Under the Colorado Highway Department design method for flexible pavements, a total thickness (base and surface) of 22 in is required for similar conditions of rainfall, frost, and comparable conditions of traffic. Annual rainfall is less than 9 in and average frost penetration about 15 in. This design is based on a tire contact pressure with the pavement of 65 lb per sq in. Average pressure over the bottom of a tie under railroad loading rarely exceeds 40 lb per sq in. Under these considerations a 19-in combined depth, including both ballast and base material, was considered adequate for the hump area and part of the classification yard. This thickness was specified to consist of 12 in of granular base with a minimum of 6 in of ballast under the ties. On the western portion of the classification yard, where maintenance of absolute grade is not of such prime importance, this thickness was modified to a total of 13 in, including 5 in of ballast.

Drainage facilities were required both for run-off and irrigation, the latter requiring diversion, and the former requiring that the area's main drainage course be carried under the classification yard. In addition, to further protect the subgrade, a system of 6-in perforated drains under the yard tracks was specified. These drains will collect rainfall over the yard area where open ditches are not feasible. Drains have been placed at approximately 300-ft intervals transverse to the tracks, at grade break points, and from retarder pits. These drains were placed after grading and base construction, with their flow lines a minimum of 2 ft below the top of the base. Backfill was a granular material of a gradation similar to standard concrete sand, except for a maximum size of ⅜ in.

The only sources of suitable granular base material with reasonable haul were river gravel deposits or old river terraces. Material from either source is very similar, consisting of coarse gravel with low quantities of fine sand. Fig. 3 shows the grain sizes for a typical sample from each source reduced to 3-in maximum size.

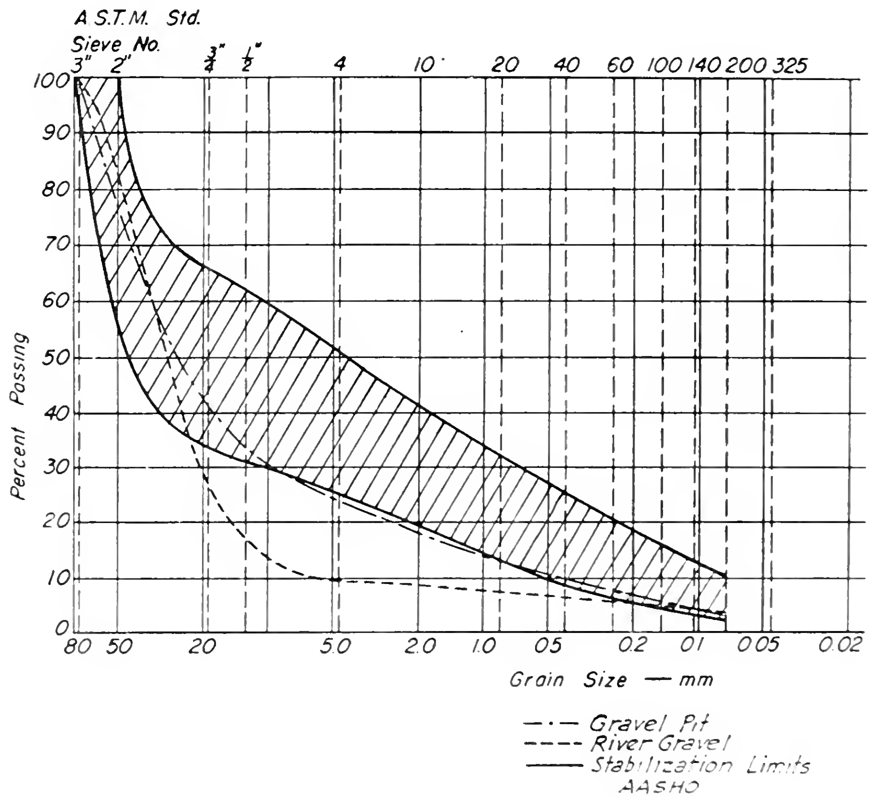


Fig. 3—Grain size accumulation curve.

To avoid waste of material the base specifications were set up to permit the use of material up to 3 in. in size. It is apparent from this graph that the material is coarse and harsh, with insufficient fines to permit compaction into a dense base course. Tests established that a mixture of 6 in of this material mixed with 1 in of subgrade soil produced a gradation that would result in a tighter and denser base. Specified limits of the stabilized mixture are shown by the shaded area on the graph of Fig. 3.

After grading, the specified depth of subgrade material was bladed into a windrow, the gravel base material placed, and the soil binder bladed over and mixed. The base was constructed in layers 4 to 6 in thick, watered as required and rolled with rubber-tired rollers and construction equipment.

The gravel pits were also the source of granular backfill for the subsurface drains, produced by screening through a ⅜-in sieve. This produced a large quantity of oversize material, which is available for crushing as top ballast material.

Compaction and moisture control were specified for both the grading and base construction. The hump itself is the only area with appreciable fill. Here an embankment about 15 ft in height is required. Some subcutting was required in areas to accommodate the base course. All embankments were constructed in layers not over 6-in compacted thickness.

Many interesting features of this project are well worth reporting but are outside the scope of this assignment. The well designed preventive measures employed should more than return the additional original cost. This job is still under construction and no data on performance are as yet available.

Part 4

Costs and Maintenance Data on Grouting Projects

The accompanying Table 1 shows pressure grouting and maintenance data on the Atchison, Topeka & Santa Fe and New York Central Railroads for 15 projects of soft-track and water-pocket stabilization. Included are yearly maintenance costs for these projects for the period since the stabilization, varying from five to nine years. It is evident from these yearly costs that there is no trend toward greater costs with the increasing age of the projects. The nine-year record indicates a considerable degree of permanence. The reduction in maintenance, with one exception, greatly exceeds the original cost of stabilization.

Table 2 shows in more condensed form data from 15 railroads. Data for an additional year have been added, which has changed the percent of savings in nine cases. In seven of these the average savings have been increased; in two they have decreased. This table also shows data indicative of the permanence of the stabilization.

The tables showing grout stabilization data have been published for six consecutive years, including the current one. The publication of these tables will not be continued as it is thought that sufficient information on a variety of projects has been presented, and that further data will not be of additional value.

Location

Thatcher, Color.
MP 595-603
Four Locations

Maxwell, N.M.
MP 684-685

Dermot, Texas
MP 748-749

Maxwell, N.M.
MP 682-683

Edgerton, Kas.
Curve 47

Taiban, N.M.
MP 704-709

Onava-Azul, N.M.
MP 761-762

Texico, N.M.
MP 649-651
Double Track

* Snyder, Texaa
MP 775-776

Avg. of Water Pock

* Brenham, Texas
MP 126 plus
Sliding Embankment

Monroe, Mich.

Port Clinton, O.

Canada Division

(" ")
(Welland, Ontario)

Hillsboro, Ill.

Corunna, Ind.

Av

Bridge 222
Guilford, Ind.

M.P. 33.16
Near Weisburg, Ind

TABLE NO.1

A.T.& S.F. GROUT TEST SECTIONS
WATER POCKETS AND SOFT TRACK

Location	Date Grouted	Length Section Miles	Mixtures	Cu.Ft. Grout per Lin.Ft. Track	Cost per Trk.Ft.	MAINTENANCE SPOTTING TRACK: Before Grouting Man Hours Per Year Per Mile	After Grouting - Man Hours Per Yr. Per Mi.: 1st Year	2nd Year	3rd Year	4th Year	5th Year	6th Year	7th Year	8th Year	9th Year	Average	Avg. Saving Man Hours Per Mile Per Year
Thatcher, Color. MP 595-603 Four Locations	5/42 to 9/42	3.4	1/8-1/40	1.42	0.535	7359	4463	2544	3742	2860	2670	2652	1525	1267	1024	2527	4832
Maxwell, N.M. MP 684-685	12/42 to 8/43	1.0	1/4-1/8	1.26	0.68	3614	1803	1424	846	1169	1218	720	736	1131		1131	2473
Dermot, Texas MP 748-749	2/43	1.0	1/8	1.45	0.56	2952	731	1443	2015	1718	304	234	266	968		960	1992
Maxwell, N.M. MP 682-683	7/43	1.0	1/8	1.05	0.65	2743	2927	1746	555	216	856	402	466	961		1016	1727
Edgerton, Kas. Curve 47	11/43	0.218	1/6	3.17	1.46	6595	1464	2840	3574	2935	2546	1921	1569	1917		2346	4249
Taiban, N.M. MP 704-709	5/44 to 7/44	5.0	1/10	2.18	0.50	1813	321	606	630	798	815	710	1129			716	1097
Onava-Arul, N.M. MP 761-762	7/45	1.0	1/16	3.95	1.58	6750	2541	1415	1813	428	1128	1328				1442	5308
Texico, N.M. MP 649-651 Double Track	12/45 to 7/46	4.0	1/16	6.21	2.43	2535	1581	629	1064	1580	1470					1265	1270
* Snyder, Texas MP 775-776	7/46	1.0	1/32	2.5	0.52	806	622	328	549	424	986					582	224
Avg. of Water Pocket Test Sections						3907	1828	1442	1643	1348	1333	1138	948	1249	1024	1332	2575
SLIDING FILL																	
* Brenham, Texas MP 126 plus Sliding Embankment	9/46 to 3/47	0.354	1/16	35.14	8.89	6215	424	234	373	474						376	5839

*A.R.E.A. designated test sections.

NEW YORK CENTRAL - GROUT TEST SECTIONS
WATER POCKETS & SOFT TRACK

Location	Date	Length	Mixture	Grout	Cost	Dollars per year per mile	Dollars per year per mile										Dollars
Monroe, Mich.	1941	0.362	1/1	1.25	0.65	7800	245	212	1875	1570	314	431	215	556	0.0	602	7198
Port Clinton, O.	1942	0.555	1/1	1.50	0.90	14600	862	829	304	0.0	0.0	0.0	0.0	0.0	0.0	222	14378
Canada Division	1943	0.827	1/1	2.77	1.60	10500	1038	1410	1760	922	1320	880	219	924		1063	9437
(" ") (Welland, Ontario)	1945	1.420	1/1	5.75	2.78	6354	994	418	275	203	212	479				430	5924
Hillsboro, Ill.	1945	0.615	1/1	4.54	1.07	13365	5760	160	660	285	284	0.0				1192	12173
Corunna, Ind.	1946	0.488	1/1	5.62	2.95	5450	211	0.0	0.0	0.0	0.0					42	5407
Average of water pocket sections -						9678	1518	505	812	497	355	358	155	493		592	9086
Sliding Fills — $ Per year for section grouted																	
Bridge 222 Guilford, Ind.	1945	233 feet	1/1	31.8	18.06	2859.72	31.20	0.0	12.96	0.0	0.0	0.0				7.36	2852
M.P. 33.16 Near Weisburg, Ind.	1947	400 feet Double tr.	1/1	15.0	9.60	228	0.0	0.0	0.0	0.0						0.0	228

Rai
"
Loc

Baltimore
Baltimo

Baltimo
"

Canadian
Stevens

M.P. 58

CB&Q - Bu
M.P. 12
Allianc
"
St. Jos

Chicago &
Near Mo
" Co
" Cl
" Sa

CMStP&P -
Near Ou

Delaware
Whiteha

Smith's

Great Nor
Near Gl

" Fa

" Wa

"

" Ne

Illinois
Robb, I
Chicago
Carbond
Near El

Louisvill
Duckers
"
Ravenna

MStP&SSM
Near Bo

Mo-Kan-Te
Moran-E

Nickel Pl
Wheelin
Near Be
"
"

Northern
Hathawa
Tacoma-

Pennsylva
North E

Four Di
Ft. Way
Toledo,
Chicago
Bedford

Virginia
Westgat

TABLE NO. 2 - GROUTING AND MAINTENANCE DATA

Railroad and Location	Year	Length of Section Reported Feet	Grout Acceptance cu.ft. per tr.ft.	Grout Mixture Cu. Ft. Cement	Sand	Fly-Ash	Gal. Asphalt	Character of Track Ballast Type & Type Instability Max Cut & Fill	Dollar Total	Cost of Grouting tr.ft.	Cost of Grouting cu.ft.	Maintenance Data Man Hrs. per Year Before Grouting	After Grouting	Savings Man Hrs. Per Year	Savings Percent	Period of Record Yrs. Before	After	Remarks Grouting Equipment & Type of Work
Baltimore & Ohio																		
Baltimore E.E. & Toledo Divs.	1946	13,191	5.92	1	14	-	-	Crushed stone, soft track, unstable fills.	35,491	2.69	0.455	11,042	5,160	5,882	53	1	1	Hydraulic, track & fill.
				1	10	-	-	Cinders, squeezes, ballast pockets.										
					14	1	1,240 ft.											
Baltimore E.F. Akron, St.L. Divs.	1947	31,619	4.40	1	7,8,14	-	-	Crushed stone, slag, soft track.	59,472	1.88	0.426	38,910	12,672	26,238	68	1	1	" " "
" " " " " "	1948	23,204	4.08	1	7,12,16	Used on some portions only.		Unstable fills.	61,375	2.64	0.531	24,538	11,444	13,094	53	1	1	" " "
Canadian National																		
Stevensville, Ont.	1945-1946	(4,847)	2.01	1	1.5	-	-	Crushed stone - gravel. 10' max fill.	14,056	2.90	(1.53)	3,440	541	2,899	84	1	5	Pneumatic, track only.
			1.67	1	1	-	-						Eliminates shims					
M.P. 58.7 Cayuga Subdivn.	1949	2,142	4.4	1	2	-	-	Crushed rock - side slips.	6,030	2.82	0.64	4,800	400	4,600	96	5	2	" track and fill.
				1	7	1	-	4' to 12' fill.										
CB&Q - Burlington																		
M.P. 123.19 Beardstown, Ill.	1946	269	14.58	1	7	1/2	2/3	Cinders - 50' sliding fill.	1,662	6.18	0.42	$2,107.28	$35.60	$2,071.68	98	1	5	Hydraulic, track & fill.
Alliance Div. M.P.438-439.2	1946	6,336	7.85	1	7	1/2	2/3	Crushed rock. Unstable low fill, heavy clay.	13,939	2.20	0.28	$2,366.00	$16.76	$2,349.24	99	1	5	" " "
" " " 458.5-459.05	1947	1,320	5.76	1	7	1/2	2/3	" " " " " " "	3,379	2.56	0.44	$2,867.80	Normal	$2,867.80	100	1	5	" " "
St. Joseph " 129.5-130.04	1947	2,884	5.23	1	4	-	-	Chatt - Unstable low fill, heavy clay.	7,441	2.58	0.49	$2,671.44	$179.03	$2,492.41	93	1	5	Pneumatic, track only.
Chicago & North Western																		
Near Mondamin, Ia.	1945	10,560	4.2	1	7	-	1	Cinders - Unstable 7' fill.	16,790	1.59	0.39	5,608	1606	4002	71	1	7	Hydraulic, track only.
" Council Bluffs, Ia.	1946	12,500	4.1	1	7	-	1	Cr.stone,gravel,cinders.Unstable 10' fill.	23,625	1.89	0.46	2,085	522	1563	75	6 mos.	6	Hydraulic & pneu.track only.Welded rail.
" Clinton, Ia.	1946	325	27.9	1	3	-	0.5	Cr.stone & cinders. Sliding 30' fill.	5,206	16.02	0.43	2,545	247	2298	90	1	6	Hydraulic, track & fill.
" Salix, Ia.	1947	6,500	4.0	1	7	-	1.5	Cinders, soft track, unstable 4' fills.	-	-	-	3,360	2298	1068	31	1	5	" " "
CMStP&P - Milwaukee																		
Near Owega, Ia.	1945	16,297	1.65	1	4	-	-	Gravel, cinders - pocketed Tr. 6' fill.	22,164	1.36	0.83	3,540	471	3069	87	1	6	Contract pneumatic, track only.
Delaware & Hudson																		
Whitehall, N.Y.	1947	(524)	2.00	1	1 1/2	-	-	Stone ballast on timber mat on wet clay.	1,593	3.04	(1.52)	1,129	10.6	1118	99	1	5	Pneumatic over mat.
		(335)	4.78	1	1 1/2	-	-	" " " " " " " "	3,312	6.93	(1.45)							" under "
Smith's Basin, N.Y.	1948	2,841	3.60	1	1 1/3	-	-	" " ,pockets,6' cut to 10' fill.	9,517	3.35	0.93	2,366	110.5	2265	96	1	4	" track only.
Great Northern																		
Near Glasgow, Mont.	1946-47	8,012	4.51	1	6	-	1	Gravel, pockets & splitting 10' fills.	13,861	1.73	0.44	11,930	218	11,712	97	1	5	Pneumatic track & fill.
												1570 c.y. bal.	145					
" Fargo, N. Dak.	1947	10,545	5.36	1	5	-	1	" , soft track, 4' fills.	19,824	1.88	0.35	15,015	390	14,625	96	1	5	" track only.
												800 c.y. bal.						
" Wahpeton, N. Dak.	1947	19,701	2.65	1	5	-	2	" " " " "	22,065	1.12	0.36	15,428	880	14,548	94	1	5	" " "
												5800 c.y. bal.	None					
" " " "	1948	10,880	4.34	1	5	-	2	" " " " "	13,056	1.20	0.28	10,680	495	10,195	95	1	4	" " "
												1500 c.y. bal.	None					
" Noyes, Minn.	1948	815	45.88	1	5	-	1 1/2	" , pockets & slipping 12' fill.	14,662	17.99	0.39	3,448	0.0	3,448	100	1	4	" track & fill.
												350 c.y. bal.	None					
Illinois Central																		
Bobb, Ill. Tunnel No. 2	1945	3,215	1.90	Cement only			-	Crushed rock, tunnel, mud boils	13,085	4.07	2.13	6,192	340	5,852	95	1	7 1/2	Hydraulic on track equipment.
Chicago Terminal	1944	80	13.90	1	4	1	-	" " soft track db.slip switch	674	8.42	0.61	100	20	80	80	1	8	Pneumatic, track only, fill ground.
Carbondale, Ill., Yard	1946	3,577	1.48	1	7	1	-	Cinders, squeezes, soft track.	1,359	0.38	0.26	2,178	120	2,058	94	1	6	Hydraulic on track equipment.
Near Elnford, Ill.	1947	1,521	23.30	1	7	1	-	Crushed slag, cinders, sliding fill.	12,442	8.18	0.35	1,248	80	1,168	94	1	5	" track & fill.
Louisville & Nashville																		
Dockers, Ky. M.P. 74	1947	400	3.6	1	2	-	-	Limestone	1,292	3.23	0.90	$1,136.	$ 8.43	$1,126	99	1	5	Hydraulic.
" " " "	1948	600	6.03	1	2	-	-	"	3,348	5.58	0.92	$4,543.	$ 34.40	$4,509	99	1	4 1/2	"
Ravenna, Ky. M.P. 232	1948	1,156	3.76	1	2 1/2	-	-	Cinders	2,682	2.32	0.62	$1,762.	$350.00	$1,412	80	1	4 1/4	"
MStP&SSM - Soo Line																		
Near Borea, Wis.	1946	4,313	2.01	1	5.2	-	-	Pit run gravel 10' unstable fill.	3,321	0.77	0.39	$1,169	$325.00	$ 844	72	8 mos.	3	Hydraulic, track only.
	1947	11,468	1.92	1	6.7	-	-	" " " 8-10' " "	7,798	0.68	0.36	$2,478	$656.00	$1,822	73	2	2	" " "
	1948	24,006	1.08	1	5.8	-	-	" " " 2-12' " "	12,723	0.53	0.49	$2,779	$710.00	$2,069	74	3	1	" " "
Mo-Kan-Texas																		
Moran-Savonburg, Kan.	1945	8,941	3.74	1	8	-	1	Chatt,pockets & soft track 10' cut & fills.	21,905	2.45	0.65	3,731 est.	520.	3,211	86	1	4 3/4	Hydraulic contract, track only.
Nickel Plate																		
Wheeling & Lake Erie Dist.																		
Near Baltic, Ohio M.P. 100	1948	600	38.48	1	2	-	-	Slag on cinders, sliding 40'-50' fill.	13,512	22.52	0.586	$3,000.	0.0	$3,000	100	1	4	Pneumatic fill grouting.
" " " M.P. 99.56	1949	429	42.69	1	2	-	-	" " " " 30'-40' "	9,592	22.36	0.524	-	0.0	-	100	-	4	" " "
" " " M.P. 99.31	1949	147	12.27	1	2	-	-	" " " " 5'-10' "	989	6.73	0.548	-	0.0	-	100	-	3	" " "
Northern Pacific																		
Hathaway, Mont. M.P. 100	1945-47	7506	2.0	1	6	-	1.2	Crushed stone. Water pockets on low fill.	11,259	1.50	0.75	$1,200	$ 293	$ 907	76	1	5	Hydraulic, track.
Tacoma-Portland, Ore.	1948	4660	17.7	1	6	-	1	Cr.Stone. Water pockets, slipping 15' fill.	45,668	9.80	0.55	$6,447	$ 572	$5,875	91	1	3	" " & fill.
	1948	1130	16.0	1	6	-	-	" " " " " 12' fill.	8,396	7.43	0.46	$ 146	0.0	146	100	1	3	" " " "
Pennsylvania																		
North Point, Md.	1936	75	Av. for Western Region	-	-	Pulv. Limestone	-	Water pocket.	700	9.33	-			1,400	-	1	15	
										Av.West. Region								
Four Divisions	1945	7408	1.29	1	-	2	-	Gravel, settlement.	10,075	1.36	1.044	16,250	1,735	14,515	89	2 1/4	3 1/4	Hydraulic.
Ft. Wayne, Ind. Div.	1945	137	1.29	1	-	2	-	Crushed stone, settlement.	186	1.36	1.044	1,315	156	1,159	88	2 1/3	4 1/3	"
Toledo, Ohio Div.	1945	7300	1.29	1	-	2	-	Gravel "	9,928	1.36	1.044	12,350	720	11,630	94	2 1/4	4 1/4	"
Chicago Terminal	1945	2388	1.29	1	-	2	-	" "	3,248	1.36	1.044	4,410	355	4,055	92	2	4	"
Bedford, Ohio	1946-47	6416	5.02	1	1	2	-	Crushed stone, soft track, 20' cut.	16,938	2.64	0.53	2,431	456	1,975	81	1	5	"
Virginian																		
Westgate, Va.	1949	540	26.8	1	4	-	-	Cinders,crushed stone,sliding 65' fill.	8,040	14.89	0.555	$8,500	$75	$8,425	99	1	3	Pneumatic, track & fill.

Report on Assignment 8

Fences

(a) Metal Fence Post—Specifications
(b) Electric Shock Fences—Specifications

L. V. Johnson (chairman, subcommittee), J. W. Purdy, L. R. Shellenbarger, R. C. Young.

Your committee reports this year on both assignments.

(a) Metal Fence Post—Specifications

This is a final report, submitted with the recommendation that it be adopted and published in the Manual, replacing the specifications now appearing on pages 1–71 and 1–72.

SPECIFICATIONS FOR METAL FENCE POSTS

1. Classes

Metal fence posts shall be divided into two classes:

(a) Posts which support the straightaway body of the fence shall be designated as line posts.

(b) Such other special posts as are needed at the end or corner of the fence and at gates, shall be designated as end, corner, and gate posts.

2. Material

Posts shall be fabricated from hot rolled steel sections meeting either of the requirements shown in the following table:

METAL QUALITY

Grade	*Tensile Properties* *Yield Str. Psi*	*Ult. Str. Psi*
Hot rolled carbon steel—minimum carbon content 0.35 percent	40,000 min	70,000 min
Hot rolled rail steel[1]	50,000 min	80,000 min

[1] As defined in the U. S. Bureau of Standards, Commercial Standard CS150–48, rail steel products shall be rolled from standard Tee-Section steel rails. No other material, such as those known by the terms "rerolled," "rail steel equivalent," and "rail steel quality" shall be substituted.

3. Strength

Finished steel fence posts shall be of sufficient strength so that when clamped rigidly, a load of 300 lb applied at 3 ft from the face of the clamp will not cause a deflection exceeding 6 in or a permanent set exceeding 2½ in. The load for this test shall be applied to the face of the post against which the fence material bears.

4. Ductility

A finished post resting upon supports 5 ft apart, and with a load applied at the center, must withstand bending 9 in from a straight line, with no signs of failure.

5. Workmanship

All posts shall be smoothly rolled or formed and shall be straight throughout their length. Each finished post shall be free from burrs or other deformation caused by fabrication. They shall also be free from slivers, depressions, seams, crop ends and evidence of being burnt. (The above does not refer to rough places caused by zinc coating when galvanized.)

Excessive bow, camber, twist, or other injurious defects shall be considered cause for rejection of such posts.

6. Finish

Painted posts shall be cleaned of all loose scale prior to finishing and one or more coats of highgrade, weather-resistant, special steel paint or enamel shall be applied and baked.

Galvanized posts shall be galvanized by the hot dip process and shall possess a uniform coating of Prime Western spelter or better grade, with not less than 2 oz per sq ft of surface.

7. Special Fabrication for Line Posts

Line posts shall be fabricated to the section agreed upon by the purchaser.

Line posts shall be tee, U, Y, channel, or other suitable section and shall have corrugations, knobs, notches, holes, or studs so placed and constructed as to engage at least 12 fence line wires in proper position in a height of 5 ft above the surface of the ground. Posts may be punched with holes in such position and of such size as will not impair the strength of the post.

If the posts are not so designed as to make anchorage for alinement unnecessary, an anchorage device shall be rigidly fabricated to bottom portion of posts. Anchor plates on line posts shall weigh 0.67 lb or more each and shall be tapered to facilitate driving. Anchor plates shall be clamped, welded, or riveted to the posts in a substantial manner to prevent displacement of anchor plates when posts are driven.

All posts shall permit the refastening of the wire at least five times without damage to the connection appliance, if an integral part of the post.

All posts shall be capable of being driven in ordinary earth without injury to the post.

All posts shall have sufficient length so that when installed with the required height above ground, ⅓ of the total length shall be underground, providing that the post shall extend into the ground not less than 2½ ft.

8. Special Fabrication for End, Corner, and Gate Posts

End, corner, and gate post assemblies shall be angle sections consisting of 2½ by 2½ by ¼ in uprights and the required number of braces, either 2 by 2 by ¼ in or an alternate of approximately equal weight, such as a 2½ by 2½ of appropriate thickness. For joining, the uprights and braces shall be supplied with the necessary holes and bolts of standard commercial quality or other satisfactory substitute, such as castings. All posts shall have sufficient length to permit installing 3 ft into the ground.

9. Weights and Shapes

Sketches shown are suggestive of typical cross sections commonly supplied. Sizes shown in Fig. 1 are approximately half scale, however, both overall and thickness dimen-

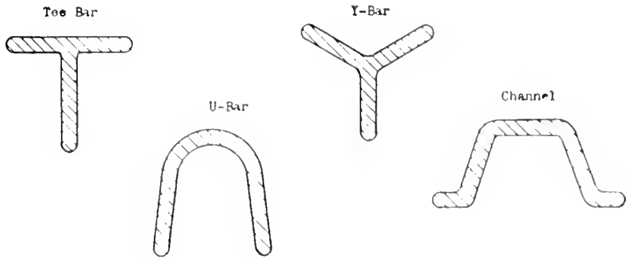


Fig. 1—Typical cross sections of steel fence posts commonly available.

sions will vary with individual post designs. All sections will conform to standard nominal weight of 1.33 lb per ft.

Sections shown do not illustrate features for attaching fence wire and preventing vertical displacement, such as rolled in lugs, notches, studs, corrugations, or punched oval, round, or slotted holes.

Nominal Weight

Line posts shall have a nominal weight of 1.33 lb per ft, exclusive of anchor plate.

Angle type end, corner and gate posts shall have a nominal weight of 4.10 lb per ft for upright members and bracing members shall have a nominal weight of 3.19 lb per ft.

Permissible variation in weight shall be a maximum of 3½ percent over or under nominal weight shown in the following tables. Weights are to be taken on the total lot of posts in each order.

Nominal Weights of Line Posts

Post Lengths Feet	*Weight* Pounds*	*Post Lengths Feet*	*Weight* Pounds*
5	7.32	7	9.98
5½	7.99	7½	10.65
6	8.65	8	11.31
6½	9.32		

* Includes anchor plates and paint.

Nominal Weights of End, Gate and Corner Assemblies

Post Assembly	*Length Feet*	*Weight* Pounds*
End or gate (1 brace)	7	51
Corner (2 braces)	7	73
End or gate (1 brace)	8	58
Corner (2 braces)	8	84
End or gate (1 brace)	9	66
Corner (2 braces)	9	94

* Includes weight of paint and bolts.

Permissible variation in length shall be a maximum of 1 in under and 2 in over the designated length of the post.

Formed Wire Fasteners

Each line post shall be furnished with not less than 5 suitable, galvanized wire fasteners or clamps of not less than 0.120 in. in diameter for attaching the fence wires to the post. Ordinary wire staples will not be considered suitable fasteners.

10. Inspection

Inspection and approval of the posts shall be made by the engineer or other authorized representative of the purchaser. Such inspection shall be made at the plant of the manufacturer, who will allow the inspector access to all operations involved and shall facilitate as much as possible the work of inspection and provide necessary facilities for inspection. Two posts out of each 200, selected by the inspector at random, shall be inspected and tested, and if they meet the requirements, the lot shall be accepted. If either fails to meet requirements, 3 other posts shall be selected in like manner by the inspector, and if any 1 of these shall fail, the lot shall be rejected.

(b) Electric Shock Fences—Specifications

Last year your committee presented as information a tentative draft of Specifications for Electric Shock Fences (Preceding, Vol. 53, 1952, pages 759 to 764, incl.) and requested comments or criticisms thereon. These specifications are now submitted with the recommendation that they be adopted and published in the Manual.

Report on Assignment 10

Ballast

(a) Tests.
(b) Ballasting practices.
(c) Special type of ballast.

A. T. Goldbeck (chairman, subcommittee), E. W. Bauman, J. E. Chubb, A. P. Crosley, H. W. Jensen, R. R. Manion, C. D. Turley, Stanton Walker, C. E. Webb.

This year your committee presents two progress reports under Assignment (a), as Parts 1 and 2.

Part 1

Research Project on Ballasts

The following is a preliminary report of the ballast tests under committee sponsorship started late in 1952. No test data is available for presentation this year. The work will be performed by the research staff of the Engineering Division of the Association of American Railroads under the general direction of G. M. Magee, director of engineering research, and Rockwell Smith, research engineer roadway. It will be supervised and reported by G. L. Hinueber, assistant research engineer roadway.

Introduction

One of the most important problems encountered in the design of railway ballast is the determination of the type and gradation of ballast material to be used. The principal purpose of ballast is to distribute the load transmitted through the rails and ties over the subgrade, and to provide adequate drainage under the ties.

In general, the coarser types of ballast have been assumed to possess the higher stabilities. To insure drainability, present specifications call for clean, open graded material. The above desirable qualities of railway ballast can be realized only so long as it remains in approximately the original condition. Therefore, resistance to crushing under impact loads imposed by heavy, fast-moving traffic is one of the important considerations in the selection of railway ballast.

Purpose and Scope

This investigation is proposed as the beginning of a research project to determine the durability and stability of various types and gradations of ballast materials with the purpose of obtaining information which will help reduce ballast costs by the rational selection of available types and gradations which will produce the best service records and lowest maintenance expenditures.

The behavior of the ballast under simulated traffic will be checked with the results of the Los Angeles abrasion test on the ballast. The Los Angeles abrasion test is in the AREA ballast specifications, but there has been considerable question as to whether or not it is a proper criterion for the selection of ballast material and the forecasting of its service behavior. Other tests which will be run in connection with these investigations are the mechanical analysis, soundness, specific gravity and absorption, and a cementing value test.

Materials

For the first series of tests the materials tested will consist of two different types of crushed stone, crushed slag and crushed gravel, with two different gradations of each being used. The gradations will conform as nearly as possible to present AREA specifications. A number of sources of each type of ballast material will be investigated.

Equipment

An oscillator combining static weight with centrifugal force to give a loading of 28,000 lb, with full relief of load between cycles, will be used on a test section which consists of 39 ft of track on 7-in by 8-in by 8-ft 6-in ties spaced 20 in on centers (See Fig. 1). The ballast rests on a semi-flexible base consisting of 10 in of crushed rock with a 2 in bituminous cover. A test section of the ballast 5 ft by 15½ ft will be separated from the remainder of the ballast by flexible partitions to prevent the material being tested from mixing with the remainder of the ballast. Provision will be made for full recovery of the ballast material from the test section so that determination of abrasion and breakdown under simulated service can be made.

Procedure

Each section will be tested by placing the oscillator across the two rails and running at a speed of 8.5 rps for a period of about 140 hr, which will give a total loading of approximately 60 million tons. This will be the equivalent of 3 years of heavy rail traffic.

Accurate sieve analysis will be made both before and after the impact test. Los Angeles abrasion, soundness, specific gravity and absorption, and cementing value tests will be made at the same time the oscillator test is in progress.

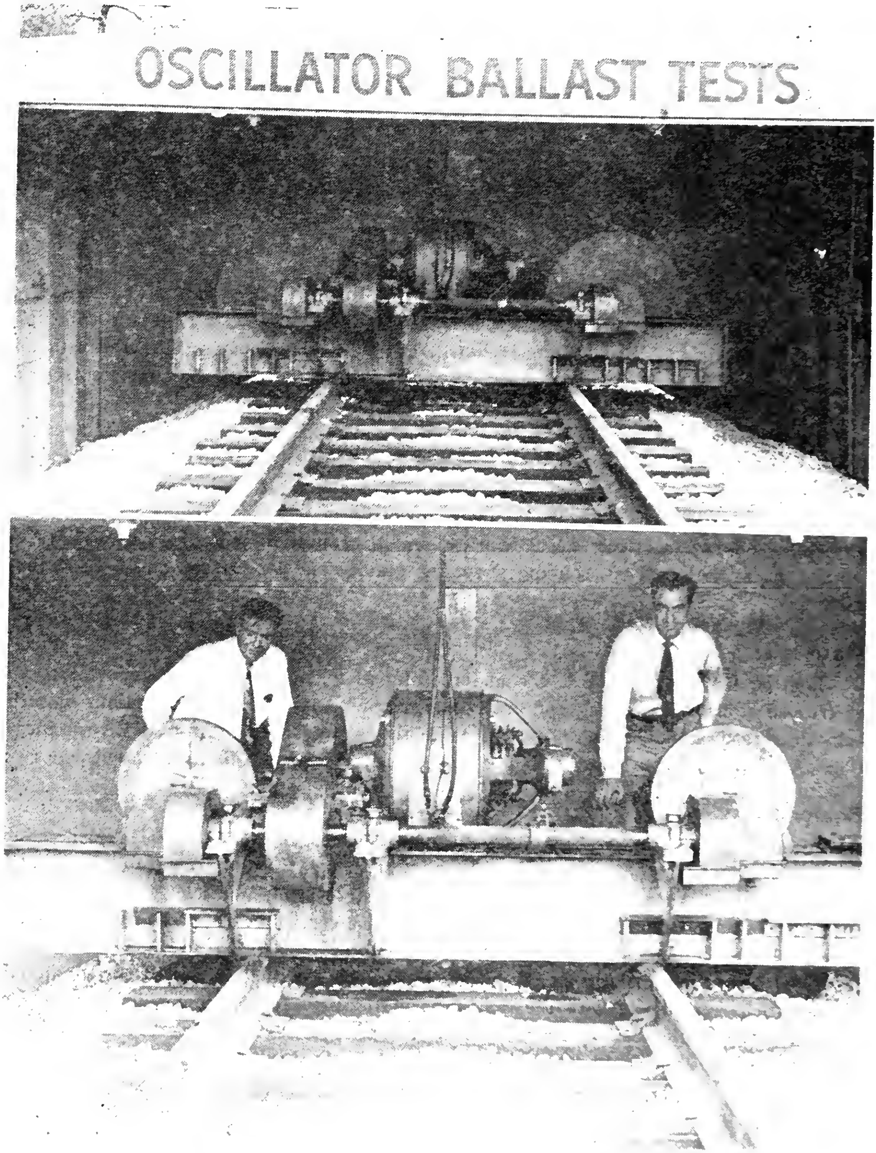


Fig. 1—Oscillator on ballast test track.

Part 2

Tests of Stone, Gravel, and Slag Railroad Ballast

This preliminary report covers an investigation of railroad ballast. Tests were performed by the laboratories of the National Crushed Stone Association, National Sand and Gravel Association, and National Slag Association, on samples of stone, gravel and slag ballast, respectively, submitted by the railroads cooperating in the investigation. This report summarizes the test data and the field performance data submitted with the samples.

The purpose of the investigation was to attempt to correlate laboratory tests with field performance of ballast, with a view toward establishing realistic and definitive specification limits. The railroads were asked to submit ballast samples from their various sources of supply and, where possible, companion samples taken from the track, together with information as to field performance.

The total number of samples received, data on field performance, and results of laboratory tests performed in the respective laboratories are reported separately for each type of ballast. The three laboratories performing these tests worked independently, using accepted test methods and procedures where applicable. The testing procedure varied somewhat among the laboratories, as did the sources of ballast submitted.

In general, most samples were rated "satisfactory" or better, few being rated "poor", and some not rated at all as to field performance. None of the three laboratories reported any significant correlation between field performance and the laboratory tests performed. The total number of samples submitted for test was small in comparison to the total number of sources of ballast available over the country. Reports from the three cooperating laboratories are in agreement that the present investigation gives no basis for establishing specification limits. It is felt that a more useful purpose could be served by testing samples of individual ballasts which are known to have poor records of service. Perhaps, in this manner some basis for evaluating the causes of the poor performance of certain materials could be established.

TEST RESULTS

National Crushed Stone Association

A total of 65 samples of stone ballast was received by the laboratory of the National Crushed Stone Association, Washington, D. C., for test in this investigation. Of these, 30 represented track samples taken from under ties and 35 were from the track shoulder or stockpiles. Since not every one of the 35 stockpile samples was accompanied by a companion track sample, the tabulation of results lists 36 ballast samples as being tested.

All stone ballast samples of source material were tested for gradation, specific gravity and absorption, magnesium sulfate soundness loss, and Los Angeles abrasion loss. In addition, the percentage of material in the track samples finer than the No. 12 sieve was determined. Most abrasion tests were run using the F (2 in to 1 in) or G (1½ in to ¾ in) grading, depending on the size of the original sample. Both gradings were used in several cases. In addition to the usual determination of loss through the No. 12 sieve, a minus No. 200 determination was made on the abrasion samples after the test.

Samples for soundness testing consisted of 2500 g of stone 1½ in to 1¼ in. in size. After 5 cycles of the magnesium sulfate soundness test, their loss was determined by re-screening over the 1¼-in sieve. In three cases, when it was not possible to use the

1½-in to 1¼-in stone because of a finer grading, sizes were selected which most nearly represented the sample, and the loss computed as an average percentage loss for the sizes tested.

Table 1 summarizes the results of the laboratory tests and field evaluation data for the 36 stone ballast samples tested. It will be noted that all but one sample was rated "good" or "satisfactory" in resistance to weathering and breakage. Abrasion losses for those rated "good" range from 9.8 to 28.2, while those for the samples rated "satisfactory" vary from 12.9 to 34.1. The "unsatisfactory" sample had an abrasion loss of 24.2. While there is a trend towards increased abrasion loss with a less satisfactory service rating, the large amount of overlapping and great range in values make it highly

TABLE 1—SUMMARY OF TESTS OF STONE BALLAST

Lot No.	Type	*Field Performance*		*Los Angeles Test*				*Minus No. 12 Track Sample*	*Loss 5 Cyc. $MgSO_4$*	*Tonnage*[7]
		Weathering and Breakage	*Pumping*	*Grading*	*% Loss*	*Minus 200 percent of*				
						Loss (—12)	*Total Sample*			
4482, 83	Trap	Good	None[4]	F	9.8	63.7	6.2	25.4	0.1	35-40
				G	14.1	53.7	7.6			
4463, 64	Trap	Good	Moderate	G	10.8	66.0	7.1	9.0	0.7	35
4501, 02	Trap	Good	None	F	13.4	67.1	9.0	0.9	0.5	--------
4504, —	Granite	Good	None	F	13.4	55.8	7.5	--------	0.4	--------
4503, —	Granite	Good	None	F	14.7	47.5	7.0	--------	0.5	--------
4487, 85	Dolo.	Good	None	G	16.7	59.2	9.9	2.0	5.4	--------
4451, 52	Lime.	Good	None	F	17.0	51.7	8.8	3.9	0.2	21.1
4508, 09	Chat	Good	None	C	19.1	16.6	3.2	14.5	4.7[1]	7
4506, 07	Chat	Good	None	G	20.1	42.6	8.6	9.7	6.3[2]	7
4534, 95	Lime.	Good	None	G	20.8	42.6	8.9	0.3	0.1	39
4499-4500	Lime.	Good	None	F	21.4	47.4	10.2	[5]	0.2	--------
4521, 22	Dolo.	Good	None	F	21.8	67.9	14.8	1.6	1.7	16.4
4496, 95	Lime.	Good	None	F	22.2	45.8	10.1	1.6	3.0	--------
4475, —	Dolo.	Good	None	F	22.4	75.1	16.8	--------	11.5	16.5
4484, 86	Lime.	Good	None	G	26.4	45.8	12.1	11.5	3.0	--------
4467, 68	Dolo.	Good	None	F	26.4	76.5	20.2	0.8	1.3	15
4497, 98	Quartz.	Good	[6]	G	28.2	43.6	12.3	3.6	5.3	28.7
4492, —	Felsite	Satis.	Moderate	F	12.9	66.3	8.6	--------	1.9	38-90
4448, 49	Lime.	Satis.	None	F	15.1	44.9	6.8	8.6	0.8	17.4
4448	--------	--------	--------	G	19.8	45.0	8.9	--------	--------	--------
4541, 36	Quartz.	Satis.	Excessive	G	19.9	39.5	7.8	13.0	0.0	36.8
4446, 47	Lime.	Satis.	[6]	G	20.1	56.0	11.2	0.7	2.1	43.0
4532, 45	Lime.	Satis.	Moderate	G	23.0	53.5	12.3	11.1	7.5	52
4477, —	Lime.	Satis.	Moderate	F	23.7	54.8	13.0	--------	4.2	25
4533, 65	Lime.	Satis.	Moderate	G	24.6	46.5	11.4	13.3	1.9	26.7
4472, 73	Lime.	Satis.	Moderate	F	24.7	77.6	19.2	10.8	0.2	25.5
				G	27.8	73.9	20.5			
4510, 11	Lime.	Satis.	None	G	25.1	43.0	10.8	5.7	3.8	22.9
4493, —	Lime.	Satis.	Moderate	G	25.6	66.8	17.1	--------	5.4	31-39
4525, 26	Lime.	Satis.	Moderate	F	26.6	51.6	13.6	1.0	1.2	--------
4523, 24	Lime.	Satis.	Moderate	F	27.3	47.9	13.0	20.4	0.5	--------
4527, 28	Dolo.	Satis.	Excessive	F	27.3	62.7	17.1	8.4	0.2	--------
4465, 66	Dolo.	Satis.	None	F	29.3	69.4	20.4	1.1	16.7	11.0
4531, 38	Dolo.	Satis.	Moderate	G	30.2	69.4	21.0	17.7	4.3	41.7
4471, 70	Dolo.	Satis.	Moderate	G	31.3	62.8	19.7	8.4	61.7	14.6
4542, 37	Quartz.	Satis.	None	G	34.1	14.6	5.0	12.8	5.6[3]	36.8
4474	Dolo.	Satis.	None	--------	--------	--------	--------	3.5	--------	10.5
4454, 53	Dolo.	Unsatis.	Moderate	F	24.2	66.2	16.0	3.1	7.2	25.0

[1] ⅜ in to No. 4 size only.
[2] Average of four sizes—1 in to No. 4.
[3] Average of three sizes—¾ in to No. 4.
[4] Little or none.
[5] Sample of insufficient quantity.
[6] Not rated.
[7] Gross Tonnage of Traffic—Millions of tons annually.
NOTE: It is possible that sample No. 4454 has been confused with No. 4471 which was described as containing an excessive amount of soft shale. Neither sample was properly identified.

questionable that any reliable correlation can be established between the field performance rating of these ballast samples and the abrasion loss.

Average soundness losses are relatively low, averaging 2.6 percent, 3.5 percent, and 7.2 percent, respectively, for those ballasts rated "good", "satisfactory" and "unsatisfactory" in resistance to weathering. It is doubtful that this is of significance, considering that, within each category there were individual samples having losses greater than 10 percent, though the generally low values for soundness loss are in line with the generally satisfactory field performance of the ballasts. The "satisfactory" rating given the samples having the extremely high soundness loss of 61.7 percent may be due to confusion as to its proper identification (see note Table 1).

Of the 36 samples tested, 2 were rated as pumping excessively. Both had "satisfactory" ratings as to resistance to weathering and breakage. The one "unsatisfactory" sample in regard to weathering had only a "moderate" rating in pumping, although the test results show no indication of excessive loss either in the abrasion or the sulfate soundness test. In view of the test results there appears to be no correlation between the tests performed on the ballasts in this investigation and their rating as to pumping. It might be of interest to note, however, that pumping was not confined to the limestone or dolomite, but also occurred with the igneous rocks and the quartzite.

National Sand and Gravel Association

A total of 17 gravel ballast samples representing only 10 sources of supply from 5 different railroads was received for test in the laboratory of the National Sand and Gravel Association at College Park, Md. There were 6 pairs of samples representing both source of supply and corresponding track samples, 3 from the source of supply only, and 2 samples from the same source taken from different locations in the track. All of the samples were tested for grading, specific gravity, absorption, resistance to abrasion and crushing, and soundness. The results are given in Table 2.

Questionnaires from eight of the ten sources of ballast were returned. One ballast was rated "unsatisfactory" and seven "satisfactory" or better. It should be noted that the area from which samples were furnished was confined to only 4 states—Ohio, Indiana, Wisconsin, and Texas. It is clear, therefore, that a representative cross section of typical gravel ballast was not received.

Complete sieve analyses were made on all samples. With the exception of aggregates from sources C and E, which contained about 50 percent of sand sizes, all of the materials, as furnished from the sources of supply conformed quite closely to the appropriate grading requirements of Specifications for Prepared Stone, Slag and Gravel Ballast of the AREA, depending on percentage of crushed particles. Companion samples from the same sources, which had been exposed to several million tons of traffic in the track, were in all cases considerably finer, indicating appreciable degradation of these materials in service. The evidence is not conclusive, however, since the original gradings of these track samples is not known.

The results of specific gravity tests give no information as to the quality of the ballast. Absorptions likewise indicated little, there being none excessively high and little variance between the source and track samples.

Losses in the Los Angeles abrasion test were all comfortably within the maximum limit of 40 percent given in AREA specifications. Ten of the 15 samples tested fell within the narrow range of 25 to 30 percent; the maximum was 35 percent. In general, the ratio of loss at 100 revolutions to that at 500 was very close to 0.20. In the 4 cases where the ratios were as high as 0.23 to 0.25 the presence of soft or friable particles might be

TABLE 2—SUMMARY OF TESTS OF GRAVEL BALLASTS

R.R. No.	*Source*	*Lot No.*	*Service Performance*	*Sp.G.*[1] *Blk. Dry*	*Abs. %*	*Abr. Loss %*[2]	*Ratio 100 to 500 Rev. Loss*	*Red. F.M. in Crushing Test*[2]	*% Loss 5 Cyc.* Na_2SO_4
1	A	2392	(Data not submitted)	2.64	1.5	26.7	0.21	1.13	6.3
1	B	2403	Satisfactory	2.59	2.0	26.0	0.21	1.14	6.0
2	C	2393	Good	2.67	1.5	28.6	0.19	1.12	7.7
3	D	2398	Unsatisfactory	2.74	0.8	27.7	0.21	[5]	2.7
		2399*	Fouling and Cementing	2.73	0.9	27.4	0.19	1.12	3.0
3	E	2400	Good	2.74	1.0	18.4	0.22	1.11	4.2
		2401*		2.74	0.9	16.7	0.20	[5]	5.2
4	F	2405*	(Data not	2.64	1.2	26.9	0.23	1.54	5.3
		2405A*	submitted)	2.62	1.6	25.4[4]	0.22	[5]	5.7
5	G	2425	Satisfactory	2.58	2.1	27.7	0.22	1.30	10.5
		2413*		2.59	2.0	[5]	[5]	[5]	5.8
5	H	2424	Satisfactory	2.60	1.9	29.1	0.23	1.41	9.6
		2439*		2.60	1.9	23.6[4]	0.21	[5]	6.8
5	K	2426	Satisfactory	2.57	2.4	34.8	0.24	1.40	11.7
		2431*		2.58	2.1	[5]	[5]	[5]	12.9
5	L	2427	Satisfactory	2.60	1.8	28.0	0.25	1.20	9.2
		2433*		2.63	1.9	20.9[6]	0.24	[5]	6.3

*Samples taken from track. All others from source of supply.
[1]For fraction coarser than No. 4 sieve.
[2]For "A" grading except as noted.
[3]Reduction in fineness modulus due to crushing of sample having initial fineness modulus of 7.00.
[4]"B" grading.
[5]Insufficient material for this test.
[6]"C" grading.

suspected. There was a slight tendency for the loss ratio, and total abrasion loss, to be lower for the track samples than for companion samples of source material, indicating that degradation of soft and friable particles in the gravel ballast occurs under traffic. No significant correlation between field performance and the abrasion test was discovered. The only sample rated "unsatisfactory" had an abrasion loss well within the range of most of the samples rated "satisfactory" or better.

A crushing test, similar to the one employed in earlier tests for the committee[1], was made on samples for which sufficient material was available. This test was made on a 3000-g sample of ballast graded 25 percent each of the 1 to ¾ in, ¾ to ½ in, ½ to ⅜ in, and ⅜ to No. 4 sizes, placed in a 6 in diameter steel cylinder and loaded to 3000 psi (85000 lb) at the rate of 35 psi per second through a steel piston on the upper surface. The load was released immediately upon reaching the maximum and a complete sieve analysis made. The reduction in fineness modulus was determined for each sample (original F.M. = 7.00) and is tabulated in Table 2. For 9 of the 10 samples tested, the range in fineness modulus after crushing was from 5.6 to 5.9. There is no basis for correlation between these data and the field rating of the sample. The tenth sample (F.M. after crushing = 5.46) had no field performance rating submitted with it.

All of the samples of ballast were subjected to 5 cycles of the sodium sulfate soundness test using all standard sizes present in amounts greater than 5 percent of the total sample as specified in ASTM method C 88–46T. The average loss, for tests in triplicate, are given in Table 2. Because of the wide spread in grading of the different samples, no attempt was made to weight the averages in accordance with sieve analyses. Except for the samples of ballast from two sources, G and K, all of the results were below the 10

[1] See Proceedings, Vol. 31, 1930, page 761.

percent limit given in AREA specifications. Note that the sample given the "unsatisfactory" rating had a low soundness loss. No significant trends can be seen from these data.

The number of samples of gravel ballast and the range in test results were so small that no conclusions can be drawn from the data given here. Most of the test results were within the limits ordinarily considered satisfactory. In no way do the test results indicate a positive basis for judging the performance of materials which would be classed as poor by conventional standards, nor do they suggest any definite specification limits.

National Slag Association

Seven samples of slag ballast were submitted to the National Slag Association laboratory at Walford, Pa., for test in this investigation. Four of these ballasts were from 1 railroad, 2 from another, and 1 from a third, altogether representing only 3 sources of slag. All samples were tested for sieve analysis, unit weight, specific gravity, absorption, sodium sulfate soundness loss, Los Angeles abrasion loss, and crushing factor. Table 3 gives a summary of the results of these tests (except the sieve analysis) and the field performance data obtained from the questionnaires.

The crushing test was made on the ¾ to ½-in and ½ to ⅜-in sizes of the ballast samples, each tested separately. A sample of 98 cu in of compact material was weighed and divided into 3 equal parts, for 3 tests on each size. The test sample was placed in a steel cylinder having an inside diameter of 5½ in, this quantity making a layer approximately 1⅜-in thick. A total pressure of 11,000 lb was then applied by means of a steel plunger working inside the cylinder and actuated by a standard compression testing machine. The load, after reaching 11,000 lb, was immediately released. The sample was then removed from the cylinder and a sieve analysis made, the crushing factor being the difference between the sum of the total percentage of material retained on the ½-in, ⅜-in, and No. 4 sieves before and after testing. The crushing factor for the various slag samples, as determined by the above method, is shown in Table 3.

None of the test results listed in Table 3 reveal any significant factor which might help distinguish between good and bad slag ballasts. All of the samples were rated "satisfactory" or better and meet specification limits for the tests run on them. The values for crushing factor ranged from 25.2 to 72.5, both maximum and minimum values being for samples from the same source, listed as "first class ballast". Abrasion and soundness losses were confined to a narrow range and show no tendency towards cor-

TABLE 3—SUMMARY OF TESTS OF SLAG BALLASTS

Sample Lab. No	*Performance Rating*	*Dry Wt. Per Cu. Ft.*		*Abs. %*	*Sp. Gr. Bulk Dry*	*Avg.[1] % Loss Na_2SO_4*	*Abrasion*		*Crushing Factor[2]*
		Loose	*Compact*				*Grading*	*% Loss*	
1	Good	82.6	93.6	0.2	2.50	0.2	F	26.6	31.2
2	Good	89.6	101.0	0.8	2.59	0.5	A	26.5	25.2
3	Good	70.0	79.6	1.8	2.26	0.2	B	33.3	72.5
4	Good	83.8	94.6	2.2	2.31	0.8	A'	28.6	58.5
5	Satisfactory	66.2	76.0	1.8	2.25	[3]	G	84.8	[3]
6	Good	78.0	88.6	2.1	2.43	0.8	A	28.9	64.5
7	Good	82.0	94.2	1.0	2.58	0.2	G	29.9	--------

[1] Average of three sizes—1½ to ¾ in, ¾ to ⅜ in, ⅜ in to No. 4.
[2] ¾ to ½-in size.
[3] Insufficient material for this test.

relation with field performance. Furthermore, the small number of samples submitted for test would tend to reduce the value of any apparently significant factor arising from such tests.

CONCLUSIONS

Generally it can be said that no correlation was found between the evaluation of field performance for the samples of ballast submitted by the railroads and the tests performed on those samples in the cooperating laboratories. The total number of samples submitted, particularly for gravel and slag, was small and so, necessarily, was the range of information obtained from them. Further, most of the ballast samples were rated at least "satisfactory" and in general met present specification limits. As such, then, these tests offer little by way of definite information which might be used in establishing realistic specification limits.

Report on Assignment 11

Chemical Control of Vegetation

C. E. Webb (chairman, subcommittee), C. R. Bergman, M. W. Cox, G. B. Harris, H. Leard.

The following report is presented as information. It is part of the work under committee sponsorship of the research staff of the Engineering Division, AAR, performed under the general direction of G. M. Magee director of engineering research, by Rockwell Smith research engineer roadway, and J. A. Fellman, assistant research engineer roadway, of the research staff.

The report is divided into two parts. Part 1 is the second annual report of the investigations performed at Iowa State College, Ames, Ia., under a cooperative agreement between the Iowa Agricultural Experiment Station of Ames and the Engineering Division. W. E. Loomis, professor of plant physiology, Iowa State College, is in charge.

Part 2, prepared by Mr. Fellman, is a resumé of some field investigations on various roads made by the research staff, AAR.

Part 1

Second Annual Report AAR Weed Control Project

W. E. Loomis and D. W. Young[1]

Research work has been continued on the railroad project with the main work centered at Ames, Iowa, and supplementary tests at Bozeman, Mont. and Gainesville, Fla. We have applied several hundred additional treatments this season along with a follow-up of last season's work. The same generous cooperation was extended by A. L. Barr and his associates of the Chicago and Northwestern, and L. R. Jones and his associates of the Fort Dodge, Des Moines and Southern.

One of the main objectives this season was to test further some of the more favorable combinations of herbicides used last year, and to check on the residual effect of the various treatments.

[1] Professor and associate, respectively, Iowa Agricultural Experiment Station, Ames, Iowa.

The mixture of 40 lb of TCA, sodium salt and 80 lb of sodium chlorate held up well under Iowa conditions in 1952. A semi-commercial test was made this year, applying the TCA–chlorate in May with a retreatment of 60 gal of oil per acre in August. These two treatments gave satisfactory control of both annual and perennial weeds for the season under Iowa conditions. The heavier applications of CMU or Borascu gave effective weed control. Where more permanent soil sterility is desired and cost is less important, these materials should prove useful. Treatments with oils of moderately high boiling point and high aromatic content also gave good weed control and appear definitely to have a place in a weed control program. Effective control of annuals was obtained with sodium arsenite. However, the dry arsenic trioxide pellets were ineffective.

In 1951 an experiment was undertaken to study the cumulative effect of repeated treatments and their carry-over as soil sterilants. CMU and Borascu were the only chemicals that persisted for more than one year, as shown by Table 1. From our studies it does not appear practical to control weeds for more than one season with one treatment. Chemical treatments may reduce weed populations and subsequent treatments can be less expensive than the first, but leaching of chemicals from the soil, combined with reinfestation, will make repeat treatments more economical than the use of an excessive rate of existing chemicals in an attempt to secure prolonged sterilization.

TABLE 1—THE EFFECT OF REPEATED TREATMENTS ON ROADBED VEGETATION
(All treatments in May of the indicated seasons)

Chemical and Rate Per Acre, Pounds	*Application*	*Percent Vegetation Control, 10/1/52*
TCA 80	'51, '52	47
"	'51	7
Chlorate 320	'51, '52	72
"	'51	8
CMU 30	'51, '52	85
"	'51	67
Borascu 3,200	'51, '52	85
"	'51	62
TCA 40-chlorate 80	'51, '52	82
"	'51	23
CMU 10-chlorate 80	'51, '52	95
"	'51	40
CMU 10-TCA 40	'51, '52	83
"	'51	35
Arsenic trioxide 640	'51, '52	3
"	'51	0

Tests were begun this season to ascertain the optimum amount of TCA and sodium chlorate to use in a herbicidal mixture. The TCA was varied from 20 to 60 lb and the chlorate from 80 to 200 lb. The experiments showed little advantage from increasing the rate of chlorate above 80 lb. In several tests 40 lb of TCA appeared to be the minimum effective rate. We have indications that two treatments of TCA 40-chlorate 80 are more effective on resistant vegetation than increased rates at a single time.

CMU was tested extensively again this year. It is a slow-acting herbicide which is effective on perennial grasses in Iowa. Rates up to 80 lb per acre showed little effect on roses, and only limited effect on wild morning glory and horsetail. Rates of CMU of 20 lb per acre have given excellent control of quack grass and smooth brome grass in Iowa and Montana. Ten pounds of CMU in combination with 80 lb of sodium chlorate has also given effective control of grasses, most herbacious, and several woody plants in Iowa, but was not effective against Bermuda grass in Florida. At present CMU is expensive and difficult to keep in a sprayable suspension, but merits further testing.

To some of the soil sterilants 2,4–D was added in an attempt to increase the control of horsetail and broad-leafed weeds. The data in Table 2 show that adding 2 lb of 2,4–D to CMU or TCA had no beneficial effect when the two were applied together.

Table 2—The Effect of Adding 2,4–D to CMU and TCA

Chemical and Rate Per Acre, Applied on 6/4/52, Pounds		*Percent Vegetation Control, 10/1/52*
CMU 10		78
"	+ 2,4–D 2	77
CMU 20		88
"	+ 2,4–D 2	87
CMU 40		100
"	+ 2,4–D 2	95
TCA 60		50
"	+ 2,4–D 2	52

An experiment was conducted to ascertain the most effective date of application of herbicide, using the two most promising combination of chemicals used last year for perennial grass control. Spray dates were November 9, 1951, April 18 and May 29, 1952. The chemicals used in pounds per acre were TCA 40-chlorate 80, and CMU 10-chlorate 80. The plots consisted of nearly pure stands of quack and brome grass.

At each spray date the CMU-chlorate mixture gave slightly better control of the perennials than the TCA-chlorate (Table 3). The CMU-chlorate plots were decidedly more effective in resisting reinfestation by annual grasses and weeds. Of the three spray dates, April appeared to be slightly more effective. The CMU-chlorate spray applied in April and May tended to hold the track free from weeds during the season (Fig. 1), while the November spraying showed considerable reinfestation of annuals toward the end of the following year. Although the TCA-chlorate mixture was nearly as effective on perennials at the three dates, reinfestation with annual weeds was more rapid following this treatment.

Table 3—The Effect of Date of Application of Herbicides on Perennial Weed Control

Date of Application	*Chemical and Rate/Acre—Lb* *TCA 40-Chlorate 80*	*CMU 10-Chlorate 80*
	Percent Vegetation Control on 10/1/52	
11/ 9/51	71	77
4/18/52	80	91
5/29/52	76	89

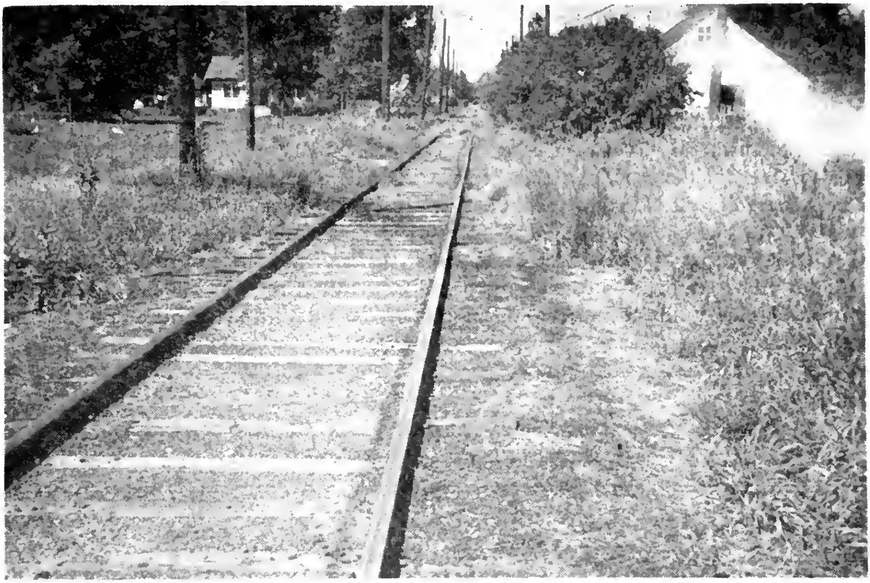


Fig. 1—CMU–chlorate applied in April and photographed in August. Quack and brome grasses were eradicated and the growth of annuals prevented at a cost of $86 per mile for chemicals. TCA–chlorate also controlled perennial grasses at a chemical cost of $40 a mile, but required burning or oil ($12 mile, cf. Fig. 2) to control reinfestation with annual weeds.

An experiment was conducted to compare the effect of applying chemicals in the dry state in a sand carrier, and spraying them in water solution. These tests were conducted on the right-of-way. The main weeds present were slough grass, porcupine grass, blue stem, marsh elder and giant rag weed. The average control of weeds is given in Table 4. In general, better control was obtained by spraying, and if machinery is avail-

Table 4—Various Chemicals Applied Dry and in Water Sprays to Railroad Right-of-Way

Chemical and Rate/Acre Pounds	*Percent Vegetation Control Applied Dry*	*Sprayed On*
CMU 10-chlorate 100	62	48
TCA 40-chlorate 100	60	83
TCA 80	60	80
Chlorate 320	55	60
CMU 40	50	67
CMU 10-TCA 40	50	85
TCA 40	43	60
Borascu, 4800	37	..
CMU 20	30	48
2,4–D, 80	28	..
Chlorate 100	27	7
CMU 10-Borascu 1600	20	..
Arsenic trioxide 800	10	..
CMU 10	10	62

able spraying is more desirable from the standpoint of uniform coverage and ease of operation, especially when a low rate of chemical is applied per acre. The apparently poor control by CMU in this experiment was due to the presence of resistant species.

Arsenic trioxide pellets have been tried as a safe way to use this chemical, with essentially no effect (cf. Tables 1 and 4). Sodium arsenite was added this year at the request of roads that have been using this chemical. Arsenic was applied in July, which was too late for the effective action of TCA-chlorate, at the rate of 160 and 640 lb an acre of arsenic trioxide equivalent. Chemical costs are estimated to have been on the order of $12 and $48 per mile. Both knock-down and seasonal control were good with the heavier rate of arsenic (Table 5). A second series of plots was started in August to test this chemical on still drier vegetation and at the three rates of 160, 320, and 640 lb an acre. Readings from this series will not be available until next year. The preliminary results suggest that arsenite may compete on a cost basis where the sometimes serious stock losses attending its use can be avoided.

Table 5—Effects of Sodium Arsenite as a Mid-Season Herbicide
(Treatments in late July, records October 1)

Chemical and Rate Pounds	*Control, Percent*
Arsenite 160	67
Arsenite 640	93
TCA 30-Chlorate 100	67
CMU 10-Chlorate 100	88

Leaching of Sodium Arsenite

Mixed vegetation growing on a silt loam soil was sprayed with 320 lb of sodium arsenite per acre. One-half-square-rod plots were selected and leached with varying amounts of water. Toxic effects on the vegetation were inversely proportional to the amount of leaching. Plots that were not leached gave rapid knock-down and effective kill of the vegetation present. Plots leached with more than 6 in of water showed no effect on the vegetation. Plots that received less than 6 in of water showed intermediate effects. Leaching was done slowly and little or no run-off occurrd. This susceptibility to leaching may limit the use of sodium arsenite in the humid areas.

Volatility of 2,4–D

Some experiments were conducted this year to determine the effects of drift and volatility of 2,4–D. A low volatile, propylene-glycol-butylether ester, and a volatile, mixed isopropyl-butyl ester, were compared at two rates in water and oil carriers.

In the first experiment on June 5 tomato plants were placed about 30 ft from the sprayed area 2 days before treatment. The 2 esters were sprayed at concentrations of 2 and 6 lb per acre in 60 gal of carrier. Wind was variable, being about 5 mph across the track. The 2-lb rate of 2,4–D showed no effect on the tomato plants. The 6-lb rate of 2,4–D, both esters in both carriers, showed effects on the tomatoes on the down-wind side. In only 1 of the 3 replications was there effect on both sides of the track, and that was with the 6-lb rate of low volatile ester in oil.

This experiment was repeated on July 15, raising the 6-lb rate of 2,4–D to 10 lb and placing the tomatoes approximately 15 ft from the edge of the sprayed area. In the second experiment the wind was again 5 to 6 mph on the day of spraying. There was no measurable drift of the 2-lb rate of the low volatile 2,4–D, but plants in 1 of the 3 replications were affected by the 2-lb rate of the volatile 2,4–D on the down-wind side. At the 10-lb rate the volatile 2,4–D affected tomato plants on both sides of the sprayed area when either carrier was used. The high rate of the low volatile ester in oil showed affect on the tomatoes on each side of the sprayed area. Where water was used as the carrier, there was an affect only on the down-wind side of the 10-lb rate of the low volatile ester.

Although the 2,4–D effect showed up on the tomatoes, even the most severely damaged matured and set fruit. Willows and wild grapes were affected by 2,4–D in the railroad right-of-way, but no 2,4–D effects appeared on a soybean field adjacent to the sprayed areas. Weed control from the two esters at both rates was comparable. However, where the heavy oil was used as a carrier for the 2,4–D there was good control of annual grasses and severe effects on some Kentucky blue grass which was present.

In an extension of these experiments, 2,4–D was applied to the main line of the C&NW to study the effect of heavy traffic in picking up and scattering dry residues of 2,4–D. Tomato plants set on the right-of-way before spraying with 10 lb of low and high-volatile esters were injured by drift when oil was used as a carrier, but not when water was used. Plants placed near the track after spraying were not injured either by volatility or dusting out.

These results suggest that drift may be more important than volatility in 2,4–D damage, and that the dangers in the use of the compound may not be great. General experience with cotton, grapes and other susceptible crops does not support such a conclusion. We suggest that 2,4–D be avoided when other chemicals can be used, that the water-soluble salts be used, and that there is no evidence of the need of heavy rates. One to 2 lb an acre may actually be more effective than a heavier dose.

Use of Oils as Herbicides

Experiments conducted last season showed that diesel oil could be fortified with dinitros and pentachlorophenols to produce effective contact weed killers. This year a number of experiments were set up to determine the factors in oils responsible for phytotoxicity and the number of times contact weed killers would have to be used to maintain a moderately clean ballast area.

One to three treatments were made with six oils (Table 6). In general, two sprays with the more effective oils gave satisfactory control of annual weeds, and helped hold perennials in check. The better oils contained about 50 percent of aromatic and olefins and had boiling points between 450 and 700 deg F. The oils were used at rate of 60 gal per acre and could be applied for approximately the same cost as burning, with the advantage of no fire damage and some preservative value for ties and rails. From a weed killing standpoint, oil sprays are easy to apply, and they offer no hazards to adjoining crops. The special value of oils probably lies in retreatments after the perennial have been removed by other chemicals.

A mile of track was sprayed in May 1952 with a mixture of TCA 30-Chlorate 100 and retreated in August with 60 gal of heavy catalytic cycle oil per acre. The two treatments gave satisfactory control of weeds for the season at a chemical cost of about $50 per mile. The latter spray was especially useful in the control of annuals, such as ragweed, crab grass and foxtail.

TABLE 6—RELATIVE EFFECTIVENESS OF VARIOUS OILS

Oil	Number of Treatments	Percent Vegetation Control 9/15/52
LHH-7	1[1]	18
	2[2]	78
	3[3]	92
Heavy cat. cycle	1	27
	2	78
	3	87
Special fuel	1	0
	2	40
	3	47
No. 200 fuel oil	1	0
+ special fuel	2	35
	3	53
No. 200 fuel oil	1	0
+ kerosene	2	8
	3	8
LHH-6	1	0
	2	0
	3	0

[1] Applied 5/29/52
[2] Applied 5/29 and 7/2/52
[3] Applied 5/29, 7/2 and 8/7/52
LHH-7, a heavy (440–750 deg F) oil, 50 percent aromatic.
Heavy cat. cycle, similar.
Special fuel, lighter (450–600 deg F) 40 percent aromatic; 200 fuel, a residual fuel low in aromatics.
LHH-6, a diesel fuel type, supposedly, but probably not, high in aromatics.

Fig. 2—The heavier aromatic oils will control annual weeds and retard perennials. One to three treatments at a chemical cost of $12 per mile each will be required. These treatments are safe, easily applied, and are recommended for many roadbed conditions.

In summary of a two-year study, applications of 40 lb of TCA sodium salt and 80 lb of sodium chlorate per acre have given effective control of quack grass, smooth brome grass, and other miscellaneous weeds. Results with this mixture have been as good as with 400 lb of sodium chlorate used alone or 100 lb of TCA sodium salt alone. Early applications, just as the perennial grass appears in the spring, have given better results than late spring or summer applications. After the perennials are removed, periodic treatments with 60 gal per acre of oil containing 50 percent aromatics and olefins, and having a final boiling point over 700 deg F, have controlled reinfestations with annual broad leaved and grassy weeds, such as ragweed, spruge, crab grass and green foxtail. Fortifying the oil with 2 lb of 2,4–D per acre may increase the value of the oil spray, especially in reducing stands of horsetail and other resistant weeds. Adding 2,4–D is feasible when there is no danger of drift to susceptible crops.

In Iowa, an April or May treatment with TCA-chlorate, combined with an August application of oil, has been the most practical first-year treatment of several hundreds tested. In Montana and Florida comparable results have been obtained, except that two TCA-chlorate sprays may be required to eradicate Bermuda grass and three or more for nut grass.

Part 2

Weed Control Report

During the summer of 1952 a number of observations were made of actual weed and brush spraying operations on different railroads, plus later inspection trips over the lines to observe the effects of spraying. The coverage this year is rather limited because many of the roads had completed their spraying before this program got underway.

This report is presented as information only with no intent that the limited observations can permit conclusions as to recommended practice.

The purpose of this investigation is twofold: First, to try to correlate methods and results of weed and brush control along different railroads in various sections of the country, and to make this information available to all roads to assist them in planning their vegetation control programs; second, to test new or different chemicals and methods to try to find better or more economical ways of controlling vegetation along railroad right-of-ways or roadbeds. During these observations note is made of the chemicals used, rate applied, types of vegetation and stage of growth, type of ballast, weather conditions, and uniformity of spray. After the final inspection an attempt is made to evaluate the importance of each of these factors.

Chlorates (sodium chlorate), used either alone or in combination with other chemicals, still seem to be the most popular treatment. Chemicals most commonly used in combination with such chlorates are TCA (sodium trichloracetate) and borates. Where conditions justify, 2,4–D is frequently used for the control of broad leaved weeds. Many tests have been made with CMU (para-chlorophenyl–1,1–dimethyl urea), both alone and in combination with other chemicals, with varying results, but its use is restricted by its cost. Borates are used extensively around bridges, trestles, storage yards and other restricted places where elimination of vegetation is desirable. Arsenicals are being used to a limited extent. A number of oil sprays are being applied, and some weed burners are used. For brush control, mixtures of 2,4–D and 2,4,5–T are most widely used.

Since vegetation and climate differ widely throughout the country each section must be dealt with separately. A treatment that gives good results in one section may not work at all in another.

When the amount of chlorate is given for a treatment it indicates the quantity of sodium chlorate used, and does not include the other chemicals mixed in to reduce the fire hazard. Costs used are for chemicals only, and are approximations based on a price of commercial formulations.

Chlorates

In central Minnesota chlorate was applied in late June at the rate of 140 lb per acre at a cost of about $24 per acre. Treatment was good for about six weeks. Most annual plants were killed and perennial vegetation top killed. After a month regrowth was apparent on such plants as perennial grasses, milkweed, bindweed *(Convolvulus arvensis)* and wild rose. Fireweed *(Kochia scoparius)* under 4 in. in height was killed. Most fireweed over 4 in high and single stemmed was not killed but was severely stunted, and continued growth was very limited. In one yard where the vegetation was as high or higher than the spray bar, the kill was streaked and spotty. The tall weeds apparently prevented complete coverage by the spray. Although the weeds were not eliminated, growth was greatly reduced for a good portion of the season. This was especially evident in yards, where there was a sharp contrast between sprayed and unsprayed tracks through July and August. On the main line perennial grasses had been perceptibly thinned out by the repeated yearly applications.

In Minnesota and Eastern South Dakota approximately 125 lb per acre of chlorate was applied in late May at a cost of about $21 an acre. In the yards the treatment was good for two months, then various grains and annual weeds started to spring up from large amounts of seed spilled from box cars, so that by the end of the season the yards were fairly well grown up to annual plants. Results on the main line and branch lines were fairly good except for problem areas. Grass was a problem on some branch lines when spraying was started three years ago. It has been thinned out considerably and now other plants, such as curly dock, milkweed, bindweed and horsetail are starting to infest the area. On some sections where there are or have been water pockets, marsh smartweed or tanweed *(Polygonum coccineum)* has become established. Two treatments this year have failed to control it. In South Dakota fireweed has been especially troublesome; two treatments have not been effective. Apparently it was killed by the first application but for these conditions 125 lb per acre is a rather light treatment and the fireweed reseeded itself. Many sections were sprayed again in July, but by that time much of the fireweed was large and branched and the effect of the chemical was limited. By the end of the season it formed a dense mat between the rails. Bushes were 3 to 4 ft tall along the shoulder.

TCA–Chlorate

In Iowa a treatment of 27 lb TCA with 123 lb sodium chlorate per acre was applied in early July at a cost of approximately $32 an acre. Annual weeds were killed, perennial grasses were controlled, tanweed was set back but not controlled. By the end of the season annual grasses, such as foxtail and crabgrass, had seeded in again and horsetail was growing strong.

In Illinois a lighter treatment of TCA-chlorate controlled perennial vegetation at the time but reduced numbers of plants, such as Canada thistle, wild rose, milkweed, bindweed, horsenettle, tanweed and horsetail showed appreciable growth after six weeks. Quack grass was greatly reduced and very slow in coming back.

In the Southeast treatments up to 80 lb TCA with 160 lb chlorate per acre did not control Bermuda grass or nut grass. Two treatments of 40 lb TCA with 80 lb chlorate, the second applied 60 days after the first, seemed to control Bermuda grass. Three treatments applied at 60-day intervals gave good control on nut grass.

Borate

Because of the large quantities required and its insoluability, borate ore is used mostly in restricted places, such as around bridges, trestles, tie piles, etc., where it does a good job of sterilizing the soil when used at the rate of 4000 lb per acre of more. It has been applied to the roadbed at the rate of approximately 2500 lb per acre with fair results for one year; it is hoped that repeated applications will build up the toxicity in the ballast and soil.

Oil

Oils, especially those with an aromatic content of around 50 percent, seem to do a good job of chemical mowing when used at the rate of at least 60 to 75 gal per acre. Costs run about $8 per acre. Two or three applications a season appear necessary.

Arsenic

There have been a number of reports on the limited use of sodium arsenite with varying results. In general, there has been a good fast initial kill and the effects fairly long lasting when at least 200 lb per acre were used.

Burning

In Illinois a light burning operation that did not appear to injure the ties just singed the vegetation. After three days plants were looking green and healthy again.

In Florida one track was heavily burned three times in three weeks, and in the fourth week the only results showing were the burned ties.

From these and other observations it appears that to control roadbed vegetation in some areas by burning would require a number of heavy burnings, each with resultant tie damage.

In the north many roads burn the roadbed section and the right-of-way in the fall to consume dead vegetation that might hold snow and ice during the winter.

Summary

Investigations have shown that the most successful weed control programs are usually started in the spring, from February in the south to early May in the north. Good results have also been obtained with late fall treatments when the subsequent spring thaw was gradual and runoff not too severe. Best results on perennial vegetation with soil sterilants, such as chlorate or TCA, have been obtained on some sections when applied just as growth is emerging or a little before. Where annual weeds have been a problem and a contact spray, such as oil, has been used, best results have occurred when plants were allowed to come up but were sprayed before they set seed. The spray should be repeated when a new crop appears.

It has been apparent from these observations that one light spray in the spring cannot be expected to control vegetation all summer. In the north one good application may last all season, while in the south two or three may be required. Also, after the control of perennial vegetation is obtained, annuals may appear later in the season. With some tough perennials, such as bindweed, horsenettle, trumpet vine and tanweed, spot treatments may be required throughout the season.

Weather seems to have a great deal of effect on results. Heavy rains a short time after application can wash away much of the chemical, whereas light rains may tend to bring soil sterilants into the soil solution and in contact with the roots. Extended periods of hot dry weather may reduce the effectiveness of many treatments, probably due in part to the low moisture content of surface soil and increased rate of breakdown of the chemicals. In many sections this past summer, drought-resistant species seemed to thrive in treated areas.

The kind of chemical used should be governed by the type of vegetation. It is best if treatments can be arranged by divisions or sections, but if this is not possible they should be aimed at the most predominant type of vegetation along the line. The treatment may or may not remain the same year after year.

No one chemical has been found that will give good results for all types of vegetation. Where perennial grasses have been the problem best results have been observed with chlorate and TCA-chlorate. Tests have shown that 2,4–D and contact killers are not effective on perennial grasses. For mixtures of perennial and annual weeds and grasses, chlorates, borates, and arsenic have been effective. Good results have been obtained on perennial and annual broadleaved weeds with chlorates, borates, arsenic and 2,4–D, while chlorates, oils and 2,4–D have been succeessful in controlling annual weeds. From these investigations minimum rates in pounds per acre appear to be chlorate 160, borate ore 3200, arsenic 200, TCA 40-chlorate 80, 2,4–D 2, and oil 60 gal.

In planning a spray program the railroads should obtain an analysis of a proposed spray and check to see that it meets their weed problem.

Brush Spraying

A considerable amount of brush spraying is being done along railroad right-of-ways. The treatment most widely used is a combination of 2,4–D and 2,4,5–T applied at the rate of 4 to 6 lb acid equivalent per acre, at a cost of about \$15 to \$22 per acre. The chemicals give every indication of doing a good job if applied properly. Almost all railroad brush spraying is done during the growing season. Complete coverage of the foliage is necessary for best results.

Last year's report contained a preliminary report on a brush spraying operation along the Western Maryland Railway in June 1951. An equal mixture of 2,4–D and 2,4,5–T was used and applied at the rate of about 6 lb acid per acre of the mixture.

Inspections during 1952 showed about 90 percent top kill of the brush. Mountain laurel and rhododendron were only slightly affected by the spray, but they are not troublesome in this locality. There has been some sprouting from locust, sassafras and box elder. The total kill was estimated at at least 75 percent. Brush along this line had usually been cut at least once each year, but on the sprayed areas no cutting was necessary in 1951 or 1952. Another thing noted was that large branches of trees that extended out into communication lines from the side were killed by the spray without necessarily killing the tree.

In a brush spraying operation along the Ottawa River in Quebec, Can., three types of treatments were used. One section was sprayed with equal parts 2,4–D and 2,4,5–T, using 2 to 3 lb acid equivalent per acre of the mixture. This is about half the rate commonly used in the United States. Another section was sprayed with a low volatile ester of 2,4–D at 2 to 3 lb acid per acre. The last section was sprayed with a mixture of 1 lb acid equivalent of 2,4–D amine and 15 lb of sodium chlorate per acre. They were all applied in approximately 120 gal of water per acre in July.

During an August inspection there were no noticeable differences in the sections, except that the 2,4-D—chlorate treatment killed the foliage faster. At this early stage only top kill would be apparent and it was about 70 percent. Species showing almost complete top kill were aspen, birch, willow and pin cherry. Hard maple, red oak and green ash were not noticably affected, except with the 2,4-D and 2,4,5-T mixture, where they showed partial kill. Inspections next spring and summer will bring out any differences in treatments, and also will make it possible to ascertain if such a light first treatment is practical.

Report of Special Committee on Continuous Welded Rail

H. B. Christianson, *Chairman*,
H. C. Archibald
T. A. Blair
Blair Blowers
C. B. Bronson
E. J. Brown
F. G. Campbell
W. E. Cornell
L. S. Crane
F. W. Creedle
J. C. DeJarnette, Jr.
R. E. Dove
P. O. Ferris
H. F. Fifield
R. J. Gammie
C. E. R. Haight
J. W. Hopkins
S. R. Hursh
T. B. Hutcheson
E. E. Martin
W. C. Perkins
L. F. Racine, *Vice Chairman*,
E. F. Salisbury
I. H. Schram
C. R. Strattman
E. C. Vandenburgh
C. E. Weller
R. P. Winton
Edward Wise, Jr.
Committee

To the American Railway Engineering Association:

Your committee reports on the following subjects:

Special Committee on Continuous Welded Rail,
H. B. Christianson, *Chairman*.

AREA Bulletin 507, February 1953.

Report on Assignment 1

Fabrication

Encompassing Methods of Welding, Space and Facilities Required, Organization, Procedure and Costs

F. W. Creedle (chairman, subcommittee), H. B. Christianson, L. S. Crane, H. F. Fifield, L. F. Racine, E. Wise, Jr., R. P. Winton.

This is the second progress report, submitted as information.

The first progress report, shown in Vol. 53, AREA Proceedings, page 683, covers a typical set-up used in fabrication of continuous welded rail by the oxyacetylene pressure welding process. The performance of welds made by this process has been satisfactory. This is shown by the fact that on one road, which has had 25,000 of these welds in track for varying periods of time up to 11 years, carrying tonnages up to total of 200 million gross tons, there have been only 2 weld failures to date, and these were due to improper cleaning of the ends of the rails, which resulted in non-fushion of the welded surfaces.

The quality of the gas pressure weld has steadily improved insofar as production of a weld which has good alinement, both laterally and vertically, is concerned. Rigid supervision at the welding machine is necessary to insure that the rails are properly lined both vertically and laterally through the machine while the weld is being made. Careful and precise workmanship is essential to the proper fabrication of continuous welded rail.

Past experience has shown that good quality welds can be made by the electric pressure process, but we feel that until such time as equipment is available which will produce satisfactory electric pressure welds at a cost comparable with present gas pressure welds, there is no need for a detailed report covering such process.

The cost of gas pressure welds depends on a number of items, the principal ones being the total number of welds to be made in a continuous operation and the amount of finishing to be done to the upset surfaces. Up-to-date information showing man-hours and costs for 4078 welds made on the Chicago & Northwestern Railway during 1952 is shown in Table 1.

TABLE 1—MAN-HOURS AND COSTS FOR 4078 WELDS MADE ON THE C&NW IN 1952

C&NW—1952—No. of Welds 4078	*Man-Hours* Total	*Man-Hours* Per Weld	*Cost* Total	*Cost* Per Weld
Welding Station				
Equipping flat cars with rollers, etc.	170	0.04	$ 280	$ 0.07
Setting up and dismantling welding equipment	346	0.08	563	0.14
Welding Operations				
Unloading rail	994	0.24	1,572	0.39
Sawing and welding operations				
Labor	14,390	3.53	23,842	5.85
Material	----	----	13,776	3.38
Loading welded rail	1,235	0.30	1,959	0.48
Watchman	1,120	0.28	1,835	0.45
Contract—Rental of equipment	----	----	4,114	1.01
Total	18,255	4.47	$47,941	$11.77

Report on Assignment 2

Laying

Encompassing Track Preparations, Transportation and Distribution of Long Rails, Installation in Track, Temperature Considerations, Closure Welds, Disposition of Rail When Continuous Rail Is Replaced, Length Limitations, Procedure at Insulated Joints, Switches, Railroad Crossings and Drawbridges, and Cost Data

F. G. Campbell (chairman, subcommittee), T. A. Blair, E. J. Brown, H. B. Christianson, T. B. Hutcheson, L. F. Racine.

This is a progress report summarizing data submitted by 24 railroads in response to a questionnaire circulated on July 10, 1951, and by 17 of these same railroads to a supplemental questionnaire issued on June 6, 1952.

The total mileage of continuous welded rail reported is 247.5 track miles, of which 208.60 miles are in open track and 38.9 miles in tunnels. The earliest installation reported was made in 1933. Installations by track miles and years are shown in the following table:

Year	*Track Miles*
1933	1.16
1934	0.95
1935	4.06
1936	1.52
1937	31.23
1939	6.04
1942	5.48
1943	6.29
1944	12.88
1945	4.81
1946	3.91
1947	18.70
1948	29.93
1949	33.05
1950	50.25
1951	37.24
Total	247.50

Rail sections installed vary from 90 lb to 140 lb, with 131 lb to 140 lb accounting for 75 percent of the total mileage, as shown in the following table:

Rail Section Pounds	*Track Miles*
90	7.20
107	9.62
110	1.07
112	7.58
115	29.87
127	1.46
129	1.38
130	3.85
131	72.89
132	79.59
133	16.85
136	4.00
140	12.14
	247.50

The maximum continuous rail length in track without any intervening joints is 19,812 ft. Maximum gradient is 1.6 percent, and maximum curvature is 12 deg 30 min.

Continuous rails have been installed at rail temperatures as low as 28 deg F, and as high as 130 deg F.

It is recommended that, wherever practicable, continuous welded rail be laid in the summer season. It is further recommended that in most of the United States and Canada, such continuous welded rail be anchored at temperatures ranging between 70 and 90 deg F. In locations in the extreme south and in the extreme north, these limits should probably be slightly increased or decreased, respectively.

Fifteen of the railroads reported no special track preparations were made in advance of laying welded rail. Of the nine roads reporting special preparations, eight surfaced the tracks in advance and, of these eight, three renewed all ties having a remaining service life of less than three, five, and ten years, respectively. One road renewed ties out-of-face with GEO plates applied, and another reported installing new tie plates under the old rail in advance of laying the welded rail.

Three principal methods were used in transporting the welded rail to where it was to be laid in track, the method used depending on several factors, such as the length of the individual strings, the number and locations of the separate installations, the transportation facilities available, and the effect upon traffic. Twelve roads transported the rails on strings of flat cars, either in regular or work trains. One used gondola cars with end doors down. Six of the roads trucked the rail by push cars propelled either by motor cars or rail crane. Five roads dragged the strings in the track or on the shoulder with a locomotive. One moved the rail on rollers from the welding site to its intended location in track.

Table 1—Cost and Method of Transporting Welded Rail to Site

Item	*Number of Railroads Reporting*	*Cost Per Track Mile of Rail*	*Year*
Rail dragged between tracks or on shoulder by work train (Max distance 1 mile—1200-ft string)	1	$ 357	1946
Rail dragged in center of track or along shoulder by locomotive	3	1 @ 635 1 @ 1353 1 No data	1947 1949 ----------
Rail dragged in track by locomotive and crane	1	195	1949–50
On strings of flat cars (Costs include unloading)	11	1 @ 310 1 @ 355 1 @ 222 200 208 226 8 No data	1937 1939 1948 1949 1950 1951 ----------
On strings of flat cars at two installations, and on push cars pulled by motor cars at two installations	1	No data	----------
On push cars pulled by motor cars	2	1 @ 464 1 No data	1947 ----------
On push cars pulled by rail crane	2	1 @ 506 1 No data	1950 ----------
On push cars pulled by motor cars at one installation, and on rollers at one installation	1 1	@ 451 No data	1948 1947
On gondola cars with end doors down (Work-train cost not included)	1	105	1948

Rail was distributed according to the manner in which it was transported. Where flat cars were used the rail was anchored at one end and the cars pulled out from under the rail, with the rail dropping in approximate longitudinal track position. Rail on push cars was either barred off or lifted by crane.

Fastenings were distributed in the same manner as for jointed track, either by work train or push cars.

Costs of distributing rail are included with the costs of transporting the rail, as shown in Table 1, and because of the different methods of reporting costs of distributing fastenings and laying rail, all such costs are included in Table 2 of costs for laying rail.

The rail-laying organization and equipment used to install welded rail are essentially the same as for jointed track. Standard rail-laying gangs are employed, and no special equipment is considered necessary, although one-half of the roads reported using one or more cranes to place the long rails. Power equipment can be used as effectively as for jointed track, except, of course, that power wrenches are used only for the removal of existing joint bolts. The man-power ordinarily used to install angle bars and bolts is eliminated, but this is offset, at least in part, by the additional labor required to line the long rails in place.

The size of the organization and the amount and types of equipment will vary according to the circumstances or practices on the individual roads, in similar manner as for jointed track. One road with substantial installations used the following representative smaller organization: Two foremen; 50 laborers, 7 of whom doubled as machine operators; a rail crane operator; 1 mechanic; and a timekeeper. The power equipment consisted of one rail crane, two spike-pulling machines, two spike-driving machines, one power wrench, two adzing machines, one rail saw and one rail drill for jointed sections, and the necessary motor and push cars. Other roads with larger organizations have used gangs of 100 to 125 men.

Actual procedures in laying welded rail will depend, among other things, upon whether the track is in the open or in a tunnel; whether it can be completely taken out of service; whether the rail is to be laid immediately after being distributed, or at some later date, as is necessary where installations are large or widely separated; and whether or not the tie plates are to be replaced.

The procedure in a typical new installation in open track on the road previously mentioned is outlined here. Methods in the various stages of installation will vary on the individual roads, of course, according to conditions and practice.

Bolts in one line of the old rail are loosened and removed, and the spikes are pulled—the pattern of removal depending upon whether the track will be kept open to traffic as long as possible or merely used for movement of the rail-laying equipment. Joint bars and rail anchors are removed. The welded rail string, which had been previously distributed along the shoulder, is lifted by crane into the center of track, placed on small dollies, and then pulled or pushed by the crane to position opposite its place in track. After passage of the crane and complete removal of the fastenings, the old rail is barred out of track.

Where new rail section and new or larger tie plates are to be installed, the old tie plates are removed, broken spikes driven into the ties, and tie plugs set and driven. Ties are then adzed with one machine making a rough cut and a second following with the finish cut and smoothing. The adzed surfaces of the ties are then sprayed with creosote.

New tie plates are then placed on the ties. Six to eight laborers then bar the welded rail into place to approximate gage. Two small jacks, about one-half rail length apart, are then used to raise the rail sufficiently to place the tie plates. The rail is then lined to final gage with two gaging teams spiking at intervals of six ties (instead of three or four as is necessary with bolted rail). Spikes are set on the intermediate ties, and the spiking is completed with the spike-driving machines, one on each side of the rail. Four to six men install anchors, which are applied or tightened only when the rail temperature is between 70 deg and 90 deg F.

Where tie-in or field welds are used, they are made as soon as possible after the rail is laid. No definite time limit can be placed on this, but these welds should be made before there is a possibility of an excessive drop in temperature. Old rails and fastenings are picked up by work train.

TABLE 2—COST OF METHOD OF LAYING CONTINUOUS WELDED RAIL IN TRACK, INCLUDING COST OF TAKING UP OLD RAIL

Item	*Number of Railroads Reporting*	**Cost Per Mile*	*Man-Hours Per Mile*	*Year*
Rail crane lift, including barring in place	6	1 @ $ 2,588	2,034	1947
		3,176	2,284	1948
		2,909	1,968	1949
		3,116	1,738	1950
		3,690	1,888	1951
		1 @ 1,545		1949–50
		1 @ 2,743		1950
		1 @ 1,468 (On existing tie plates)	1,324	1948
		2,438 (on new tie plates)	2,201	1948
		1 @ 5,132 (Part track pans)	3,394	1949
Two rail cranes	2	1 @ 3,543		1947
		1 No data		
Locomotive crane lift	1	No data		
Rail crane and two side-lift cranes	1	3,687		1948
Off-track crane	1	3,814 (Incl. surfacing)	3,666	1947
Two rail cranes at two locations, barred into place two locations	1	No data		
Rail barred into place	3	1 @ 1,935 (GEO fstgs. reused)		1946
		1 @ 3,990 (Tunnel)		1942
		@ 3,520 (Tunnel)		1945
		1 No data		
Tie plates renewed in advance, one line of spikes pulled, welded rail set in, spikes replaced	1	No data		
Same organization as for jointed track	1	No data		
Rail laid and welded in place	1	No data		
No description	6	1 @ 6,900 (Open)		1937
		10,440 (Tunnel)		1946
		10,370 (Tunnel)		1949–50
		1 @ 1,198 (GEO)		1939
		4 No data		

*Cost includes distribution of fastenings.

The length of strings of continuous welded rail considered by the various roads to be the most economical from the standpoint of welding, transporting, laying and anchoring in track varied from 500 to 1600 ft. The actual length would, of course, depend upon the circumstances in each case, such as the space available at the welding site, the transportation facilities available, and traffic conditions.

Twelve of the roads reported no special construction was used adjacent to insulated joints or turnouts, and three reported that no such joints or turnouts were involved. Four roads use a short rail, varying in length from 15 to 37 ft, on one side of the insulated joint, while three reported using a single rail on each side of the insulated joint. Short rails were also used at turnouts, two roads specifying bolted rail ahead of the stock rail and behind the frog. One reported using short rails between railroad crossing legs and the ends of welded rail, and the bolting of the ends of welded rail directly to bridge expansion points at drawbridges.

Eleven of the 24 railroads connect long welded strings by making tie-in or field welds, with costs running between $30 and $40 per weld.

One road reported 6 tie-in weld failures (out of a total of 461); 1 reported 1 failure; another 2; and 1 reported "very few" compared to the total made.

No unusual ballast conditions were noted, except that 3 roads reported extending the shoulders from 5 to 10 in for welded rail, and 1 placed additional ballast in a tunnel. None of the roads indicated that cross tie sizes or spacing were any different than for jointed track, except that when a weld falls on a tie, that tie must be respaced or the tie plate modified on account of the excess metal on the base of the rail. When ties are respaced on this account, the work usually cannot be done until a considerable time after the rail is laid. One method of modifying tie plates, which has been used quite extensively, is merely to cut the plates in half. These half tie plates can then be inserted under the rail on opposite sides of the weld during the rail-laying operation. These half tie plates can be left in service permanently, and thus avoid the necessity of respacing the tie. If, however, it is considered desirable to respace the tie, this can be done at any time following the rail laying and the half tie plate replaced with a whole tie plate.

The disposition of welded rail after removal from track was reported by nine roads. Five cut the rail into lengths varying from 50 to 400 ft, and installed these lengths in secondary main tracks, yard tracks, or sidings. One relaid the rail in yard lead tracks, two scrapped the rail, and one restored it to track where it had been torn out by derailments.

Table 3—Comparison of Estimated Costs to Relay Rail in Secondary Tracks

Number of Railroads Reporting	*Cost Per Track Mile*	
	Welded	*Jointed*
1	$7,560 (1950)	$6,283 (1950)
1	4,300	2,920
1 78-ft lengths	4,100	3,065
1	$1,500 to 2,000 More	
2	Approx same	

So little welded rail has been taken up and relaid, and this has been done in such small quantities, that it appears logical to assume that if this should be done under normal conditions, the costs would be a great deal less than those reported.

Report on Assignment 3

Fastenings

Encompassing Rail Expansion, Types and Number of Anti-Creeping Devices on Welded Track and Adjacent Jointed Track, Type of Joint Bar at Ends of Welded Sections, Tie Plate and Spike Requirements, and Cost Data

J. W. Hopkins (chairman, subcommittee), H. B. Christianson, W. E. Cornell, J. C. De Jarnette, Jr., E. E. Martin, L. F. Racine, C. R. Strattman.

This is the second progress report, and is submitted as information. Your committee believes that it has developed sufficient information to make specific recommendations covering certain subjects under its assignment.

The report submitted in the Proceedings, Vol. 49, 1948, page 325, by the Subcommittee on Fastenings for Continuous Welded Rail, Committee 5—Track, collaborating with Committee 4—Rail, gives a formula for computing the required anchorage to resist movement due to temperature stresses in rail at the ends of sections of welded rail. This formula depends on the resistance provided per tie, which will vary considerably depending on the size, quantity and condition of ballast, condition of ties, and holding power of the anti-creeping device against the tie.

Assuming a temperature range of 70 deg F from the median temperature, and using a value of 800 lb per tie resistance, with 132 RE rail, indicates that 220 ties should be anchored at each end for movement in either direction. This does not take into account the fact that for minimum temperatures the ballast will be frozen and the resistance per tie will increase appreciably. It would therefore seem that the figure arrived at above is somewhat conservative. This is confirmed by reports from railroads in reply to questionnaire about welded-rail track.

Accordingly, your committee is recommending that 6 rail lengths (234 ft) be fully box-anchored at the ends of welded rail sections of track and on connecting conventional bolted track. This recommendation is for the minimum amount of anchorage for tracks carrying both one-way and two-way traffic to take care of temperature stresses, but it will also provide anchorage against rail creepage due to train movements.

The amount of intermediate anchorage required depends on both the rail creepage due to traffic and other conditions, and also on the gap which might open up in the rail due to a break. For average one-way traffic, it is recommended that anchors be placed on alternate ties in the direction of traffic, with every fourth tie box-anchored for back-up movements; and for average two-way traffic, that alternate ties be box-anchored throughout the length of the welded rail section. Traffic requirements, including speeds and classes of trains, should be considered in deciding on the amount and pattern of anchorage.

It should be pointed out that the committee makes no recommendations as to the type of rail anchor or clip that is to be used. From the replies received to the questionnaire submitted to railroads it can be stated that both rail anchors holding in one direction only, and rail clips holding in both directions, have been used satisfactorily.

The recommendation for the number of anchors for both one-way and two-way traffic is slightly higher than that made by Committee 5—Track, on the number and placing of anti-creepers for conventional bolted track, contained in the Proceedings, Vol. 49, 1948, page 362. It is felt that this somewhat higher number of anchors is necessary to protect against possible rail breakage.

Joints at the ends or within the limits of stretches of continuous welded rail must be fully bolted. Six-hole joint bars are recommended. Care should be exercised to see that all field-drilled bolt holes are properly spaced to assure uniform distribution of loading on all bolts.

Cost data concerning anchorage and tie plate and spike requirements for welded rail track compared with conventional bolted track will vary considerably on various roads, depending on their standards for anchorage. However, a comparison of the recommendations contained in this report with those made by Committee 5—Track, in the Proceedings, Vol. 49, 1948, for one mile of continuous-welded-rail track, indicates that on track carrying one-way traffic the cost of anchorage for welded rail will be about double that on bolted track; and on track carrying two-way traffic the increased cost will be about 63 percent.

Practically all of the roads replying on welded rail use double-shoulder tie plates, mostly AREA standard plates. Also, the pattern of spiking is about the same as standard for conventional bolted track. With the exception of the GEO construction, all roads replying used two line spikes per tie plate and one or two hold-down spikes per plate, with one exception where a compression clip was substituted for one line spike for track on a curve. It seems, therefore, that a definite recommendation can be made that welded-rail track can be laid using the same type of tie plates and the same pattern of spiking used for conventional bolted track. Under this recommendation the cost of tie plates and spikes will be the same for both welded-rail track and conventional bolted track.

Report on Assignment 4

Maintenance

Encompassing Maintenance of Rail, Track, Fastenings, Ties, and Ballast, Including Out-Of-Face Resurfacing and Reballasting, and Cost Data

C. E. Weller (chairman, subcommittee), C. B. Bronson, H. B. Christianson, R. E. Dove, S. R. Hursh, W. C. Perkins, L. F. Racine, E. F. Salisbury.

Conclusions and recommendations on maintenance of continuous welded rail, presented as information:

Out-of-face resurfacing, reballasting, general tie renewals, etc., may be made provided temperatures are the same, or lower, than the temperature at which the continuous welded rail was initially laid. If such operations are carried out at higher temperatures than when the rail was laid, sufficient precautions must be taken to guard against buckling of track.

The ballast section of continuous welded rail must be maintained to full standard section.

Spot tie renewals may be made, except that disturbance of the ballast for long stretches at temperatures above that at which the continuous welded rail was laid, and pulling of spikes on several adjacent ties, must be avoided.

The replacement of broken or defective rail in stretches of continuous welded rail may be handled by cutting in a length of rail. Permanent cuts should be made by a rail saw. Since welded rail usually is in tension a majority of the time, when a section of welded rail is replaced at a temperature appreciably below that at which it was initially laid, a shorter rail should be inserted at the first opportunity when the temperature is near that at which the continuous welded rail was laid in order to avoid the possibility of concentrating compressive stresses in the rail. It is recommended that a permanent record of the laying temperature be kept in the proper division office, where it will be immediately available. It is also recommended that the laying temperature be painted on the rail, or otherwise indicated, for the benefit of the forces making future changes.

Rails shorter than 39 ft should be installed adjacent to insulated joints to permit proper maintenance.

To date no unusual detrimental maintenance experiences have developed due to derailments.

Experience with welded rail in open track today indicates that maintenance savings of approximately 25 percent may be possible in comparison with jointed track under the same conditions.

Report on Assignment 5

Economics

of Continuous Welded Rail Versus Jointed Track

I. H. Schram (chairman, subcommittee), H. C. Archibald, B. Blowers, P. O. Ferris, R. J. Gammie, L. F. Racine, E. C. Vandenburgh.

This is a progress report, submitted as information, and includes a comparison of the annual cost of welded track and jointed track, taking into consideration first cost, maintenance cost, life and salvage value of each type of rail. It is based on data received in reply to a questionnaire submitted to railroads having experience with welded rail.

The data included in the report are that submitted by the ten railroads which had installed in excess of two miles of welded track, exclusive of tunnels. The economics of welded track have been divided between the 131-lb rail or heavier, 112-lb and 115-lb rail, and 90-lb rail (the only installation reported of rail less than 112 lb was one of 90 lb).

In supplying the data, the ten railroads furnished information of record as far as it was obtainable, but much of it, such as increased life of welded rail, maintenance cost, etc., was necessarily estimated by the reporting railroads due to the fact that very little of the welded rail has been worn out in service, and much of the rail in the heavier weights with which it is compared is also still in service. However, the data are based on the judgment of the chief engineers of the reporting railroads and, it is felt, when averaged, are as accurate as possible at this stage of development. The information is submitted in this form as it is felt that it will be many years before any better data are obtainable and that this information will be of value to the railroads of the country in determining their policy on the subject.

The data pertaining to 131-lb rail or heavier, as submitted by 6 railroads, indicate that the average additional cost to install welded track is $3872 per mile. These reports also show that an annual maintenance saving of $513 per mile is obtained on welded track. Capitalized at 5 percent, this maintenance saving will offset the additional cost of welded rail in 7 years. Since the reports show that the average life of welded rail is 26 years, the saving in maintenance cost would be made 19 years in each 26-year period, or an average annual saving of $375 per mile.

In addition to the above maintenance saving, the reports show that rail in welded track has an extended life of 7 years, or 26 years for welded track, compared with 19 years for jointed track. The difference in value of new rail (at $86 per gross ton) and relayer rail (at $33 per gross ton) is approximately $11,000 per track mile. The annual investment to accumulate $11,000 in 19 years (using an interest rate of 5 percent) is $360, while the annual investment to accumulate the same sum in 26 years is $215, or an annual saving of $145 per mile.

The out-of-face surfacing cycle, according to the reports, is extended an average of at least 15 percent where there is welded track. Out-of-face surfacing, including the renewal of 500 ties per mile and a 3-in ballast life, is estimated to cost $7000 per mile. Using an average cycle of 6 years between out-of-face surfacing programs, a 15 percent extension of cycles will result in an annual saving of $175 per mile.

The cost to relay welded track in secondary or yard tracks has not as yet been very well developed. Few roads have had welded rail installations in service a sufficient period of time to require relaying. However, from the few roads reporting, it appears that it will probably cost approximately $1200 more per mile to relay welded track than jointed track. Using 26 years as the average life of welded rail, the annual sum required to capitalize $1200 in 26 years is $24.

The above costs are summarized as follows:

Net annual maintenance saving	$375
Annual saving account longer life of rail	145
Annual saving account extended out-of-face surfacing program cycle	175
	$695
Annual additional cost to relay welded track	24
Total annual saving per mile	$671

The average annual tonnage carried on tracks used for this summary is 18,359,000 tons.

The data pertaining to 112-lb and 115-lb welded rail were furnished by 3 railroads having in excess of 2 miles of welded track, exclusive of tunnels. On the same basis as that used for the 131-lb and heavier rail, the data submitted for 112-lb and 115-lb rail results in a summary as follows:

Net annual maintenance saving	$354
Annual saving account longer life of rail	125
Annual saving account extended out-of-face surfacing program cycle	175
	$654
Annual additional cost to relay welded track	24
Total annual saving per mile	$630

The average annual tonnage carried on tracks used for this summary is 11,700,000 tons.

The one road reporting 90-lb welded rail does not include the annual maintenance costs on welded track. Without this figure it is not possible to compute annual savings.

While the analysis of the reports shows a definite economy in the use of welded track, about 85 percent of the track installed has been on tangent track. The only road with a large percentage of curvature (the Delaware & Hudson, with about 32 percent on curves) shows a very short life for either type of track, although it does indicate much longer life for welded track than for jointed track. Since welded track should be worked only when the temperature is at or near the installation temperature, it would be a problem to obtain efficiency from the maintenance forces if any division is predominantly welded construction.

It is apparent that a substantial saving will be made by the use of welded rail at locations where the mechanical wear of rail is not excessive from curvature or grade. The difference between the initial cost of welded and jointed track will be reduced with wider use, as more efficient methods of handling are developed. This fact is apparent from the reports that show the least differences in initial cost on those roads that have installed the greatest mileages of welded track with modern welding methods.

The cost of welded track is influenced by a wide variety of conditions that are variable for each railroad. A location for the welding station must be selected that will best balance all the requirements, including length of haul of welded strings, available space for the station set-up, availability of power, the possibility of a source of oxygen supply to utilize an oxygen cascade system, and sufficient stockpiling space.

The lengths of welded strings vary on the reporting roads from about 800 to 1600 ft. Considerations affecting these lengths include the effect upon traffic during unloading and laying operations, transportation facilities available and equipped for handling this rail, capacity of cranes handling strings of rail, and the number of welds made in an 8-hr day (usually about 40). The length of strings determines the number of field welds that must be made, and it is best to keep these to the minimum as they are both expensive and not as satisfactory as pressure welds.

The costs as reported by the various railroads and used in the preparation of this report are shown in Table 1.

TABLE 1
COST DATA COMPARING WELDED WITH JOINTED TRACK

MILES OF WELDED TRACK	RAILROAD	WT OF RAIL	COST PER MILE OF TRACK WELDED RAIL	COST PER MILE OF TRACK JOINTED RAIL	ADDITIONAL COST OF WELDED RAIL PER MILE OF TRACK	PERCENT OF INCREASED COST		ANNUAL MAINTENANCE WELDED TRACK PER MILE	ANNUAL MAINTENANCE JOINTED TRACK PER MILE	ANNUAL SAVING ON MAINTENANCE WITH WELDED TRACK PER MILE		LIFE OF RAIL IN WELDED TRACK	LIFE OF RAIL IN JOINTED TRACK	INCREASED LIFE OF WELDED RAIL OVER JOINTED RAIL	TIME CYCLE -OUT-OF-FACE SURFACE WELDED TRACK	TIME CYCLE -OUT-OF-FACE SURFACE JOINTED TRACK	COST TO RELAY WELDED TRACK	COST TO RELAY JOINTED TRACK	DIFFERENCE IN COST TO RELAY
		LB	$	$	$		TONNAGE	$	$	$	PERCENT	YEARS	YEARS	PERCENT	YEARS	YEARS	$	$	$
91.5	E J & E	132	32,712	31,706	1,006	3	15,000,000	1,140 (401 Man Hr)	1,600 (756 Man Hr)	460	29	30	25	20	8	5	4,100	3,065	1,035
42.0	D & H	131	33,000	30,000	3,000	10	24,000,000	625	1,180	555	47	12	5	50 Est	Same	Same	-	1,750	-
10.4	UNION PACIFIC	133	-	-	2,700	-	25,000,000	2,000	2,200	200	9	-	15	-	Same	Same	-	-	-
5.6	P & L E	132	25,200	20,000	5,200	26	18,672,000	800 (600 Man Hr)	1,500 (850 Man Hr)	700	47	-	-	-	4	2	-	-	-
5.0	A T & S F	132	27,067	23,809	3,258	14	19,000,000	935	1,325	390	29	27.5	25	10	9	10	-	-	-
4.9	LEHIGH VALLEY	136	38,370	30,300	8,070	27	8,480,000	608	1,380	772	56	35	25	40	6	3	Wear to scrap in main track		
AVG	131 LB to 136 LB	rail	31,270	27,163	3,872	14	18,359,000	1,013	1,531	513	33	26	19	37	6.7	5.0	-	-	-
18.5	C & N W	115	28,771	27,644	1,127	4	15,000,000	-	-	425	-	24	18	33	6.5	5	20,945	21,785	840
4.1	C S S & S B	115	28,906	26,564	2,342	9	-	-	-	-	-	-	-	-	-	-	-	-	-
2.25	C I & L	112	32,062	29,835	2,227	7	8,400,000	-	1,600	-	-	-	25	-	10	7	-	-	-
AVG	112 LB to 115 LB	rail	24,913	23,014	1,899	7	11,780,000	-	-	425	-	24	18	-	8.25	5.0	-	-	-
7.2	ILL CENTRAL	90	19,316	17,140	2,176	13	7,345,000	-	1,467	-	-	30	25	20	8	6	-	-	-

Report of Committee 4—Rail

C. J. Code, *Chairman,*
J. B. Akers
E. L. Anderson
T. A. Blair
B. Bristow
C. B. Bronson
W. J. Burton
E. E. Chapman
B. Chappell
C. M. Chumley
H. R. Clarke
L. S. Crane
W. J. Cruse
J. C. DeJarnette, Jr.
R. A. Emerson
Frank Fahland
P. O. Ferris
C. J. Geyer
E. L. Gosnell
J. L. Gressitt
R. L. Groover
C. B. Harveson
W. H. Hobbs
S. R. Hursh
K. K. Kessler
N. W. Kopp
L. R. Lamport
C. C. Lathey
W. B. Leaf
H. S. Loeffler
E. E. Mayo
Ray McBrian
E. H. McGovern
L. T. Nuckols
Embert Osland
E. E. Oviatt
R. E. Patterson
W. C. Perkins
G. A. Phillips
G. L. Plow
B. R. Meyers, *Vice Chairman,*
W. G. Powrie
R. B. Rhode
J. G. Roney
J. C. Ryan
E. F. Salisbury
I. H. Schram
J. F. Shaffer
S. H. Shepley
A. A. Shillander
W. D. Simpson
G. L. Smith
A. P. Talbot
J. S. Wearn
H. F. Whitmore
R. P. Winton
Edward Wise, Jr.
J. E. Yewell

Committee

To the American Railway Engineering Association:

Your committee reports on the following subjects:

1. Revision of Manual.

   Progress report, including review of all Manual material and recommendations for reapproval or revision .... page 1176

2. Conditions affecting service life of rail, causes of rail failures and defects, in collaboration with AISI Technical Committee on Rail and Joint Bars.

   Progress report including as Appendix 2–a 1952 Report on Investigation of Failures in Control-Cooled Rail .... page 1186

3. Rail Failure Statistics covering (a) all failures; (b) transverse fissures; (c) performance of control-cooled rail.

   Progress report including statistics on rail failures reported up to December 31, 1951 .... page 1194

4. Rail end batter; causes and remedies.

   No report.

5. Economic value of various sizes of rail.

   Progress report, presented as information .... page 1212

6. Service tests of various types of joint bars.

   Progress report, presented as information .... page 1213

7. Joint bar wear and failures; revision of design and specification for new bars, including insulated joints, and bars for maintenance repairs.

   Progress report, presented as information .... page 1221

   Appendix 7–a Report on Rolling-Load Tests of Joint Bars .... page 1223

   Appendix 7–b Report on Service Tests on the Burlington Railroad near Fort Morgan, Colo. .... page 1237

11. Means of conserving labor and materials, including the adaptation of substitute noncritical materials, and specifications for the reclamation of released materials, tools and equipment, collaborating with Committee 3–A, General Reclamation, Purchases and Stores Division, AAR.

No report.

THE COMMITTEE ON RAIL,
C. J. CODE, *Chairman*.

AREA Bulletin 507, February 1953.

Report on Assignment 1

Revision of Manual

B. R. Meyers (chairman, subcommittee), C. J. Code, E. L. Anderson, W. J. Burton, C. J. Geyer, E. L. Gosnell, J. L. Gressitt, R. L. Groover, W. H. Hobbs, C. C. Lathey, H. S. Loeffler, Ray McBrian, L. T. Nuckols, E. E. Oviatt, R. E. Patterson, G. L. Plow, R. B. Rhode, J. C. Ryan, E. F. Salisbury, S. H. Shepley, A. A. Shillander, G. L. Smith, J. S. Wearn, Edward Wise, Jr., H. F. Whitmore

During the past year your committee, with the assistance of the other subcommittees, has reviewed and studied all the material in Chapter 4 to bring it up to date prior to reprinting of the manual. These reapprovals, changes and additions are submitted with the recommendation that they be adopted and published in the Manual.

Glossary

Reapprove items referring to Chapter 4, with following changes:

Revise definition for "cant" to read:

CANT.—The inward inclination of a rail, effected by the use of inclined-surface tie plates, usually expressed as a rate of inclination, such as 1 in 40, etc.

Add new definition:

DECARBURIZED SURFACE.—The portion of steel at and near the surface in which the carbon content has been reduced as the result of heating in a medium that reacts with the carbon.

Revise definition for "End Hardening" to read:

END HARDENING.—Heat treatment of the top portion of the heads of rails at the ends to minimize rail batter.

Withdraw present definition for "Compromise Joint" and join Committee 5 in the revision of their definition to read as follows:

COMPROMISE JOINT.—Joint bars designed to connect rails of different fishing height and section, or rails of the same section but of different joint drillings.

Add to present definition for "Cropping", the following: "Also cutting off the ends of used rails to eliminate battered or damaged portions."

Add to definition for "Crushed Head", the following: "of a rail."

Add new definition:

PLATENS.—The two plates of a testing machine which apply the load to the test specimen.

Revise definition for "Split Web" to read:

SPLIT WEB.—A longitudinal or diagonal transverse crack in the web of a rail.

Add new definition:

TREAD.—The top surface of the head of a rail which contacts wheels.

Pages 4–1 to 4–6, incl.

SPECIFICATIONS FOR OPEN-HEARTH STEEL RAILS

Reapprove with the following changes:

Delete center headings designated I, II, III and IV for uniformity with other specifications of chapter.

Revise Art. 203 to read as follows (Recommended by AISI to permit use of spectrograph):

Separate analyses shall be made from ladle tests representing one of the first three and one of the last three applied full ingots of the heat to determine the percentage of carbon, manganese, phosphorous, sulfur, and silicon. Determinations may be made chemically or spectrographically. The average analysis of the ladle tests shall conform to the requirements of Art. 201. Upon request, samples shall be furnished to the inspector for check analysis.

Pages 4–7 to 4–11, incl.

RECOMMENDED RAIL SECTIONS

Reapprove with following changes:

Delete central angle of 14-in radius arc at top of head in Figs. 1 and 2, and incorporate other minor editorial changes in these two figures to provide uniformity with Figs. 3 and 4.

Modify dimensioning in Fig. 5 to conform to system of dimensioning on other RE rail sections.

Change present rail weight designations in Figs. 1, 2, 3, 4 and 5 to nominal rail designations—90 RA–A, 100 RE, 115 RE, 132 RE, and 133 RE, respectively.

Add to table under Fig. 1 the following: "Calculated weight, lb per yd—90.0".

Add to table under Fig. 2 the following: "Calculated weight, lb per yd—101.5".

Add to table under Fig. 3 the following: "Calculated weight, lb per yd—114.7".

Add to table under Fig. 4 the following: "Calculated weight, lb per yd—132.1".

Add to table under Fig. 5 the following: "Calculated weight, lb per yd—133.4".

Page 4–12

APPLICATION OF WELDED BONDS

Reapprove without change.

GENERAL REQUIREMENTS OF A RAIL JOINT

Reapprove with following change:

Add "and contraction" at end of item 3.

BEVELING OR SLOTTING OF RAIL ENDS

Reapprove without change.

Pages 4–15 and 4–16

SPECIFICATIONS FOR DROP TEST MACHINE

Reapprove with following change:

Change "4 feet 6 inches" in item 1 to read "4 feet 8 inches" (this will then agree with item 5, which is correct).

Pages 4–17 to 4–19, incl.

SPECIFICATIONS FOR HIGH-CARBON-STEEL JOINT BARS

Reapprove with changes proposed in Exhibit "A".

Changes are editorial to bring these specifications up to date. Changes are similar to those made in Specifications for Quenched Carbon-Steel Joint Bars in 1951.

Pages 4–21 to 4–23, incl.

SPECIFICATIONS FOR QUENCHED CARBON-STEEL JOINT BARS

Reapprove with following change proposed by AISI:

9(a) delete "equal to" in last line and substitute therefor "not greater than."

9(b) delete "equal to" in fourth line and substitute therefor "not greater than."

Pages 4–25 to 4–28.3, incl.

JOINT BARS

Reapprove Figs. 10 to 16, incl., with the following changes: Revise drawing of track nut in each figure to correspond to Fig. 3 and Table 3—Track Bolt Nuts, as approved at 1952 annual meeting and shown on Manual page 4–36.

For the sake of uniformity with joint bar assembly drawings—Figs. 10 and 11 and with rail section drawings, pages 4–7 to 4–11, incl., as revised, change rail weight designations shown in the rail head cross sections in Figs. 12, 13, 14, 15 and 16 to show nominal rail designations—115 RE, 132 RE, 132 RE, 133 RE, and 133 RE, respectively.

Add new page immediately following page 4–28.3 to be titled "Recommended Head Easement for Joint Bar." See attached marked Exhibit "B".

Page 28.4

Delete plans for Track Bolt and Nuts, Fig. 17, and reapprove balance of Fig. 17 without change.

(Design of track bolts and nuts now covered on pages 4–33 to 36, incl.).

Page 4–28.5

RAIL DRILLINGS, BAR PUNCHING AND TRACK BOLTS

Reapprove table with the following changes:

Delete words "See Fig. 17" in the table heading, and delete from the footnote the words "For design and dimensions of nuts, see Fig. 17."

In substitution for the foregoing, add a dagger (†) at the end of table heading, and add new explanatory footnote, as follows:

† See Fig. 9 (former Fig. 17) for bar punching and rail drillings, and Figs. 1, 2 and 3 and Tables 1, 2 and 3—Design for Track Bolts and Nuts—for dimensions of track bolts and nuts.

Pages 4–29 to 32, incl.

SPECIFICATIONS FOR HEAT-TREATED CARBON-STEEL AND ALLOY-STEEL TRACK BOLTS

Reapprove with following changes:

Add in title "AND CARBON-STEEL NUTS"

For uniformity with other specifications delete the following center headings and make the other changes noted:

(4–29) Manufacture

(4–29) Chemical Properties and Tests

(4–30) Physical Requirements

(4–30) 8(a). Delete "equal to" in third line and substitute therefor "not greater than".

8(b). Delete "equal to" in third line and substitute therefor "not greater than".

(4–31) 9. Revise "Note" to read as follows:

Note—The above is predicated on minimum thickness of medium carbon nut being equal to the nominal bolt diameter; minimum thickness of low carbon nut ⅛ in greater than nominal bolt diameter.

(4–31) Design and Tolerance

(4–31) Manufacture

(4–32) Marking and Inspection

Pages 4–33 to 4–36, incl.

DESIGN FOR TRACK BOLTS

Reapprove with following change:

Add "AND NUTS" to heading.

Pages 4–37 to 4–39, incl.

SPECIFICATIONS FOR SPRING WASHERS

Reapprove with following changes:

For uniformity with other specifications:

(4–37) Delete "I General Scope" in center of page and make it an article heading at the left of the page, reading: 101. General Scope.

(4–37) Delete "II Material" in center of page and move to left to read: 201. Material.

(4–37) Delete "III Physical Requirements".

(4–38) Delete "IV Accuracy of Manufacture".

(4–39) Delete "V Identification".

(4–39) Delete "VI Acceptance Requirements".

(4–38) In table in Par. 302(a) add at bottom data for spring washer for 1¼-in bolt with same specifications as listed for 1⅛-in bolt. (Track bolt tables list 1¼-in bolts.)

Pages 4–41 to 4–52, incl.

RAIL RECORD FORMS

Reapprove with following changes:

Form 401–D Substitute new form as per attached sample marked Exhibit C.

Form 402–A Revise definition for "Split Web" to agree with proposed revised definition in Glossary.

Form 402–C(a) Revise Par. 4 as follows:

Change words "Research Engineer" in fourth and fifth lines to read "Director of Engineering Research" and end the first sentence after the words "Director of Engineering Research." Delete remainder of paragraph. Add to the corrected paragraph: Also, one copy of this report, together with 12-in pieces of the rail, one from each side of the fissure, shall be sent to the Rails Investigation, University of Illinois, Materials Testing Laboratory, Urbana, Ill., as soon as possible after the date of failure. Rails should be marked with crayon or tagged showing Mill, Heat Number and Year Rolled.

Add following new Par. 9 after Par. 8, and renumber remaining paragraphs:

Under "Web-In Joint" list all failures where the cause of rail removal is a bolt hole or a fillet crack, regardless of whether it is a service failure or was detected by visual inspection or by inspection with any of the various types of defect detecting instruments or equipment, including the supersonic type.

In Par. 14 delete data for 152-lb PRR rail and add following data—

140 lb PS 220.94 tons

152 lb PS 238.23 tons

155 lb PS 244.35 tons

Pages 4–53 to 4–54.4, incl.

MEASUREMENT OF PROFILES AND BATTER OF RAIL

Reapprove without change, except move center headings from center of page to left hand side for uniformity.

Page 4–55

BUILDING UP OF RAIL ENDS IN TRACK

Revise to read as follows:

RECONDITIONING RAIL ENDS

Reconditioning of rail ends by welding, grinding or cropping is recommended as good practice.

Add following new Recommended Practice:

END HARDENING OF RAILS AT MILLS

Control-cooled rails shall be used for end-hardened product.

End-hardened rails shall be hot stamped with letters CH in the web of the rail ahead of the heat number.

Water shall not be used as a quenching medium.

Longitudinal and transverse sections showing the typical distribution of the hardness pattern produced by any proposed process shall, upon request of purchaser, be submitted to the purchaser for approval before production on the contract is started.

The heat-effected zone shall cover the full width of the rail head and extend longitudinally a minimum of 1½ in from the end of the rail. The effected hardness zone ½ in from the end of the rail shall be at least ¼ in deep.

The hardness measured at a spot on the center line of the head ¼ in to ½ in from the end of the rail shall show a Brinell hardness number range of 331 to 401 when decarburized surface has been removed. A report of hardness determinations representing two rail specimens from each heat shall be given to the purchaser or his representative.

The manufacturer reserves the right to re-treat any rails which fail to meet the required Brinell hardness number range.

Chamfering shall be done in such manner as will avoid the formation of grinding cracks.

Exhibit A

Proposed Form for Changed Articles in

SPECIFICATIONS FOR HIGH-CARBON-STEEL JOINT BARS

1. Scope

These specifications cover high-carbon-steel joint bars for general use in standard railroad tracks. They may be used for the joint bars of insulated joints.

2. Process

The steel shall be made by either or both of the following processes: open-hearth or electric-furnace.

3. Discard

No change.

4. Heating

No change.

5. Chemical Composition

No change.

6. Ladle Analysis

An analysis of each heat of steel shall be made by the manufacturer to determine the percentages of carbon, manganese, phosphorus, and sulfur. This analysis shall be made from a test ingot taken during the pouring of the heat. The chemical composition thus determined shall be reported to the purchaser or his representative, and the percentages of carbon and phosphorus shall conform to the requirements specified in Art. 5.

7. Check Analysis

An analysis may be made by the purchaser from a finished joint bar representing each heat. The percentage of carbon thus determined shall conform to the requirement specified in Art. 5, and the phosphorus content shall not exceed that specified by more than 25 percent.

8. Tensile Properties

The material shall conform to the following requirements as to tensile properties:

Tensile strength, min, psi	85,000
Elongation in 2 in, min, percent	15

9. Bending Properties

(Substitute for present Arts. 9 and 10)

(a) Bend Test.

The bend test specimen specified in Art. 10 shall stand being bent cold through 90 deg without cracking on the outside of the bent portion around a pin the diameter of which is not greater than three times the thickness of the specimen.

(b) Optional Bend Test.

If preferred by the manufacturer and approved by the purchaser, the following bend test may be substituted for that described in Par. (a): A piece of the finished bar shall stand being bent cold through 45 deg without cracking on the outside of the bent portion around a pin the diameter of which is not greater than three times the greatest thickness of the section.

10. Test Specimens

(Substitute for present Art. 11)

Tension and bend test specimens shall be taken from the finished joint bars. Tension test specimens shall be machined to the form and dimensions shown in Fig. 1. Bend test specimens may be ½ in square in section or rectangular in section with two parallel faces as rolled and with corners rounded to a radius not over $\frac{1}{16}$ in.

11. Number of Tests

(Substitute for present Art. 12)

(a) One tension and one bend test shall be made from each heat.

No change in (b) or (c).

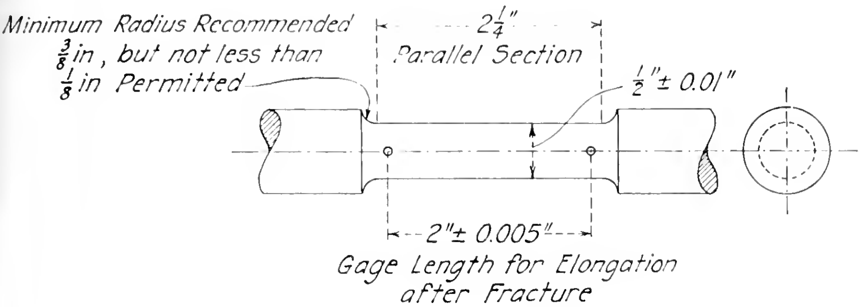


Fig. 1—Standard round tension test specimen with 2-in gage length.

NOTE—The gage length, parallel section, and fillets shall be as shown, but the ends may be of any shape to fit the holders of the testing machine in such a way that the load shall be axial.

12. Workmanship

(Substitute for present Art. 13)

The joint bars shall be smoothly rolled, true to template, and shall accurately fit the rails for which they are intended. The bars shall be sheared to length, and the punching and slotting shall conform to the dimensions specified by the purchaser. A variation of plus or minus $\frac{1}{32}$ in from the specified size of holes, of plus or minus $\frac{1}{16}$ in from the specified location of holes, and of plus or minus $\frac{1}{8}$ in from the specified length of joint bar will be permitted. Any variation from a straight line in a vertical plane shall be such as will make the bars high in the center. The camber in either plane shall not exceed $\frac{1}{32}$ in. in 24-in bars and $\frac{1}{8}$ in. in 36-in bars.

13. Finish

(Present Art. 14)

No change.

14. Marking and Stamping

(Substitute for present Art. 15)

The name or brand of the manufacturer, the section designation, and the year of manufacture shall be rolled in raised letters and figures on the side of the rolled bars, and a portion of this marking shall appear on each finished joint bar. A serial number representing the heat shall be hot stamped on the outside of the web of each bar, near one end.

15. Inspection

(Present Art. 16)

No change.

16. Rejection

(Substitute for present Art. 17)

(a) Unless otherwise specified, any rejection based on tests made in accordance with Art. 7 shall be reported to the manufacturer within five working days from the receipt of samples by the purchaser.

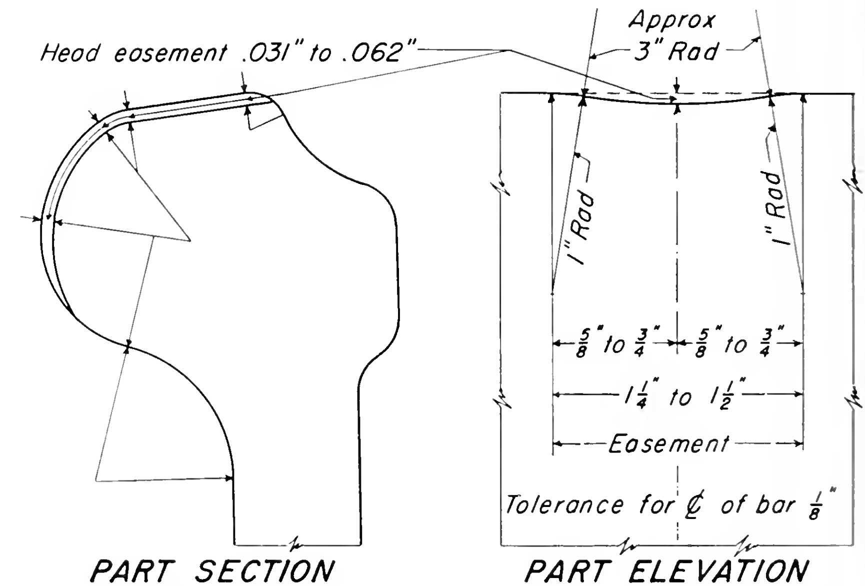
(b) Material that shows injurious defects subsequent to its acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

17. Rehearing

(Present Art. 18)

No change.

Exhibit B



NOTE:
While sketch shows easement for headfree bars, same dimensions will apply for head contact bars.

Recommended head easement for joint bars.

Exhibit C

RECORD OF CONTROL-COOLED RAILS

401-D

For Rail Report

No..................

RAIL MANUFACTURER.................. WORKS...................

Date..............

Sheet...........of

..............Sheets

RAILROAD.................. RAIL SECTION............... AIR TEMP.............. RAILS PER INGOT...............

Heat Number	Container Number	Date Charged	Time of Charging		Charging Temp. °F		Control Temp. After.......Hrs.		Lid on Container (Hours)	No. Rails in Container	Identification of Rails in Container	
			Start	Finish	Min	Max	# Elapsed Time	Temp. °F			Letter	Ingot

Number of hours is from the time the bottom tier is placed in the container.
The lids of all containers covered by this report remained in place for at least 10 hours.
Rails were not removed from containers until the temperature of the top layer had fallen to 300°F or lower.

Report on Assignment 2

Conditions Affecting Service Life of Rail, Causes of Rail Failures and Defects

In Collaboration with AISI Technical Committee on Rail and Joint Bars

C. J. Code (chairman, subcommittee), C. B. Bronson, E. E. Chapman, H. R. Clarke, L. S. Crane, W. J. Cruse, R. A. Emerson, J. L. Gressitt, Ray McBrian, B. R. Meyers, L. T. Nuckols, W. C. Perkins, R. P. Winton.

This subcommittee is responsible for the research work carried on under joint sponsorship with the Technical Committee on Rail and Joint Bars of the American Iron & Steel Institute. Subcommittee 2 meets annually or more often with representatives of the AISI as the Joint Contact Committee. In addition to following up the research work, the Joint Contact Committee serves as a clearing house for discussion of other problems of mutual interest, including specification changes.

The research work jointly sponsored includes:

1. Investigation of Rail Failures—University of Illinois.
2. Investigation of Shelly Spots and Head Checks in Rail—University of Illinois.
3. Investigation of Shelly Spots and Head Checks in Rail—Battelle Memorial Institute.

Professor Cramer's report of Investigation of Failures in Control-Cooled Railroad Rail is presented herewith as Appendix 2–a.

Professor Cramer's report on Shelly Rail studies is presented as Appendix 8–a in conjunction with the report of Subcommittee 8.

Report from Battelle Institute is included as Appendix 8–b.

Supplemental to the work of Battelle Institute and the University of Illinois, the group has also jointly sponsored a short term project, the investigation of stresses in the rail head due to wheel contact, using photoelastic methods. Progress is reported by subcommittee 8.

Appendix 2–a

Investigation of Failures in Control-Cooled Railroad Rails

By R. E. Cramer

Research Associate Professor of Engineering Materials, University of Illinois

Organization and Acknowledgment

This is a cooperative investigation financed equally by the Association of American Railroads and the American Iron and Steel Institute, using testing facilities of the University of Illinois. Previous reports have appeared annually in the Proceedings of the American Railway Engineering Association. The program is supervised by a committee composed of engineers from both the AREA Rail committee and AISI Technical Committee on Rails and Joint Bars.

The following student test assistants have worked for the investigation on a part time basis for one semester or more during the past year: Don Yeager, Fred Mobley, Claude Jones.

Control-Cooled Rails Which Failed in Service

Since the last report was written, October 1, 1951, 48 failed control-cooled rails have been sent to the University Laboratory for examination, and reports have been prepared on each failure for the railroad engineer, the steel mill producing the rail, and the AREA rail engineer who compiles the rail failure statistics.

Table 1 gives a summary of these failures.

Table 2 lists each rail separately.

TABLE 1—SUMMARY OF RAIL FAILURES

Transverse Fissures from Shatter Cracks	2
Transverse Fissures from Hot Torn Steel	13
Transverse Fissures from Inclusion	2
Fractures from Welded Engine Burns	4
Bolt Hole Crack	2
Base Break at Seam	3
Lap on Rail Tread	1
Detail Fracture from Arc Weld on Rail Tread	1
Engine Burn Fractures	2
Web Failure at Raised Letter S	1
Compound Fissure in Hand Butt Weld	1
Detail Fractures from Shelling	15
Fracture from Pipe in Web	1
Total	48

Transverse Fissures from Shatter Cracks

One of the two control-cooled rails which developed transverse fissures from shatter cracks was a Gary rail, rolled in 1936. The Gary Mill did not have tight fitting lids on their containers in 1936, which can explain this failure of the control-cooling process. The second control-cooled rail which developed a transverse fissure from shatter crack was an 85-lb rail rolled at the Dominion Steel Mill in Nova Scotia in 1940. This is the first control-cooled rail from this mill that has been sent to this laboratory and found to contain shatter cracks since they started control cooling rails in 1931.

Transverse Fissures from Hot Torn Steel

The number of transverse fissures from hot torn steel in control-cooled rails increased from 7 last year to 13 this year. The following tabulation shows the mills and the years the rails were rolled:

Steelton—1940–1940–1942–1942–1944–1944–1945–1949
Lackawanna—1944–1947
Inland—1938–1944–1951

As will be noted, all of these rails but three were rolled before 1946 when the cause of porosity in rails was determined to be over-heating of the blooms prior to the shaping of the rails in the rolling mills.

Transverse Fissures from Inclusions

One transverse fissure from inclusion is shown in Fig. 1a. It has a small cavity at the nucleus of the fissure. Fig. 1b is a longitudinal section at about 4X magnification through the nucleus, which shows another rather large inclusion adjacent to the nucleus. It is thought this inclusion is a small piece of firebrick or refractory material and that

TABLE 2—FAILED CONTROL-COOLED RAILS EXAMINED BETWEEN OCT. 1, 1951, AND OCT. 1, 1952

D.F. = detailed fracture; T.F. = transverse fissure; C.F. = compound fissure; P.F. = progressive fracture

Source of Failed Rail	*Laboratory Failed Rail Number*	*Size of Rail*	*Mill*	*Heat Number Rail Letter Ingot No.*	*Date Rolled*	*Classification of Failure*
IC	709	112	Gary	35424	3-1943	Bolt hole crack
N&W	710	132	E. Thomson	09E580-F-6	12-1950	Base break at seam
NYC	711	127	Lackawanna	1619-D-18	11-1944	T.F. from hot torn steel
RF&P	712	140	Steelton	82700-A-16	12-1950	Lap below rail tread
SP	714	113	Colorado	1096-A-18	2-1942	P.F. from welded engine burn
B&O	715	131	Steelton	88651-E-17	12-1945	T.F. from hot torn steel
C&O	716	131	Inland	36510-B-21	1-1940	P.F. from welded engine burn
C&O	717	131	Inland	18774-A-20	8-1938	T.F. from hot torn steel
C&O	718	131	Gary	661439-E-6	8-1946	P.F. from welded engine burn
AT&SF	723	112	Colorado	7234-F-8	5-1939	T.F. from inclusion
NYC&St L	724	110	E. Thomson	214322-A-17	6-1942	D.F. from arc weld
Erie	725	112	Gary	60332-B-2	8-1938	Engine burn fracture
SP	726	113	Steelton	89596-E-2	12-1940	T.F. from hot torn steel
B&O	727	131	Steelton	89172-4	3-1940	T.F. from hot torn steel
SP	728	131	Tennessee	880037-20	1945	Web failure at letter S
C&NW	729	112	Gary	53537-F-4	12-1936	T.F. from shatter crack
AT&SF	730	112	Colorado	-------	1934	C.F. in hand butt weld
N&W	732	131	Steelton	81490-B-19	9-1942	T.F. from hot torn steel
NYC&StL	733	131	Lackawanna	5066-A-14	1-1947	T.F. from hot torn steel
C&O	734	132	Steelton	89237-B-1	5-1949	T.F. from hot torn steel
B&M	735	112	Lackawanna	29197-A-17	7-1936	Bolt hole crack
C&O	736	132	Inland	30582-G-15	12-1951	Base break at seam
N&W	737	131	E. Thomson	210440-D-29	9-1943	T.F. from inclusion
B&O	738	131	Steelton	82431-B-13	8-1944	T.F. from hot torn steel
C&O	739	132	Inland	14932-E-20	1-1951	T.F. from hot torn steel
T&NO	740	113	Colorado	16526-F	1942	D.F. from shelling
T&NO	741	113	Colorado	3308-B-8	1945	Engine burn fracture
T&NO	742	113	Colorado	5307-A-5	1942	D.F. from shelling
T&NO	743	113	Colorado	14514-C-3	1942	D.F. from shelling
T&NO	744	113	Colorado	1528-F-2	1942	D.F. from shelling
C&O	745	131	Steelton	86056-D-11	2-1946	D.F. from shelling
T&NO	746	112	Steelton	88016-C-9	1935	D.F. from shelling
CN	747	85	Dominion	D463-A-4	1941	D.F. from shelling
CN	748	85	Dominion	8483-F-6	1940	T.F. from shatter cracks
CN	749	85	Dominion	-------	1945	Base break at seam
AT&SF	750	131	Colorado	11041-C-13	1-1942	D.F. from shelling
AT&SF	751	131	Colorado	13503-D-8	12-1941	D.F. from shelling
T&NO	752	113	Colorado	4576-A-6	11-1941	Fracture from pipe in web
CB&Q	753	131	Inland	33687-A-8	1944	T.F. from hot torn steel
StL—SF	754	112	Tennessee	-------	1942	D.F. from shelling
StL—SF	755	112	Tennessee	-------	1942	D.F. from shelling
StL—SF	756	112	Tennessee	-------	1943	D.F. from shelling
C&O	757	131	Gary	52233-F-4	5-1937	P.F. from welded engine burn
B&M	758	112	Steelton	83232	1944	T.F. from hot torn steel
B&M	759	107	Steelton	-------	1942	T.F. from hot torn steel
B&M	760	112	Steelton	87257-E-11	5-1944	D.F. from shelling
B&M	761	112	E. Thomson	11228-A-28	6-1944	D.F. from shelling
B&M	762	112	E. Thomson	08F238-A-29	1944	D.F. from shelling

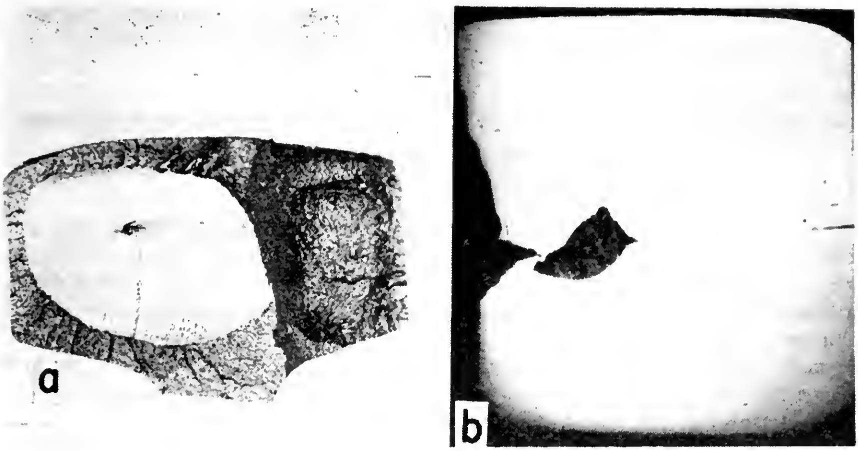


Fig. 1—Transverse fissure from inclusion.
a. Fissure with small cavity at nucleus.
b. Longitudinal section through nucleus. Magnification about 4X. Unetched.

there was a similar inclusion in the nucleus of the transverse fissure which dropped out when the rail was fractured. A similar condition was found in the other rail which developed a transverse fissure from an inclusion.

Fractures from Welded Engine Burns

In past reports internal failures from welded engine burns have been called transverse fissures from welded engine burns. This terminology was discussed by the AREA Rail committee, and it was decided to change this classification to fractures from welded engine burns. There were four such failures examined during the past year. Fig. 2a shows one of these failures, and Fig. 2b shows an etched cross section through the welded area. The latter figure also shows horizontal cracks at the bottom of the weld deposited

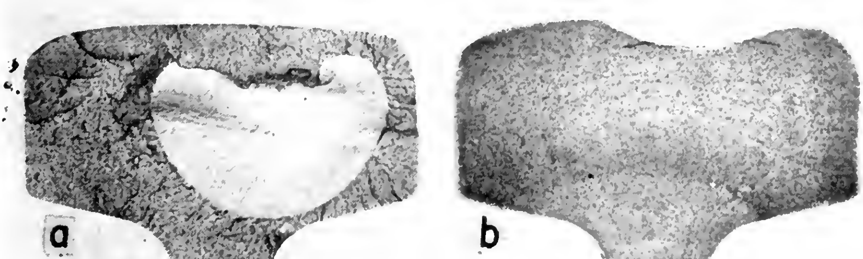


Fig. 2—Fracture from welded engine burn
a. Fissure has developed downward from horizontal crack.
b. Etched cross section showing weld deposited metal and horizontal cracks. Etched in hot 50 percent hydrochloric acid.

metal. The number of rails which break from welded engine burns appears to be small compared to the number of engine burn fractures which develop from engine burns that are not welded. While the ratio of welded to un-welded engine burns in service is not known, the 1950 figures show 336 failures in rails with engine burns which had not been welded, compared with 4 failures in welded engine burns sent to this laboratory for examination.

Bolt Hole Failures

A number of rails with bolt hole failures have been examined, which were not control-cooled rails and which are not included in Table 2. Rail 709 is shown in Fig. 3a and is a typical bolt hole crack in a control-cooled 1943 rail. This bolt hole is shown in Fig. 3b after pressing the hole full of aluminum so it could be polished and examined with the microscope. This same procedure was used on all the specimens used for study. No martensite or other hard metallographic constituents were found at any of the bolt holes examined. There is usually a layer of cold-worked metal at the edge of the bolt holes, as shown in Fig. 3d, which is a photomicrograph at about 300X magnification. The one observation which was common to most bolt hole failures was that the failures started at the edge of the rail webs, as shown in Fig. 3c, where the start of the fatigue crack is outlined in ink. It is thought that stress concentration at the sharp corner of a bolt hole, often aided by corrosion pitting both from inside the hole and from the side of the web, start most bolt hole failures.

Lap on Rail Tread

One unusual rail defect found by a detector car is included, although it had not as yet caused the rail to fail. It had been in track less than a year and apparently was located by the detector car the first time the rail was inspected. It was a lap or seam containing mill scale extending to a depth of ¼ in below the rail tread but sealed almost completely at the surface of the rail. An etched cross section of the lap is shown at about 30X magnification in Fig. 4. The mill scale has decarburized the adjacent steel forming a network of ferrite around the oxide. The lap was reported to be several feet in length in the rail. It is interesting to know that a detector car was able to locate this defect under the surface of the rail tread.

Detail Fracture from Arc Weld

During the last several years a few failures have been examined that have resulted from building up rail batter by arc welding. Fig. 5a is a 65 percent detail fracture from this cause 1 ft from the rail end. Fig. 5b is an etched cross section of the rail head showing that four beads have been placed on the rail tread and there are shrinkage cracks in 3 of the beads. Fig. 5c shows the rail tread etched in acid to open up the shrinkage cracks, which run longitudinally in the center of the weld beads. It has been reported that such shrinkage cracks can be avoided by proper preheating of the rails previous to the arc welding operation.

Fracture From Pipe in Web

One "A" rail failed from a pipe in the rail web. This fracture started as a horizontal crack in the rail web and turned up through the rail head and down through the rail base. Fig. 6 shows the area along the pipe where the fracture started and where it turned up through the rail head. Although this pipe was found to be 5 ft in length it did not extend to the end of the "A" rail and could not be detected when the rail was inspected at the steel mill.

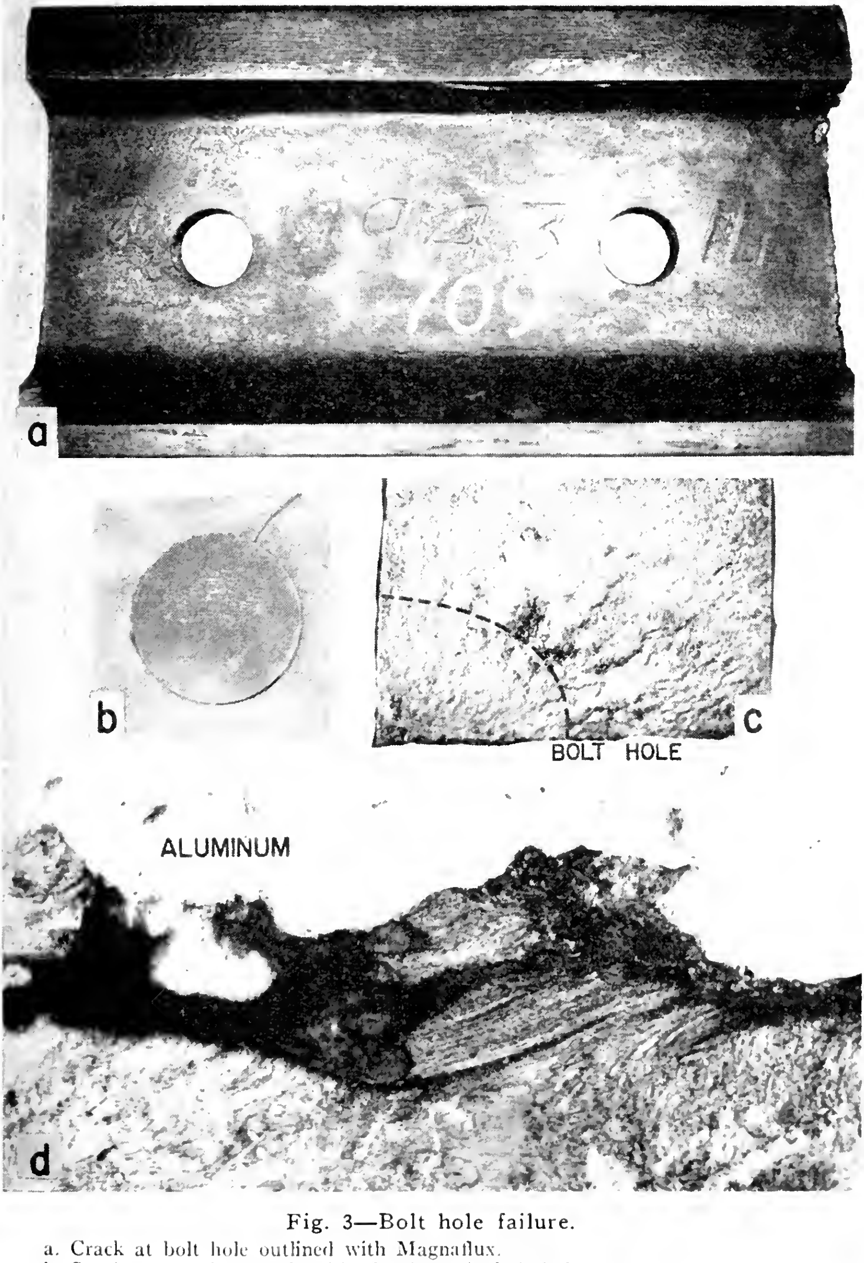


Fig. 3—Bolt hole failure.

a. Crack at bolt hole outlined with Magnaflux.
b. Specimen cut from web with aluminum in bolt hole.
c. Web opened up showing start of fatigue crack.
d. Photomicrograph showing cold-worked layer. Magnification about 300X. Etched in 2 percent nital.

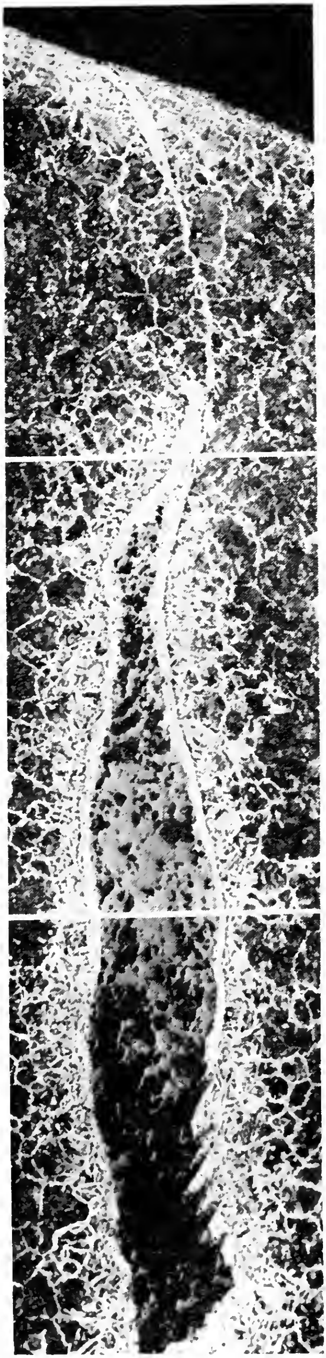


Fig. 4—Lap on rail tread; photomicrograph of cross section. Magnification about 30X. Etched in 2 percent nital.

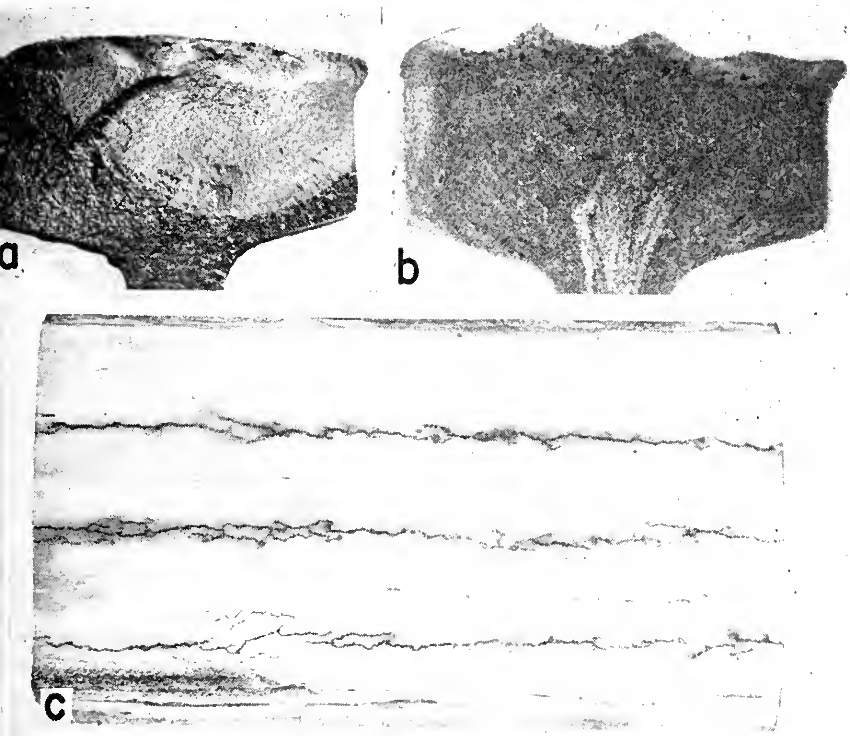


Fig. 5—Detail fracture from arc welding.

a. 65 percent detail fracture.
b. Etched cross section showing weld beads.
c. Etched tread of rail showing cracks. (b. and c. etched in hot 50 percent hydrochloric acid.

Fig. 6—Pipe in web of an "A" rail which caused failure.

Report on Assignment 3

Rail Failure Statistics, Covering (a) All Failures; (b) Transverse Fissures; (c) Performance of Control-Cooled Rail

C. J. Code (chairman, subcommittee), B. Bristow, C. B. Bronson, E. L. Gosnell, C. B. Harveson, W. H. Hobbs, N. W. Kopp, B. R. Meyers, L. T. Nuckols, Embert Osland, G. L. Plow, J. G. Roney, I. H. Schram, S. H. Shepley, A. A. Shillander, H. F. Whitmore.

These statistics present the rail failures reported to December 31, 1951, and are submitted as information. They include the failures reported by 66 railroads on all of their main-line railway mileage, which constitutes practically all of the main line track in the United States and Canada. This report was prepared by Kurt Kannowski, metallurgist of the AAR Engineering Division research staff, under the direction of G. M. Magee, director of engineering research.

The accompanying tables and diagrams have been prepared to indicate the extent of control of the transverse fissure problem that is being obtained by the use of control-cooled rail and detector car testing, to give data on the quality of each year's rollings for the various mills, and to show the types of failures that are occurring on the various railroads as related to the mill producing the rail.

Transverse Fissure Failures

In the report last year the marked reduction in transverse fissures service failures since 1943 was pointed out (Fig. 1), and it was explained that this reduction was due to the replacement of non-control-cooled rail with control-cooled rail, and to the detection of transverse fissures by detector cars and their removal before service failure occurred. It was also stated that if the decline in service transverse fissures continued at the same rate as from 1943 to 1950, the number of service transverse fissures would be negligible within a few years.

It will be observed from Table 1 and Fig. 1, line A, that the reduction in number of service transverse fissure failures in 1951 did not materialize to the extent anticipated. The number of service transverse fissures reported in 1950 was 1767, and this was only reduced to 1672 in 1951. Several of the larger roads, including the AT&SF, Erie, L&N, NYC, PRR, SP, and Southern, had more service failures in 1951 than in 1950. About the same mileage of control-cooled rail was laid in 1950 as in 1949 and 1948 (Table 3), and there continues to be practically no transverse fissure failures developing in control-cooled rail. Evidently the removal of transverse fissures by detector cars did not affect the same rate of improvement as in previous years, in spite of the fact that more transverse defects were detected in 1951 than in 1950 (Fig. 1). There were approximately 210,000 detector car test miles in 1951, and in addition to the 32,027 transverse defects, 5944 engine-burn fractures and 30,568 other defects, including vertical and horizontal split heads, were detected. Corresponding data for 1950 are not available, so it is not known how the number of detector car test miles in 1951 compared with 1950. It appears that the amount of detector car testing will be an important factor in obtaining a further reduction in transverse fissure service failures.

Mill Performance

The quality of steel and the excellence of rolling mill practice is reflected by Figs. 2 and 3. Fig. 2, giving the number of service and detected failures occurring during the first five years of service, shows that the 1946 rollings have the same low failure rate as he 1945 rollings. In Fig. 3, giving the failure rates by individual mills, the indicated erformance is in general good. The rate of failures in the 1950 and 1949 Algoma rollings s quite high, and this is due principally to base failures in the 100 RE headfree section n the Canadian Pacific. The failure rate in the 1941 to 1944 Carnegie–E.T. rollings is educed compared to last year's report by rail being removed from service in which an bnormally high number of web failures within joint bar limits had developed. The 945 Colorado rollings showed a high failure rate last year, and this increased substan- ially this year. These failures were mostly CF's and DF's on the Union Pacific. The 941 rollings for Lackawanna showed a high rate last year and an even higher rate this ear, due to a large number of web failures within joint bar limits on the New York Central. The 1950 Lackawanna rollings show an unusually high rate for the first year f service. This was due principally to 20 "other head" failures on the Great Northern nd 7 VSH failures on the Grand Trunk Western.

Generally, the mill performance as indicated by the failure statistics appears good. The high rates for certain rollings appear to be influenced by local conditions on a few ailways rather than by the quality of the steel. Except for the 1949 and 1950 Algoma ollings and the 1950 Lackawanna rollings, the failure rates for the years 1948, 1949, nd 1950, following adoption of the new rail sections, are reduced about one-half as ompared to the years 1945, 1946, and 1947, preceding their adoption. The service period or the new sections has not been long enough to definitely evaluate their merits in pre- venting web failures within joint bar limits, but the above comparison is very ncouraging.

Types of Failures

It is evident from Table 6 that compound fissures and detail fractures, and web failures within joint bar limits, are the most prevalent types of failures occurring in control-cooled rail. These two classifications comprised 63 percent of all failures reported to December 31, 1950, and 65 percent to December 31, 1951. Table 7 shows that the majority of these failures have occurred on a few railroads. The CF's and DF's are relatively high on the N&W, UP, NYC, D&H, PRR, RF&P, and L&N. These roads are all experiencing difficulty with shelly rail and probably most of this classification is detail fractures from shelling.

Web failures within joint bar limits are relatively high on the CP, B&O, PRR, NYC, and the L&N. A report of bolt hole and fillet failures in rail rolled since 1937 occurring in 1951 gave the following:

	Detected	*Service*
Bolt Hole Failures	2457	2572
Fillet Failures	4017	708
Total	6474	3280

The total of service and detected failures for 1951 of 9754 is almost equal to the total "Web-in Jt." failures reported in Table 7 for a 10-year period. Several roads have not reported fillet failures and bolt hole cracks detected by supersonic detectors as rail failures, and a modification of Form 402–C (a) is proposed this year to establish a uniform basis of reporting.

It is expected that the new rail designs and bolt hole spacing, and the research work underway on corrosion prevention and bolt hole finishing will materially reduce the incidence of failures within joint bar limits.

Since most of the CF's and DF's appear to be detail fractures from shelling, a remedy for the shelly rail problem may be expected to bring this type of failure under control.

Table 8 shows that the control-cooling process continues to be effective in the prevention of transverse fissures from shatter cracks.

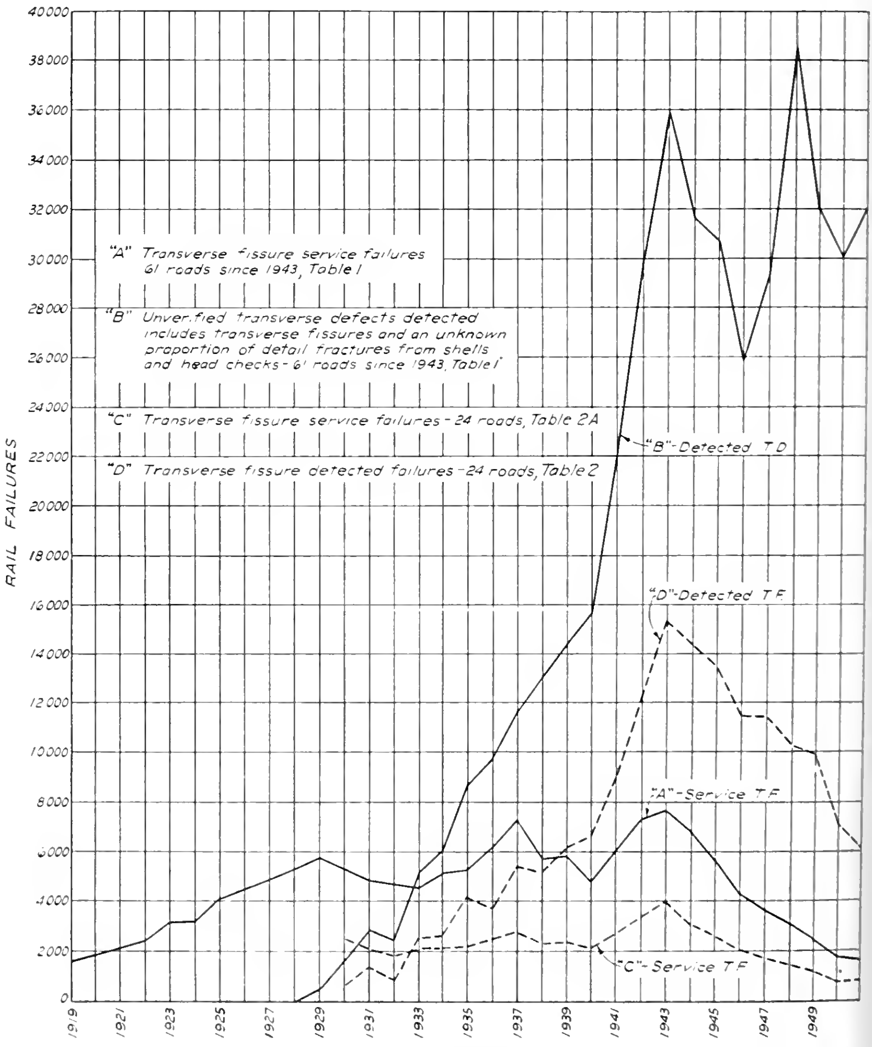


FIG 1—ANNUAL SERVICE RAIL FAILURES DUE TO TRANSVERSE FISSURES AND TO DETECTED TRANSVERSE DEFECTS AS REPORTED BY ALL RAILROADS

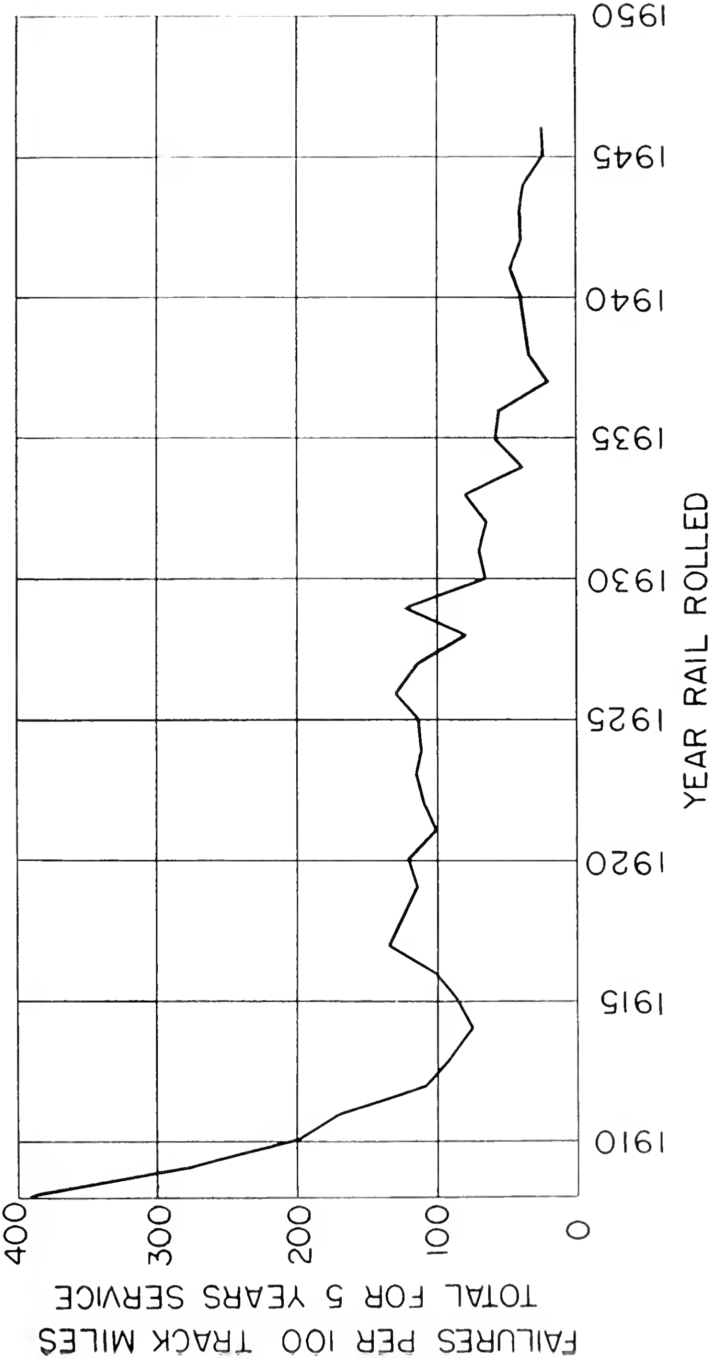


FIG. 2- SERVICE AND DETECTED FAILURES IN UNITED STATES AND CANADA

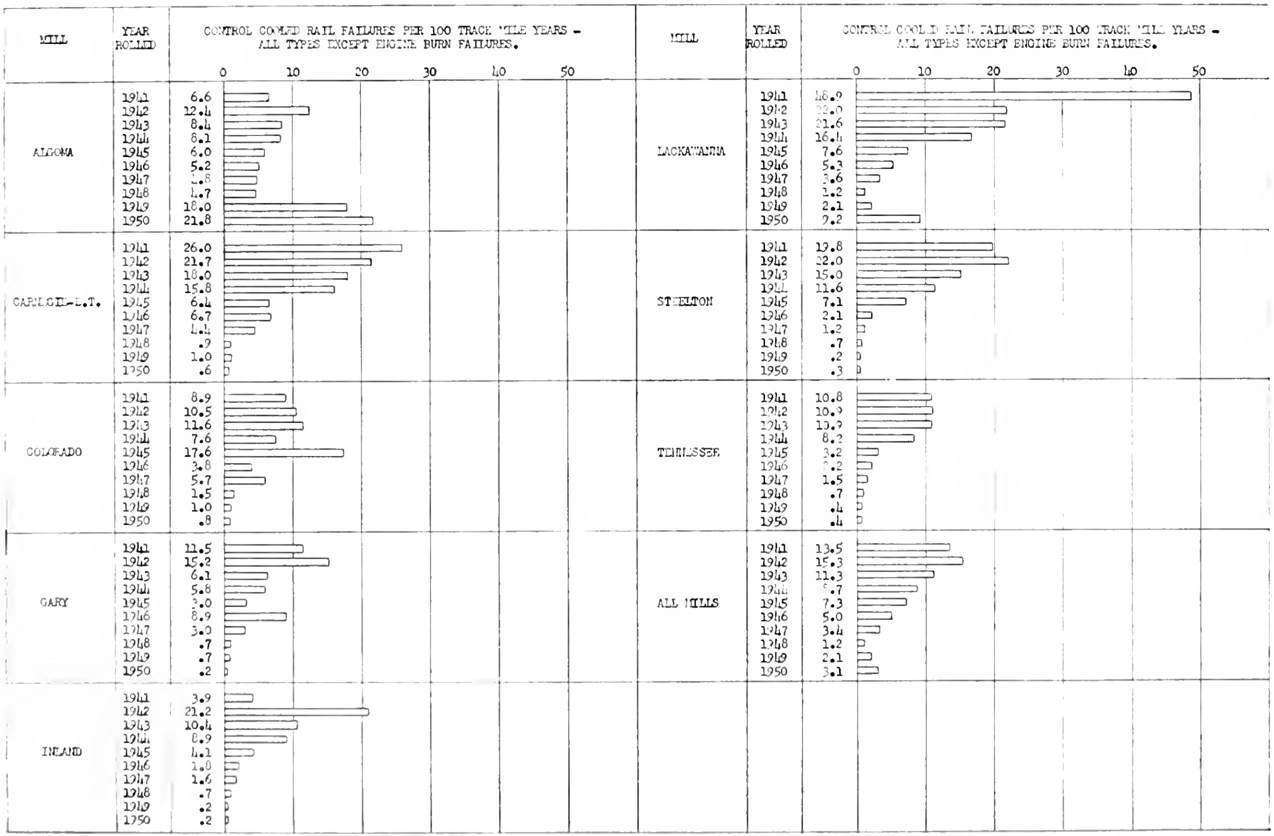


Fig. 3 - Control Cooled Rail Failure Rates to December 31, 1951 by Mills - All Types Except Engine Burn Failures - Service and Detected.

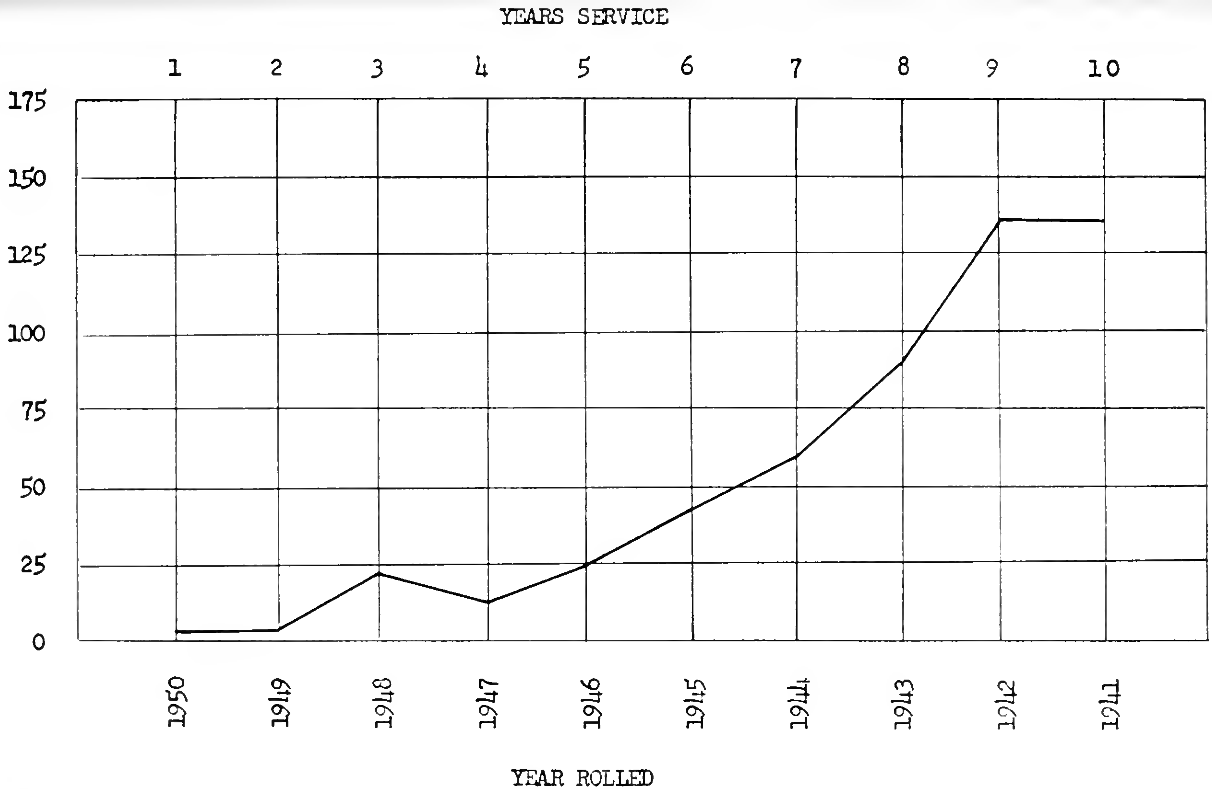


Fig. 4 - Control Cooled Rail Failures to December 31, 1951 Per 100 Track Miles - All Types Excluding Engine Burn Fractures - Service and Detected.

TABLE 1—SERVICE FAILURES FROM TRANSVERSE FISSURES AND DETECTED FAILURES FROM TRANSVERSE DEFECTS, BY RAILROADS AND BY YEAR FAILED—ALL ROLLINGS BY ALL PROCESSES

	Service Failures											Detected Failures										
Year Failed	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951	Total	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951	Total
AT&SF	341	455	307	141	157	112	92	103	39	52	1799	566	831	647	538	580	388	1358	1449	1110	1169	8636
ACL	250	218	267	50	51	43	14	7	12	9	921	809	1220	870	1302	924	1120	1491	919	944	758	10357
Ban & Aroos	3	3	4	3	1	2	0	0	1	0	17	0	0	0	0	49	0	26	16	19	7	117
B&OCT	—	—	2	0	0	12	9	5	1	2	31	—	—	0	0	0	0	2	15	5	2	24
B&LE	—	—	10	6	9	3	5	3	3	2	41	—	—	0	0	0	0	0	0	0	0	0
B&M	20	42	64	17	11	26	31	16	14	7	248	661	884	276	695	315	212	379	300	375	356	4453
B&O	588	425	367	332	205	209	177	100	156	100	2659	1421	1269	780	844	978	801	713	780	733	745	9061
CP	425	381	238	274	214	184	181	131	77	75	2180	5201	5964	5064	4957	3105	4338	3546	3787	2866	3800	42628
C of Ga	62	77	61	58	31	40	31	18	17	24	419	223	407	179	157	184	0	426	275	274	243	2368
C of NJ	77	77	71	48	45	61	65	37	48	14	543	0	0	0	0	3	0	0	0	0	0	3
C&EI	31	48	51	62	57	42	33	41	17	15	397	138	271	352	304	338	316	317	320	265	212	2833
C&O Ches Dist	123	107	71	57	68	88	64	37	22	29	637	417	540	393	458	465	559	1108	845	512	637	5303
C&O PM Dist	9	15	4	1	1	0	0	0	0	0	30	111	124	87	27	23	0	11	5	2	6	396
C&NW	162	168	160	135	137	168	149	118	84	85	1366	1463	1495	1578	1641	1176	1461	976	1159	816	1216	12981
CB&Q	272	323	287	244	141	152	144	65	59	59	1752	774	1733	1245	1342	1408	885	954	975	465	679	10460
CI&L	—	—	12	16	8	6	7	0	4	4	51	—	—	19	21	57	2	114	77	151	80	521
CMStP&P	119	136	136	132	79	87	89	61	48	42	929	684	468	1062	1083	1069	1173	914	1080	675	763	8971
CRI&P	158	247	183	168	123	127	83	47	48	56	1240	390	605	645	643	527	552	596	620	445	369	5392
C&S	—	—	26	21	3	10	3	5	2	0	70	—	—	28	47	82	17	189	72	164	55	654
D&H	—	—	67	31	14	19	12	12	6	10	171	—	—	192	196	114	111	314	508	306	430	2171
DL&W	96	23	27	29	36	22	17	8	7	3	268	1089	369	333	300	303	375	319	186	270	225	3769
D&RGW	—	—	203	212	159	22	31	15	16	14	672	—	—	114	254	190	14	695	373	741	545	3026
Erie	210	207	177	99	98	87	58	43	24	52	1055	405	1133	971	549	666	619	776	570	543	1169	7401
FEC	—	—	152	92	67	86	55	39	27	1	519	—	—	367	119	164	279	182	243	26	13	1393
GN	225	261	243	247	266	175	175	+102	85	94	1873	258	366	430	535	516	430	1531	936	1167	1069	7238
GM&O	57	48	29	54	—	26	35	—	—	—	249	28	298	306	60	—	265	274	—	—	—	1231
GTW	—	—	43	43	13	20	27	19	11	9	185	—	—	112	112	83	89	110	123	118	85	832
IC (Sys)	699	534	311	197	64	65	59	69	53	55	2106	1483	2000	1925	1907	1314	1418	1650	1284	1296	1226	15503
KCS	—	—	14	21	4	0	10	8	4	6	67	—	—	178	66	94	0	94	73	100	93	698
L&HR	10	1	8	0	0	4	0	0	0	1	24	24	0	24	13	12	6	0	0	0	11	90
L&NE	8	3	5	2	7	2	5	0	0	0	30	27	12	4	15	16	13	36	4	12	12	151
LV	79	41	33	49	22	22	14	6	14	12	292	171	128	189	156	67	127	55	126	87	163	1269
L&N	202	217	160	159	116	133	115	60	48	63	1273	925	800	747	684	648	653	933	864	743	843	7840
Long Island	—	—	—	—	—	—	—	0	0	—	0	—	—	—	—	—	—	—	25	26	18	69

TABLE 1 (Continued)

Year Failed	Service Failures											Detected Failures										
	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951	Total	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951	Total
Me Cen	-----	-----	12	15	14	0	0	7	6	2	56	-----	-----	21	63	50	0	0	74	130	89	427
MStP&SSM	-----	-----	13	49	23	30	21	17	11	11	175	-----	-----	39	24	96	90	95	73	104	116	637
MKT	81	131	92	57	28	31	30	24	16	19	509	455	249	515	214	141	118	576	532	359	290	3449
MoPacRR	-----	288	-----	-----	-----	-----	-----	-----	*47	44	322	-----	1328	-----	-----	-----	-----	-----	-----	1109	835	3272
MoPac Lines	-----	68	25	24	31	42	4	24	10	28	256	-----	502	728	399	462	507	553	518	370	473	4512
NC&StL	39	57	58	43	32	19	9	9	7	6	279	126	218	172	184	68	84	104	59	45	43	1103
NYC (Sys)†	617	652	406	344	225	202	173	165	154	177	3115	623	844	559	1119	750	724	1484	1508	1306	1344	10261
NYC&StL	-----	192	86	47	29	45	37	21	19	16	492	-----	392	318	199	215	172	128	118	106	84	1732
NYC Transit	-----	-----	3	3	6	2	15	-----	-----	-----	29	-----	-----	0	0	0	0	0	-----	-----	-----	0
NYNH&H	34	24	21	14	3	5	4	2	3	1	111	121	268	136	74	86	68	172	79	116	77	1197
NYO&W	32	16	62	6	1	24	24	12	21	25	223	0	0	53	0	56	2	0	0	11	20	142
N&W	9	2	3	1	5	3	2	3	3	1	32	49	34	40	40	58	17	129	84	130	124	705
NP	241	317	310	288	289	188	129	90	73	11	1936	470	589	440	471	702	475	431	473	347	377	4775
PRR††	440	517	365	415	290	259	255	430	92	103	3166	858	799	1026	909	646	644	1865	1166	1876	1844	11633
P&LE	-----	-----	4	0	3	0	1	0	0	1	9	-----	-----	4	6	1	5	36	22	29	12	115
Reading	267	172	173	70	49	47	0	0	0	0	778	0	0	367	735	287	321	1236	404	241	451	4042
RF&P	27	28	31	27	20	12	10	6	1	0	162	168	238	228	207	176	106	514	195	172	128	2132
Rutland	1	1	3	1	2	1	0	0	0	4	13	8	0	0	0	0	9	0	0	0	28	45
Seaboard	-----	-----	49	23	24	21	11	18	22	7	175	-----	-----	197	159	299	440	412	299	454	324	2584
SP (Pac Lines)	452	426	445	267	209	179	162	98	68	75	2381	1610	2002	1536	1377	1362	909	1243	1012	952	960	12963
Sou (Sys)	337	311	278	277	246	188	171	98	98	106	2110	2454	3541	2360	1955	1835	1998	2643	2009	1927	1682	22404
StLSF	-----	-----	111	142	102	101	74	52	17	16	615	-----	-----	573	655	415	532	664	639	515	377	4370
T&NO	-----	-----	239	186	123	66	112	99	90	88	1003	-----	-----	795	924	837	739	951	1006	958	788	6998
T&P	93	160	128	124	72	71	46	22	16	8	740	758	839	869	582	524	0	393	173	152	114	4404
UP (Sys)	447	389	226	241	176	172	55	19	23	13	1761	4479	3045	1587	1356	1148	4957	4149	3613	3429	4142	31905
Va	16	12	11	13	10	4	6	1	0	0	67	173	114	114	0	0	0	152	24	60	73	710
WMd	48	35	26	27	14	33	25	3	16	15	242	228	152	184	133	144	224	418	302	138	133	2056
W&LE	-----	-----	3	3	5	1	0	3	7	-----	22	-----	-----	0	3	3	0	8	5	11	-----	30
ALL ROADS	7407	7795	6976	5707	4238	3801	3166	2398	1767	1672	44893	29848	36071	31978	30813	25831	29364	38445	32396	30303	32027	316445

*Includes all transverse defects.
No report received.
†Includes IHB failures.
††Including LI RR and PRSL 1940 to 1948, incl.
= Include engine-burn fractures.

TABLE 2—SERVICE AND VERIFIED DETECTED TRANSVERSE FISSURE FAILURES BY RAILROAD AND BY YEAR FAILED REPORTED BY ROADS WHICH BREAK THEIR DETECTED RAILS. ALL ROLLINGS BY ALL PROCESSES

Year Failed	Service Failures 1942	1943	1944	1945	1946	1947	1948	1949	1950	1951	Total	Detected Failures 1942	1943	1944	1945	1946	1947	1948	1949	1950	1951	Total
AT&SF	341	455	307	141	157	112	92	103	39	52	1799	566	831	647	538	580	388	298	488	359	362	5057
Ban & Aroos	3	3	4	3	1	2	0	0	1	0	17	0	0	0	0	49	0	26	11	19	7	112
CP	425	381	238	274	214	184	181	131	77	75	2180	5201	5946	5064	4957	3105	4338	3545	3787	2866	1900	40709
C&EI	31	48	51	62	57	42	33	41	17	15	397	138	271	352	304	338	316	312	320	245	187	2783
CB&Q	272	323	287	244	141	152	144	65	59	59	1746	774	1733	1245	1342	1408	885	887	884	426	528	10112
CMStP&P	119	136	136	132	79	87	89	61	48	42	929	684	468	1062	1083	1069	1173	734	901	557	567	8298
C&S			26	21	3	10	3	5	2	0	70			28	47	82	17	56	37	53	45	365
Erie	210	207	177	99	98	87	58	43	24	52	1055	405	1133	971	549	666	619	595	469	463	362	6232
GTW			43	43	13	20	27	19	11	9	185			112	112	83	89	106	123	118	85	828
GN	225	261	243	247	266	175	175	102	85	94	1873	258	366	430	535	516	430	631	599	519	546	4830
L&N	202	217	160	159	116	133	115	0	48	63	1213	925	800	747	684	648	653	662	0	483	524	6126
Long Island*								0	0	0	0								25	26	18	69
MKT	81	131	92	57	28	31	30	24	16	19	509	455	249	515	214	141	118	280	264	176	265	2677
NC&StL	39	57	58	43	32	19	9	9	7	6	279	126	218	172	184	68	84	87	58	39	34	1070
NYC (Sys)	617	652	406	344	225	202	173	165	154	177	3115	623	844	559	1119	750	724	690	693	673	648	7323
NYC&StL		192	86	47	29	45	37	21	19	16	492		392	318	199	215	172	128	116	0	0	1540
NYNH&H	34	24	21	14	3	5	4	2	3	1	111	121	268	136	74	86	68	132	60	107	64	1116
N&W	9	2	3	1	5	3	2	3	3	1	32	49	34	40	40	58	17	29	28	32	16	343
NP	241	317	310	288	289	188	129	90	73	11	1936	470	589	440	471	702	475	355	441	41	22	4006
PRR	440	517	365	415	290	259	255	430	92	103	3166	858	799	1026	909	646	644	404	16	0	0	5302
P&LE			4	0	3	0	1	0	0	1	9			4	6	1	5	0	0	3	3	22
RF&P	27	28	31	27	20	12	10	6	1	0	162	168	238	228	207	176	106	147	49	22	12	1353
Rutland	1	1	3	1	2	1	0	0	0	4	13	8	0	0	0	0	9	0	0	0	14	31
Va	16	12	11	13	10	4	6	1	0	0	73	173	114	114	0	0	0	1	0	0	0	402
W Md	48	35	26	27	14	33	25	3	16	15	242	228	152	184	133	144	224	210	141	66	77	1559
Total	3381	3999	3088	2702	2095	1806	1598	1324	795	815	21603	12230	15445	14394	13707	11531	11554	10315	9510	7293	6286	112265

*Included in PRR prior to 1949.

TABLE 3 - TONS OF RAILS AND TRACK MILES OF EACH YEAR'S ROLLINGS 1941 - 1950 INCL., REPORTED BY 64 RAILROADS.

Year Rolled	OH CONTROL COOLED ONLY		BRUNORIZED AND OTHER PROCESS		TOTAL	
	TONS	TRACK MILES	TONS	TRACK MILES	TONS	TRACK MILES
1941	822,838	4,438.45	40,414	232.09	863,252	4,670.54
1942	1,089,627	5,874.97	14,129	95.61	1,103,756	5,970.58
1943	1,266,383	6,887.90	11,443	77.24	1,277,826	6,965.14
1944	1,530,164	8,252.41	7,845	54.12	1,538,009	8,306.53
1945	1,507,471	8,047.68	0	0	1,507,471	8,047.68
1946	1,239,882	6,588.50	0	0	1,239,882	6,588.50
1947	1,405,192	7,280.77	0	0	1,405,192	7,280.77
1948	1,294,254	6,669.01	0	0	1,294,254	6,669.01
1949	1,153,879	6,029.31	0	0	1,153,879	6,029.31
1950	1,174,216	6,173.38	0	0	1,174,216	6,173.38
TOTAL	12,483,906	66,242.38	73,831	459.06	12,557,737	66,701.33

TABLE 4 - SERVICE AND DETECTED FAILURES OF ALL TYPES EXCEPT ENGINE BURN FAILURES ACCUMULATED FROM DATE ROLLED TO DECEMBER 31, 1951 PER 100 AVERAGE TRACK MILES, CONTROL COOLED RAIL ONLY, IN ALL ROLLINGS, FROM ALL MILLS.

Year Rolled	Years of Service									
	1	2	3	4	5	6	7	8	9	10
1941	-	4.2	9.3	24.3	46.3	66.1	90.6	116.1	145.2	131.6
1942	2.3	6.0	11.6	24.9	37.7	54.8	74.8	101.4	136.0	
1943	3.4	8.4	16.5	23.9	34.9	48.7	66.1	88.5		
1944	3.6	7.2	13.8	19.4	33.3	46.1	65.5			
1945	1.4	4.1	8.6	15.7	28.8	43.9				
1946	1.2	2.9	6.6	12.9	25.3					
1947	0.9	3.1	6.5	13.7						
1948	0.7	1.6	3.6							
1949	1.7	4.1								
1950	3.1									

Note: - indicates figures are not available.

TABLE 5 - TRACK MILES AND 1951 FAILURES, ALL TYPES, IN ROLLINGS 1941 TO 1950, INCL., OPEN-HEARTH CONTROL-COOLED RAIL ONLY

ROAD	TRACK MILES BY MILL											1951 FAILURES ONLY	
	ALG.	CARN	COLO	DOM	GARY	INL'D	LACKA	MD	STLTN	TENN	TOTAL	EBFS EXCL	EBFS ONLY
AT&SF			2989		1085	161					4234	225	0
ACL		101							580	972	1654	16	7
B&O		1050			394	18	223		563		2249	179	134
B&OCT					19	26					45	1	0
B&AROOST		3							154		157	0	0
B&LE		124									124	2	0
BCC&ALB					7		187		5		199	5	1
B&M		135					181		112		428	12	0
CP	4538			260			185				4983	682	0
C of GA.										403	403	41	0
C&O-CHES. E REGN.		80			1115	428	47		192		1862	172	40
C&O-PM	92	228				99	70				489	5	2
C&EI					231	32					263	13	0
C&NW					841	168	103				1112	97	0
CB&Q			1267		859	160					2286	146	1
CCC&StL					861		45				906	231	2
CI&L					111	22					133	1	0
CMStP&P					1511	390					1901	6	0
CRI&P			314		1199	342					1855	66	0
C&S			64								64	2	0
D&H									396		396	172	2
DL&W		85					307				392	0	0
D&RGW			545								545	90	0
ERIE		759			247	31	141				1178	26	2
FEC		40							90	527	657	5	1
GTW					358	82	48				488	27	0
GN			170		755	188	264				1377	190	2
IC					1662	631				382	2675	109	5
IHB						22					22	0	0
KCS					431	46					477	0	0
L&HR									31		31	0	0
L&NE									55		55	5	0
L.I.									130		130	0	0
LV							350				350	3	0
L&N					197					1688	1885	306	4
Me. Cen.							89				89	3	0
Mich.Cen.	315				302		3				620	25	21
MStP&SSM					166	107	101				374	11	0
MKT			108		485	94					687	8	0
MP RR			1240		504	163				30	1937	35	0
MP LINES		15	419							179	613	11	0
NC&StL										502	502	75	0
NYC-E					58		1307				1365	1552	16
NYC-W					595	57	107				759	321	27
NYC&StL		237			482	103	229				1051	174	0
NYNH&H		256							296		552	21	3
N&W		1044							392		1436	218	10
NP			551		751	82	374				1758	64	8
PRR		1368			741	112			1393		3614	1248	206
P&E						33					33	0	0
P&LE		170									170	117	0
READING									490		490	0	0
RF&P									155		155	39	0
RUTLAND							3				3	2	0
SAL		3							838	544	1385	20	0
StLSF					10	50				755	815	11	0
SP			3579						31	78	3688	442	68
SOUTHERN					115				770	1313	2198	141	12
T&NO			794							67	861	34	0
T&P			611							134	745	14	0
UP			2379		1033	158					3570	2152	7
Va.		102							150		252	19	0
W. Md.		115							167		282	37	0
W&LE													
JCL									205		205	0	0
NY&LB									28		28	3	0
Total	4945	5915	15030	260	17124	3805	4364		7224	7575	66242	9631	581

TABLE 6 - ACCUMULATED FAILURES AND FAILURES PER 100 TRACK MILES, IN ROLLINGS 1941 to 1950, INCLUSIVE FROM DATE ROLLED TO DECEMBER 31, 1951, SERVICE AND DETECTED, BY MILL AND TYPE OF FAILURE.

OH CONTROL COLLED RAIL ONLY

MILL	ACCUMULATED FAILURES TO DECEMBER 31, 1951 (EXCL. EBFs)									ALL TYPES	TRACK MILES	TRACK MILE YEARS	FAILURES PER 100 TRACK MI. YEARS
	TF VER U of I	CF & DF	VSH	HSH	OTHER HEAD	BROKEN	WEB IN JT.	WEB OTHER	BASE				
ALGOMA	2	9	323	15	302	123	437	62	870	2,143	4,945	26,322	8.14
CARNEGIE(ET)	4	433	87	127	147	173	1,996	1,004	6	3,977	5,915	30,152	13.19
COLORADO	0	3,882	622	742	543	117	408	799	14	7,127	15,030	82,221	8.67
DOMINION	0	0	1	0	1	2	23	3	3	33	260	565	5.84
GARY	1	2,268	173	112	396	363	3,390	570	88	7,362	17,124	95,174	7.74
INLAND	8	418	52	22	38	140	586	107	28	1,399	3,805	19,583	7.15
LACKAWANNA	20	218	49	44	120	106	2,904	80	176	3,717	4,364	22,195	16.75
MARYLAND	-	-	-	-	-	-	-	-	-	-	-	-	-
STEELTON	20	1,948	39	92	111	282	953	203	5	3,653	7,224	35,814	10.20
TENNESSEE	0	350	189	578	262	349	753	317	67	2,865	7,575	40,633	7.05
ALL MILLS	55	9,526	1,535	1,733	1,920	1,655	11,450	3,145	1257	32,276	66,242	352,659	9.15
FAILURES 100 TR. MI. YEARS	.02	2.70	.43	.49	.55	.47	3.24	.89	.36	9.15			

TABLE 7 - ACCUMULATED FAILURES OF ALL TYPES OF OH CONTROL COOLED RAIL ONLY, IN ROLLINGS 1941-1950, INCL., ACCUMULATED TO DECEMBER 31, 1951, SEGREGATED BY ROADS AND MILLS, FROM TABLE 6, EXCLUSIVE OF ENGINE BURN FRACTURES SHOWN SEPARATELY FOR 1950 ONLY AND TOTAL ACCUMULATED 1943-1951, INCL.

ROADS	TF Ver UofI	CF & DF	VSH	HSH	Other Head	Broken	Web In Jt.	Web Other	Base	FAILURES TOTALS EBFs Excl. Accum. Total	EBFs Excl. 1951	EBFs Only 1943 1951	EBFs Only 1951
ALGOMA													
CP	1	8	321	14	301	123	433	60	868	2129	660	0	0
C&O-PM	0	1	1	0	0	0	0	0	0	2	0	0	0
NYC-MC	1	0	1	1	1	0	4	2	2	12	2	5	3
TOTAL	2	9	323	15	302	123	437	62	870	2143	662	5	3
CARNEGIE													
B&O	0	84	34	19	56	14	310	149	0	666	89	180	60
B&LE	0	1	1	1	0	1	0	0	0	4	2	0	0
B&M	3	3	1	1	10	3	1	24	0	46	4	0	0
C&O-Ches	0	1	0	0	0	0	2	0	0	3	0	0	0
C&O-PM	0	0	4	0	1	0	0	0	0	5	2	1	1
DL&W	0	0	1	0	0	0	0	0	0	1	0	0	0
ERIE	0	15	1	5	5	2	3	12	1	44	9	7	1
FEC	0	0	0	0	2	0	6	0	0	8	1	0	0
NYNH&H	0	17	10	18	1	3	20	0	0	69	14	11	1
N&W	1	195	3	25	21	0	44	44	1	334	97	34	6
NYCStL	0	2	6	11	25	27	57	27	3	158	42	8	8
PRR	0	91	17	30	25	59	1436	723	1	2382	511	276	87
P&LE	0	2	3	1	1	0	116	7	0	130	117	15	0
Va.	0	21	1	8	0	36	1	9	0	76	9	0	0
WM	0	1	6	7	0	28	0	9	0	51	16	0	0
W&LE													
TOTAL	4	433	87	127	147	173	1996	1004	6	3977	913	532	156
COLORADO													
ATSF	0	176	86	69	12	26	102	29	3	503	205	0	0
CB&Q	0	1	28	16	11	4	102	23	1	186	119	2	0
CRI&P	0	0	18	1	8	25	2	0	3	57	13	0	0
D&RGW	0	191	14	26	12	5	11	6	0	265	90	0	0
MKT	0	0	3	5	2	1	1	2	0	14	2	0	0
MP	0	4	50	16	41	6	40	22	1	180	15	0	0
MP LINES	0	0	8	3	2	8	11	3	0	35	9	7	0
NP	0	2	11	2	14	8	8	7	0	52	20	6	2
SP	0	58	292	453	264	27	87	505	6	1692	366	121	61
T&NO	0	8	17	18	18	6	2	67	0	136	29	0	0
T&P	0	0	5	1	1	1	13	1	0	22	4	0	0
UP	0	3442	90	132	155	0	29	134	0	3982	1566	5	5
C&S	0	0	0	0	2	0	0	0	0	2	2	0	0
GN	0	0	0	0	1	0	0	0	0	1	0	0	0
TOTAL	0	3882	622	742	543	117	408	799	14	7127	2440	141	68

TABLE 7 - CONTINUED

ROADS	TF Ver UofI	CF & DF	VSH	HSH	Other Head	Broken	Web: In Jt.	Web: Other	Base	FAILURES TOTALS: EBFs Excl. Accum. Total	FAILURES TOTALS: EBFs Excl. 1951	FAILURES TOTALS: EBFs Only 1943 1951	FAILURES TOTALS: EBFs Only 1951
DOMINION													
CP	0	0	1	0	1	2	23	3	3	33	11	0	0
Total	0	0	1	0	1	2	23	3	3	33	11	0	0
GARY													
AT&SF	0	0	12	3	5	6	21	0	0	47	20	0	0
B&O	0	1	8	2	9	1	162	11	4	198	36	90	27
B&OCT	0	0	0	1	0	0	1	0	0	2	1	0	0
Bos&Al	0	0	0	0	0	0	3	0	0	3	1	0	0
C&O-Ches	1	190	6	8	7	9	50	26	0	297	68	192	34
C&O-PM													
C&EI	0	0	4	2	13	0	26	4	0	49	13	3	0
C&NW	0	14	10	4	27	63	319	9	7	453	73	1	0
CB&Q	0	6	7	5	9	3	27	7	2	66	25	2	1
CMStP&P	0	1	4	0	7	38	1	6	6	63	2	0	0
CRI&P	0	0	6	9	21	103	8	5	13	165	45	0	0
CCC&StL	0	8	8	4	28	5	244	63	3	363	226	7	2
ERIE	0	17	1	0	0	2	4	8	1	33	9	2	1
GTW	0	1	7	0	8	54	14	2	30	116	21	0	0
GN	0	241	12	4	89	1	33	11	0	391	133	2	2
IC	0	36	36	13	8	10	124	16	4	247	50	7	4
KCS	0	26	4	0	1	2	0	6	1	40	0	9	0
L&N	0	7	0	0	0	0	1	3	0	11	8	0	0
NYC-MC	0	2	3	6	7	0	20	10	0	48	22	29	17
MStPSSM	0	0	4	0	2	8	0	0	4	18	3	0	0
MKT	0	0	6	3	8	0	20	5	0	42	6	0	0
MP	0	7	4	6	3	5	18	25	2	70	12	0	0
NC&StL	0	0	1	0	2	0	1	1	0	5	1	0	0
NYC-E	0	90	2	8	7	0	436	0	0	543	318	3	2
NYC-W	0	72	3	0	41	2	445	0	0	563	223	61	22
NYC&StL	0	7	4	5	24	6	241	28	1	316	88	1	0
NP	0	2	5	2	28	19	8	3	8	75	26	6	0
PRR	0	52	10	3	1	23	1156	223	0	1468	324	36	15
StLSF	0	0	0	0	1	0	0	1	0	2	0	0	0
SOUTHERN	0	1	0	0	1	3	1	3	1	10	1	1	1
UP	0	1486	6	25	39	0	6	94	1	1657	546	4	2
CI&L	0	1	0	0	0	0	0	0	0	1	0	0	0
TOTAL	1	2268	173	113	396	363	3390	570	88	7362	2301	456	130

TABLE 7 - CONTINUED

ROADS	TF Ver UofI	CF & DF	VSH	HSH	Other Head	Broken	Web In Jt.	Web Other	Base	FAILURES TOTALS EBFs Excl. Accum. Total	EBFs Excl. 1951	EBFs Only 1943-1951	EBFs Only 1951
INLAND													
B&O	0	2	1	0	0	0	3	0	0	6	3	0	0
B&OCT	0	1	0	0	0	1	0	0	0	2	0	0	0
C&O-Ches	7	229	8	3	5	12	33	8	0	305	56	61	4
C&O-PM	0	2	3	0	0	0	0	0	1	6	2	0	0
C&EI	0	0	2	0	0	0	0	0	0	2	0	3	0
C&NW	0	10	5	3	1	20	37	2	5	83	22	0	0
CB&Q	0	0	1	3	2	2	2	1	0	11	2	0	0
CMStP&P	1	0	1	1	8	33	1	2	2	49	4	0	0
CRI&P	0	0	0	1	2	17	4	1	2	27	8	0	0
ERIE	0	1	0	0	0	1	2	3	0	7	2	0	0
GTW	0	0	2	0	3	17	0	0	6	28	1	0	0
GN	0	0	1	1	4	0	2	0	1	9	0	0	0
IC	0	46	15	1	0	6	50	6	3	127	36	2	0
IHB	0	0	0	0	0	4	8	2	0	14	0	0	0
MStPSSM	0	0	1	0	0	10	0	1	4	16	0	0	0
MKT	0	1	4	2	2	0	1	3	0	13	0	1	0
MP	0	4	2	2	3	1	14	3	0	29	7	0	0
NYC-W	0	7	2	0	0	2	8	5	0	24	7	1	0
NYC&StL	0	3	2	0	3	2	70	3	2	85	18	0	0
NP	0	0	0	0	0	1	0	0	2	3	0	0	0
PRR	0	16	0	4	1	11	351	64	0	447	88	5	0
UP	0	96	1	1	4	0	0	0	0	102	40	0	0
CI&L	0	0	1	0	0	0	0	0	0	1	1	0	0
KCS	0	0	0	0	0	0	0	3	0	3	0	0	0
TOTAL	8	418	52	22	38	140	586	107	28	1399	297	73	4
LACKAWANNA													
B&O	0	22	2	0	0	2	17	15	0	58	6	33	4
Bos.& Alb.	0	0	1	0	0	0	14	1	3	19	4	2	1
B&M	8	7	1	1	11	9	0	1	2	40	5	1	0
CP	0	0	5	1	34	0	13	5	36	94	10	0	0
C&NW	0	0	0	0	4	0	0	0	2	6	2	0	0
CCC&StL	0	0	1	0	6	1	8	9	0	25	5	0	0
DL&W	0	1	4	4	1	0	2	2	6	20	0	1	0
ERIE	0	14	0	0	0	3	0	8	1	26	6	1	0
GTW	0	0	14	0	0	4	0	0	3	21	5	0	0
GN	0	26	4	3	38	0	14	2	6	93	57	0	0
LV	4	5	1	0	0	11	6	20	21	68	3	0	0
MC	0	0	1	0	3	0	0	2	0	6	3	0	0
NYC-MC	0	0	0	0	0	0	1	0	0	1	1	3	1
MStPSSM	0	0	1	0	0	11	0	0	5	17	8	1	0
NYC-E	4	135	8	32	9	13	2253	1	13	2468	1234	24	14
NYC-W	0	1	3	2	3	0	531	2	1	543	91	18	5
NYC&StL	3	2	0	1	9	4	41	8	1	69	26	0	0
NP	0	1	2	0	2	34	4	4	57	104	18	8	6
C&O-PM	0	0	1	0	0	1	0	0	2	4	1	1	1
PRR													
RUTLAND	0	0	0	0	0	13	0	0	17	30	2	0	0
C&O-Ches.	1	4	0	0	0	0	0	0	0	5	4	0	0
TOTAL	20	218	49	44	120	106	2904	80	176	3717	1491	93	32

TABLE 7 - CONTINUED

ROADS	TF Ver UofI	CF & DF	VSH	HSH	Other Head	Broken	Web In Jt.	Web Other	Base	FAILURES TOTALS EBFs Excl. Accum. Total	EBFs Excl. 1951	EBFs Only 1943 1951	EBFs Only 1951
STEELTON													
AT&SF													
B&O	6	51	8	8	21	2	52	37	2	187	45	164	43
BAN&AROOS	0	0	1	0	0	1	0	0	0	2	0	0	0
BOS&ALB	0	0	0	0	1	0	0	0	0	1	0	0	0
B&M	1	3	2	1	9	8	1	2	0	27	3	1	0
C&O-Ches	0	144	5	8	4	0	10	5	0	176	44	7	2
D&H	1	425	2	31	6	8	13	32	1	519	172	15	2
FEC	0	0	0	1	0	0	0	0	0	1	0	1	0
L&NE	0	1	0	0	1	0	1	5	0	8	5	0	0
NYNH&H	3	25	2	2	0	2	12	0	0	46	7	12	2
N&W	6	132	0	7	7	0	84	17	0	253	121	23	4
PRR	0	781	1	20	54	186	748	9	0	1799	325	170	104
RDG	0	0	0	0	0	7	0	1	0	8	0	1	0
RF&P	0	287	5	2	2	0	9	0	0	305	39	8	0
SAL	1	1	1	0	0	6	5	6	1	21	4	0	0
SOUTHERN	2	35	0	0	3	18	5	0	0	63	11	24	0
SP	0	5	3	11	3	1	0	63	0	86	6	5	0
T&NO													
VA	0	54	2	1	0	18	6	17	1	99	10	0	0
WM	0	1	7	0	0	24	0	8	0	40	21	0	0
JCL	0	3	0	0	0	1	3	1	0	8	0	0	0
NY&LB	0	0	0	0	0	0	4	0	0	4	3	0	0
TOTAL	20	1948	39	92	111	282	953	203	5	3653	816	431	157
TENNESSEE													
ACL	0	3	12	9	1	3	38	5	5	76	16	12	7
CGA	0	8	8	12	11	8	74	7	9	137	41	14	0
FEC	0	1	0	2	1	4	12	2	2	24	4	11	1
IC	0	8	18	7	0	8	63	5	2	111	23	4	1
LN	0	250	78	242	34	58	379	63	17	1121	298	18	4
MP	0	0	1	2	4	2	3	3	0	15	1	0	0
MP LINES	0	0	0	0	1	0	2	0	0	3	2	0	0
NC&StL	0	21	36	85	104	20	121	48	9	444	74	0	0
SAL	0	3	3	12	3	40	10	5	8	84	16	3	0
StL&SF	0	17	14	6	25	18	3	35	1	119	11	0	0
SOUTHERN	0	25	6	27	73	180	19	98	11	439	129	42	11
SP LINES	0	13	13	173	4	6	2	41	1	253	70	11	7
T&P	0	1	0	1	1	2	27	0	2	34	10	0	0
T&NO	0	0	0	0	0	0	0	5	0	5	5	0	0
TOTAL	0	350	189	578	262	349	753	317	67	2865	700	115	31
ALL MILLS	55	9526	1535	1733	1920	1655	11450	3145	1257	32276	9631	1846	581

TABLE 8 - ACCUMULATED TRANSVERSE FISSURE FAILURES AND FRACTURES FROM WELDED ENGINE BURNS IN CONTROL COOLED RAIL AS VERIFIED BY LABORATORY INVESTIGATION, BY ROAD, MILL AND YEAR ROLLED TO OCTOBER 1, 1952.

Roads	Mills	1935	1936	1937	1938	1939	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951	Total
CP	Algoma					1(a)	1						1(a)						3
Mich. C.	Algoma					1(a)			1(a)										2
PM	Algoma						1												1
NYNH&H	Carnegie (ET)			1(d)															1
N&W	Carnegie (ET)					1				1(f)									2
AT&SF	Colorado					1(d)													1
SP	Colorado								1(b)										1
CN	Dominion						1(a)												1
C&O	Gary		2(b)	1(b)		1(b)	1(b)						1(b)						6
C&NW	Gary		3(a)	2(a)															5
CB&Q	Gary		3(a)																3
GN	Gary		1(a)																1
NYC	Gary				1(a)														1
Wabash	Gary			1(a)															1
AT&SF	Inland							1											1
CB&Q	Inland										1								1
C&O	Inland	1	4(o)	3	3		1(b)	6			1	1						1	21
CMStP&P	Inland										1								1
GN	Inland					1(e)													1
UP	Inland					3	3												6
C&O	Lackawanna															1			1
LV	Lackawanna								3	1									4
NYC	Lackawanna								1	1	2								4
NYC&StL	Lackawanna								2		1			1					4
AT&SF	Steelton			3															3
B&O	Steelton						1	1	2	1	1	1	1						8
B&M	Steelton						2		1		1								4
CofNJ	Steelton									1									1
C&O	Steelton	4		1	4		2									1			12
D&H	Steelton				1	2	1(f)		1	1									6
MP	Steelton			1															1
N&W	Steelton					1	1		6					1					9
NYNH&H	Steelton			3		2	1		1	2									9
PRR	Steelton		2																2

TABLE 8 (Cont.) - ACCUMULATED TRANSVERSE FISSURE FAILURES AND FRACTURES FROM WELDED ENGINE BURNS IN CONTROL COOLED RAIL AS VERIFIED BY LABORATORY INVESTIGATION, BY ROAD, MILL AND YEAR ROLLED TO OCTOBER 1, 1952.

Roads	Mills	1935	1936	1937	1938	1939	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951	Total
RF&P	Steelton			1			1								1				3
SAL	Steelton							2		1									3
SoRy	Steelton							1		1									2
SP	Steelton		18	2	6	4	1												31
Va.	Steelton						1												1
L&N	Tennessee							1(f)											1
SP	Tennessee		1(a)																1
TOTAL		5	34	19	15	18	19	12	19	10	8	2	3	2	1	2	0	1	170

TABLE 8 (Cont.) - ACCUMULATED TRANSVERSE FISSURE FAILURES AND FRACTURES FROM WELDED ENGINE BURNS IN CONTROL COOLED RAIL AS VERIFIED BY LABORATORY INVESTIGATION, BY MILL AND YEAR ROLLED TO OCTOBER 1, 1952.

Mills	1935	1936	1937	1938	1939	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951	Total
Algoma					2	2		1				1						6
Carnegie (ET)			1		1				1									3
Colorado	*				1			1										2
Dominion						1												1
Gary		9	4	1	1	1						1						17
Inland	1	4	3	3	4	4	7			3	1						1	31
Lackawanna								6	2	3			1		1			13
Steelton	4	20	11	11	9	11	4	11	7	2	1	1	1	1	1			95
Tennessee		1					1											2
TOTAL	5	34	19	15	18	19	12	19	10	8	2	3	2	1	2	0	1	170

Note: (a) T.F. TRANSVERSE FISSURE from shatter cracks due to use of improper cooling box covers. (b) P.F. PROGRESSIVE FRACTURE from welded engine burns. (c) One P.F. from welded engine burn. (d) T.F. from silicate inclusion (e) T.F. from small hole near welded joint. (f) T.F. from inclusions. Summary - 17 T.F.'s from shatter cracks, 12 P.F.'s from welded engine burns, 5 T.F.'s from inclusions, 1 T.F. from small hole near welded joint, 135 T.F.'s from hot torn steel.

* No cc rail rolled.

Report on Assignment 5

Economic Value of Various Sizes of Rail

A. A. Shillander (chairman, subcommittee), E. L. Anderson, W. J. Burton, B. Chappell, C. M. Chumley, C. J. Code, R. A. Emerson, P. O. Ferris, W. H. Hobbs, N. W. Kopp, W. B. Leaf, H. S. Loeffler, E. E Mayo, Ray McBrian, B. R. Meyers, Embert Osland, R. E. Patterson, G. A. Phillips, J. G. Roney, R. B. Rhode, J. C. Ryan, J. F. Shaffer, W. D. Simpson, A. P. Talbot, J. S. Wearn.

Your committee submits the following report of progress as information. It is a continuation of maintenance charges in Study A for last year, computed to show average in eight years.

Study A

Results of Study of Illinois Central Railroad
Northward Track, Mattoon to Savoy, Ill.
Test Sections of 112-lb and 131-lb Rail

112-lb Rail

M.P. 163.68 to M.P. 172.73 (Laid in 1942)
M.P. 152.24 to M.P. 163.68 (Laid in 1943)
(Station 10142+58 to Station 11224+95)
Total track miles maintained (108,173 trk ft) 20.48
No. turnouts maintained 18
No. railroad crossings maintanied ... 1
No. public grade crossings maintained 22
No. private grade crossings maintained 2

131-lb Rail

M.P. 132.00 to M.P. 152.24 (Laid in 1944)
(Station 11224+95 to Station 11293+98)
Total track miles maintained (106,747 trk ft) 20.21
No. turnouts maintained 21
No. railroad crossings maintained ... 3
No. public grade crossings maintained 22
No. private grade crossings maintained 6

Both Test Sections Computed at 1944 Prices

Average Annual Traffic Density—28,000,000 Gross Tons

Rail and Other Track Material	*Investment Charges Per Mile*			
	112 Lb		*131 Lb*	
Gross cost	$12,643		$14,413	
Less est. salvage	Cr. 4,284		Cr. 5,011	
Net cost	8,359		9,402	
Total cost to lay	1,338		1,473	
Total cost to place	9,697		10,875	
Estimated life—years	15 yr		25 yr	
Annual Cost				
Rail and Other Track Material		$ 557		$ 376
Laying		89		59
*Interest at 6%		839		953
Total annual cost		$1,485		$1,388
Percent decrease in investment cost				Cr. 6.5

*On gross outlay for material and labor.

COMPARISON OF TWO TEST SECTIONS—LABOR AND MATERIALS

112-Lb Rail						*131-Lb Rail*					
Year	*Man-Hours*	*Cross Ties*	*Switch Ties*	*Ballast Cu Yd*	*Rail Failures*	*Year*	*Man-Hours*	*Cross Ties*	*Switch Ties*	*Ballast Cu Yd*	*Rail Failures*
1942											
1943	49,427	14,148	3 #10-0	12,419	-----	1944	52,742	21,555	5 #10-0	13,102	-
1944	8,165	102	1 #15-0	337	-----	1945	2,643	-------	-------	600	-----
1945	13,842	4,665	--------	4,958	-----	1946	7,582	91	-------	2,300	-----
1946	23,046	8,221	--------	11,450	-----	1947	15,137	3,478	-------	6,100	-----
1947	12,746	4,101	1 #15-0	5,400	1	1948	5,961	764	1 #10-0	3,750	-----
1948	19,855	3,671	--------	5,800	-----	1949	13,570	200	1 #10-0	2,350	-----
1949	31,106	10,687	3 #10-0	8,350	3	1950	32,995	8,083	--------	6,840	-----
1950	13,818	3,466	--------	3,160	9	1951	12,333	1,193	--------	1,050	-----
Total	172,005	49,061		51,884			142,963	35,364		36,092	

112 lb—$\frac{172,005}{20.48 \times 8}$ = 1050 man-hours per mile per year

131 lb—$\frac{142,963}{20.66 \times 8}$ = 865 man-hours per mile per year

Saving of 185 man-hours per mile per year by use of 131-lb rail.

AVERAGE OF EIGHT YEARS

Annual Cost	*Maintenance Charges Per Mile*	
	112 Lb 20.48 Mi.	*131 Lb 20.66 Mi. (T)*
Labor hours	1,050	865
Cost at $.65	$ 682	$ 562
Cross ties	299	214
Cost at $1.87	$ 559	$ 400
Ballast (stone)	316	218
Cost at $.781	$ 246	$ 170
Total Maintenance	1,487	1,132
Percent saving	--------------	23.8
Total Annual Cost	$2,972	$2,520
Saving by use of 131-lb material	--------------	452
Percent saving	--------------	15.2

(T) Adjusted for additional turnouts and crossings.

Report on Assignment 6

Service Tests of Various Types of Joint Bars

T. A. Blair (chairman, subcommittee), J. B. Akers, W. J. Burton, E. E. Chapman, B. Chappell, L. S. Crane, C. J. Code, J. C. De Jarnette, Frank Fahland, P. O. Ferris, R. L. Groover, K. K. Kessler, N. W. Kopp, W. B. Leaf, H. S. Loeffler, E. E. Mayo, B. R. Meyers, E. H. McGovern, Embert M. Osland, G. A. Phillips, G. L. Plow, E. F. Salisbury, J. F. Shaffer, S. H. Shepley, G. L. Smith, J. S. Wearn, R. P. Winton.

This is a progress report, presented as information. The field work, analysis of data, and report of the measurements covered in this report were carried out by Kurt Kannowski, metallurgist, and other members of the Engineering Division research staff of the Association of American Railroads, under the direction of G. M. Magee, director of engineering research.

Description of 1948 Service Installations

The report of the committee in 1949 described the two service installations of various types of joint bars for the new 115 and 132 RE rail sections. Subsequently, at the request of the Rail Joint Company, an additional joint bar design of the long-toe or angle-type was added to each of the two installations. The service test sections of 132 RE joint bars are located on the eastbound main track of the Atchison, Topeka & Santa Fe Railway, 100 miles west of Chicago. Each test section is ½ mile in length, all located on tangent track. The test installation includes the following different test sections:

Location V–132 headfree, 36 in, 6–6–7⅛ in, new AREA punching, 6-hole bars, placed in August 1948.

Location W–132 RE headfree, 36 in, 9–9⅛–9 in punching, 4-hole bars, placed in August 1948.

Location X–132 RE, 36 in, 6½–6½–5⅛–6½–6½ in, old AREA punching, 6 hole bars, placed in August 1948.

Location Y–132 Rail Joint Co., K–42, headfree, 36 in, 6½–6½–5⅛–6½–6½ in, old AREA punching, 6-hole bars, placed in March 1949.

Location Z–132 Rail Joint Co., K–44, headfree, long-toe design, 39 in, 6½–6½–5⅛–6½–6½ in, old AREA punching, 6-hole bars, placed in March 1949.

It will be observed from the above that this test installation for 132 RE rail includes a comparison of three different designs of joint bars, and in the case of the new AREA headfree joint bar includes three different bolt hole spacings. Fig. 1, page 572, of AREA Bulletin 486, February 1950, shows the exact location of each test section, tied into mile posts and highways, and includes the designation letter and description of each.

In October 1948 measurements were made of rail surface profile, joint camber and out-to-out distances of bars on locations V, W, and X to provide base measurements for determining the rate of rail-end batter, joint droop, and fishing surface wear. Corresponding measurements were made at locations Y and X in May 1949 and October 1949, respectively. Complete measurements were made in July 1950, June 1951, and July 1952. The results of all of these tests are shown on figures 1, 2, and 3.

The test sections of the new 115 RE rail were installed on the westbound main track of the Chicago & North Western Railway near Sterling, Ill., 106 miles west of Chicago on the Omaha line. Each test section includes 100 joints and is approximately 2000 ft long. Location EE, the long-toe or angle-bar design, was added in May 1949, the other sections having been placed in November 1948. This test installation now includes the following sections, all on tangent track.

Location AA—115 RE headfree, 36 in, 9–9⅛ in punching, 4-hole bars.

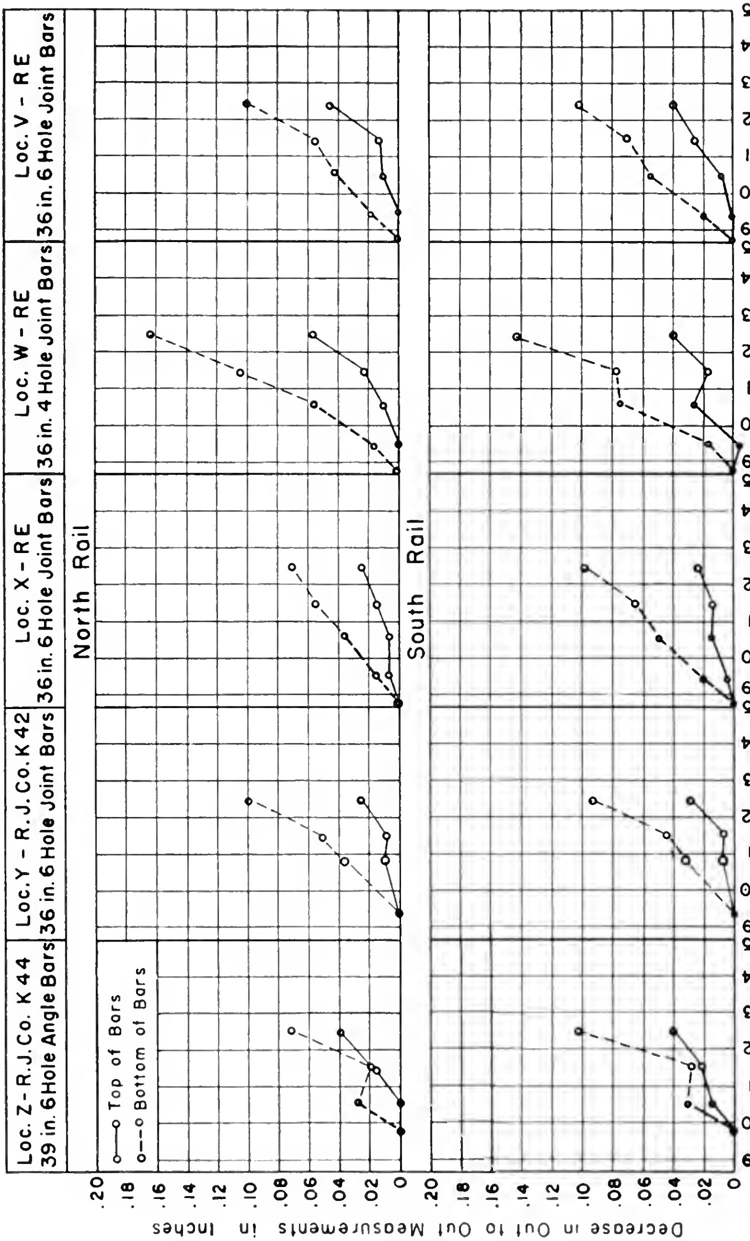
Location BB—115 RE headfree, 36 in, 6–6–7⅛–6–6, new AREA punching, 6-hole bars.

Location CC—115 R. J. Co., K–22, headfree, 36 in, 6–6–7⅛–6–6 in, new AREA punching, 6-hole bars.

Location DD—115 R. J. Co., K–4, headfree, 36 in, 6–6–7⅛–6–6 in, new AREA punching, 6-hole bars.

Location EE—115 R. J. Co., K–24, headfree, long-toe design, 39 in, 6–6–7⅛–6–6 in, new AREA punching, 6-hole bars.

(Text continued on page 1221)



Note: Out to Out measurements are the average of 30 joints on each rail at all test locations.

Fig. 1 — Change in Out to Out Distances at Middle of Joint Bars, A.T. & S.F. Ry.

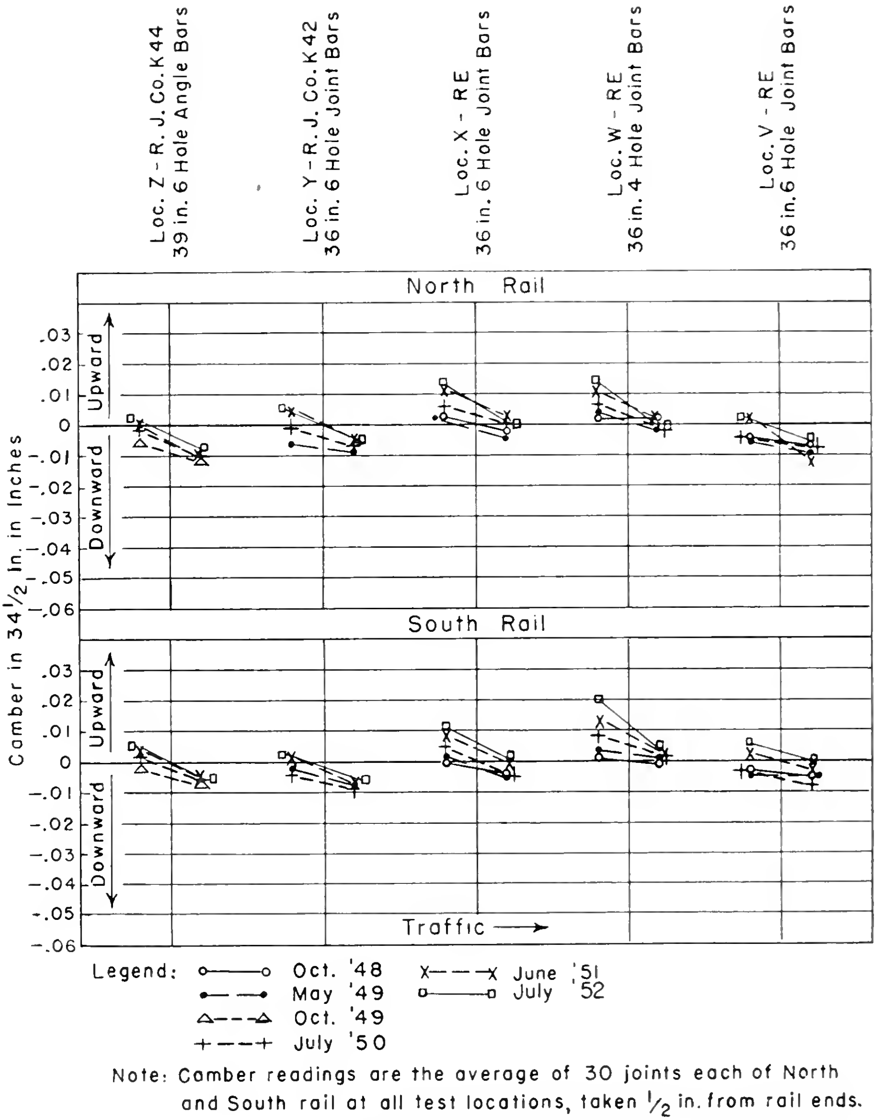
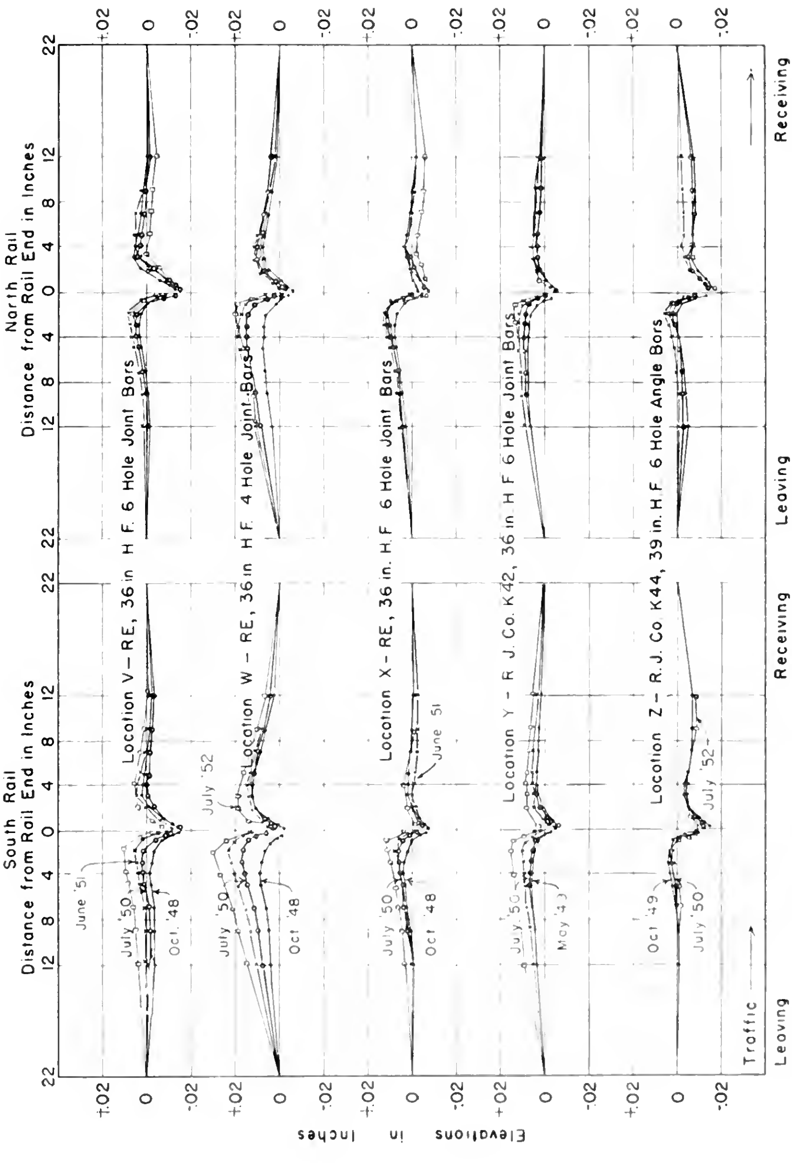
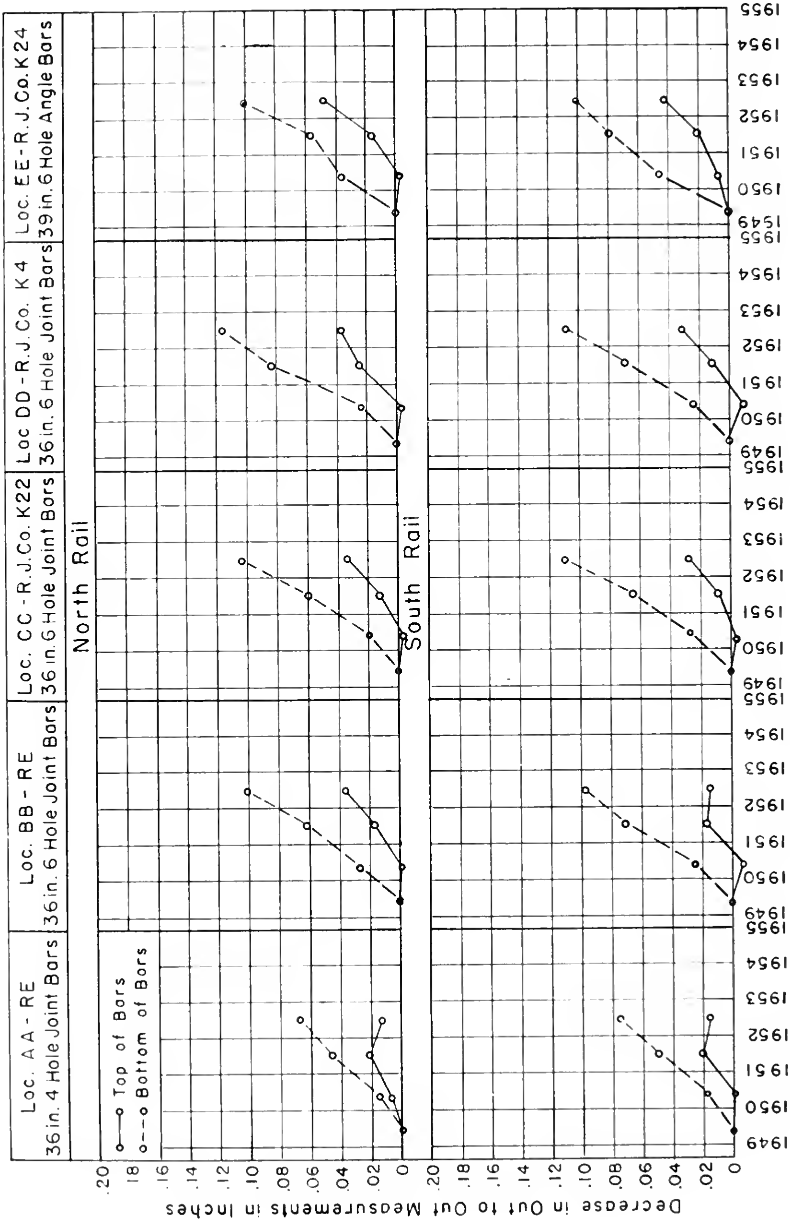


Fig 2— Top of Rail Camber in $34^1/_2$ in., A.T. & S.F. Ry. 1948 to 1951.



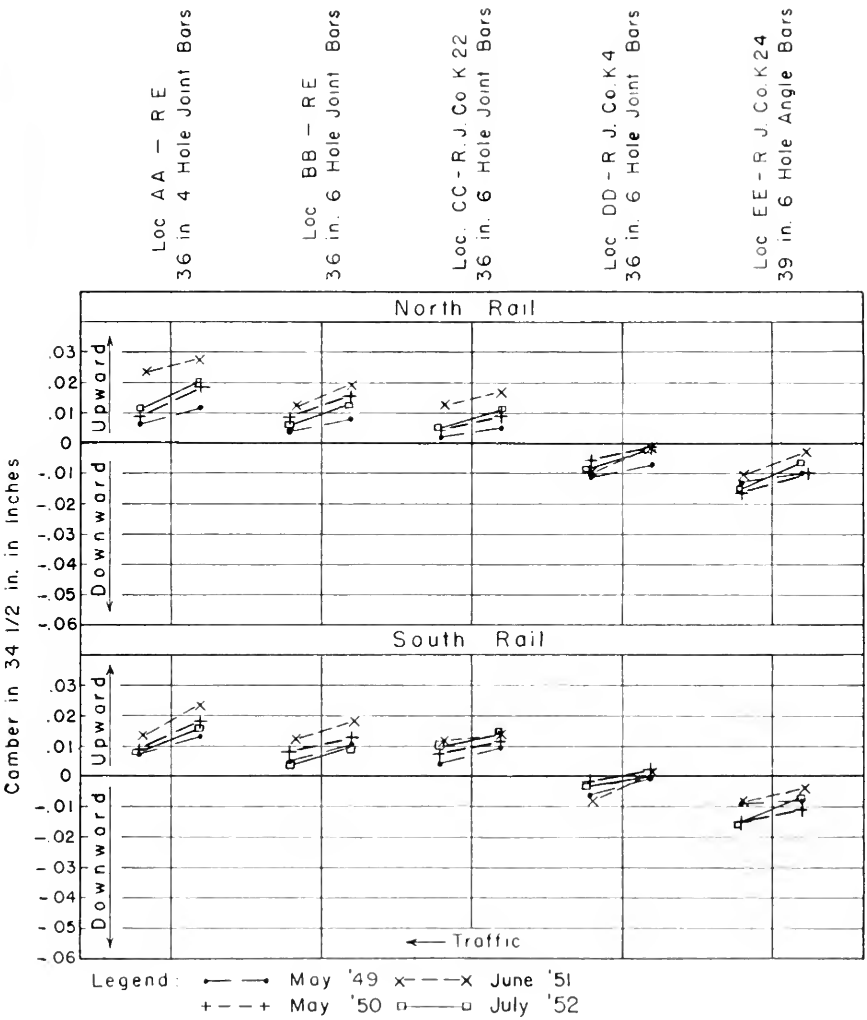
Note: Profile elevations are the average of 15 joints of each rail

Fig 3 — Rail Surface Profile, A T & S F Ry., 1948 to 1952.



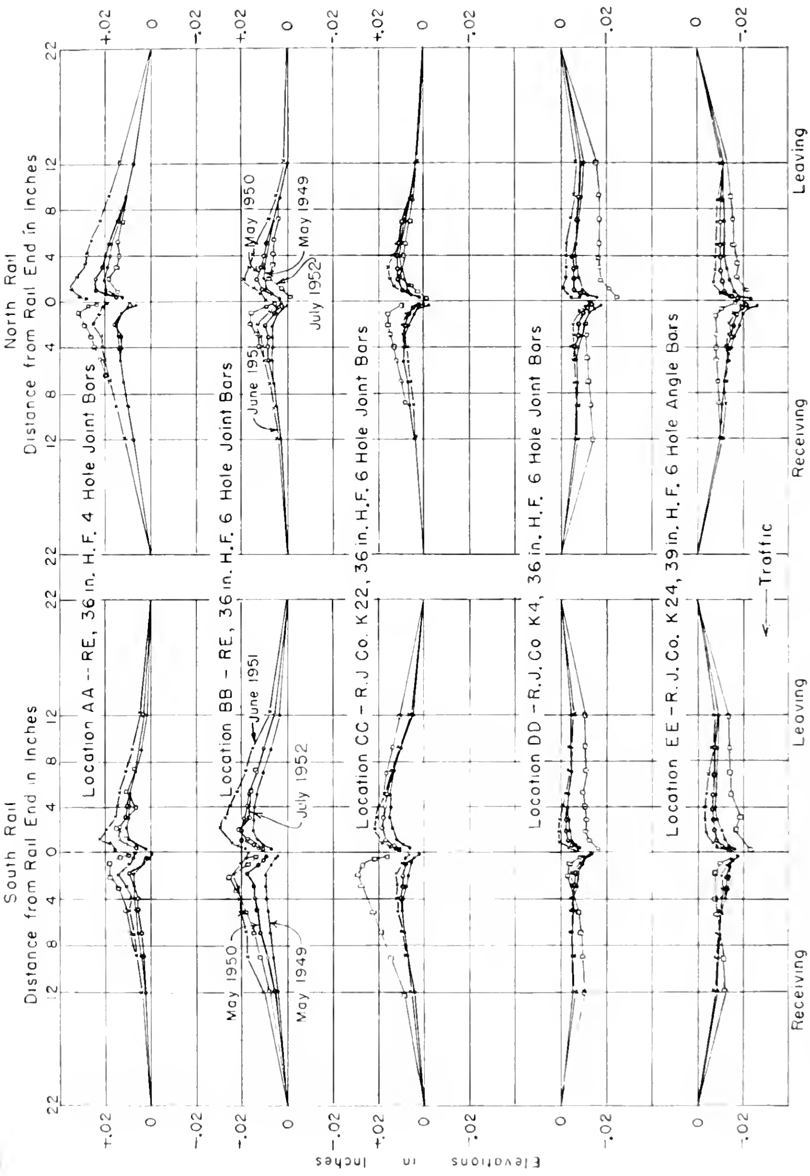
Note: Out to Out measurements are the average of 30 joints on each rail at all test locations.

Fig 4— Change in Out to Out Distances at Middle of Joint Bars, C. & N. W. Ry.



Note: Camber readings are the average of 30 joints each of North and South rail at all test locations, taken 1/2 in from rail ends.

Fig. 5 — Top of Rail Camber in 34 1/2 in., C & N.W Ry 1949 to 1951



Note Profile elevations are the average of 15 joints of each rail

Fig 6 — Rail Surface Profile, C & N W. Ry., 1949 to 1952.

The designation letters for locations AA to DD are the reverse of the order given in the report of 1949. This change was made after location EE was added to have the sections in alphabetical order in track.

It will also be noted that the above includes four different designs of joint bars and also includes for the new 115 AREA headfree design a test section with the new AREA punching and a test section with a 4-hole punching for a 36-in length bar. Fig. 2 on page 573 of AREA Bulletin 486, February 1950, shows mile posts, highways, designation letters, and joint bar description relative to each test section. Measurements of rail surface profile, joint camber, and out-to-out distances of bars were made in May 1949, May 1950, May 1951, and July 1952. The results of these measurements are shown on Figs. 4, 5 and 6.

Conclusion

In the early phase of the life of the joint bars no great difference in the performance may be expected, which is shown on Figs. 1–6. It may be noted, though, that the change in out-to-out distances at the middle of the 36-in, 4-hole RE joint bars on location W on the AT&SF is greater than that of the other types of joint bars. With this exception the performance of the joint bars at both test installations has been normal to date.

Report on Assignment 7

Joint Bar Wear and Failures; Revision of Design and Specifications for New Bars, Including Insulated Joints, and Bars for Maintenance Repairs

E. E. Chapman (chairman, subcommittee), C. J. Code, B. R. Meyers, J. B. Akers, T. A. Blair, W. J. Burton, C. M. Chumley, H. R. Clarke, L. S. Crane, J. C. DeJarnette, Jr., Frank Fahland, J. L. Gressitt, R. L. Groover, W. H. Hobbs, S. R. Hursh, L. R. Lamport, E. E. Mayo, E. H. McGovern, E. Osland, G. A. Phillips, G. L. Plow, J. C. Ryan, I. H. Schram, J. F. Shaffer, S. H. Shepley, A. P. Talbot, H. F. Whitmore.

This is a progress report, submitted as information, which includes in Appendix 7–a the Eleventh Progress Report on Rolling-Load Tests of Joint Bars being conducted at the University of Illinois under the direction of Prof. R. S. Jensen, and in Appendix 7–b a report of the service tests on the Burlington Railroad near Fort Morgan, Colo., of 112-lb joint bars of different metallurgies.

Proposed revisions to Specifications for Quenched Carbon-Steel Joint Bars are being given consideration, as follows:

Tensile Properties: Paragraph 8(a): The minimum tensile strength requirement be increased from 100,000 to 110,000 psi so as to make it compatible with the 70,000 psi minimum yield point requirement. This recommendation has not as yet been taken up with the Joint Contact Committee.

Yield Point: Paragraph 8(b): In favor of retaining this paragraph as written and do not recommend changing yield point to yield strength.

During the past year laboratory and service tests have been planned on two groups of 132 RE bars that were rolled in 1948 and removed in 1951 from Santa Fe track and salvaged by special heat treatment. Also included with these bars are two groups of new bars rolled in 1952. The four groups of test bars, from which samples have been sent to the University of Illinois for investigation, are as follows:

1. Twenty-four joint bars with pressed easement and mill quenched.
2. Twenty-four joint bars with ground easement, requenched 1525 deg F.
3. Twenty-four joint bars with ground easement, requenched 1525 deg F and tempered 800 deg F.
4. Twenty-four joint bars mill quenched and easement ground 1½ in to 1⅝ in long and 3/32 in deep.

There are approximately 1100 bars from each of the two groups of reheat-treated joint bars for service test and 800 bars mill quenched with ground easement. The remainder of the 4½-mile test section between Ridgeton and Lebo, Kan., on the Eastern Division of AT&SF, will be installed with the pressed easement, mill quenched joint bar.

It is the opinion of the subcommittee that a recommended practice for the bevelling of rail ends should be included with other recommendations concerning rail. In order

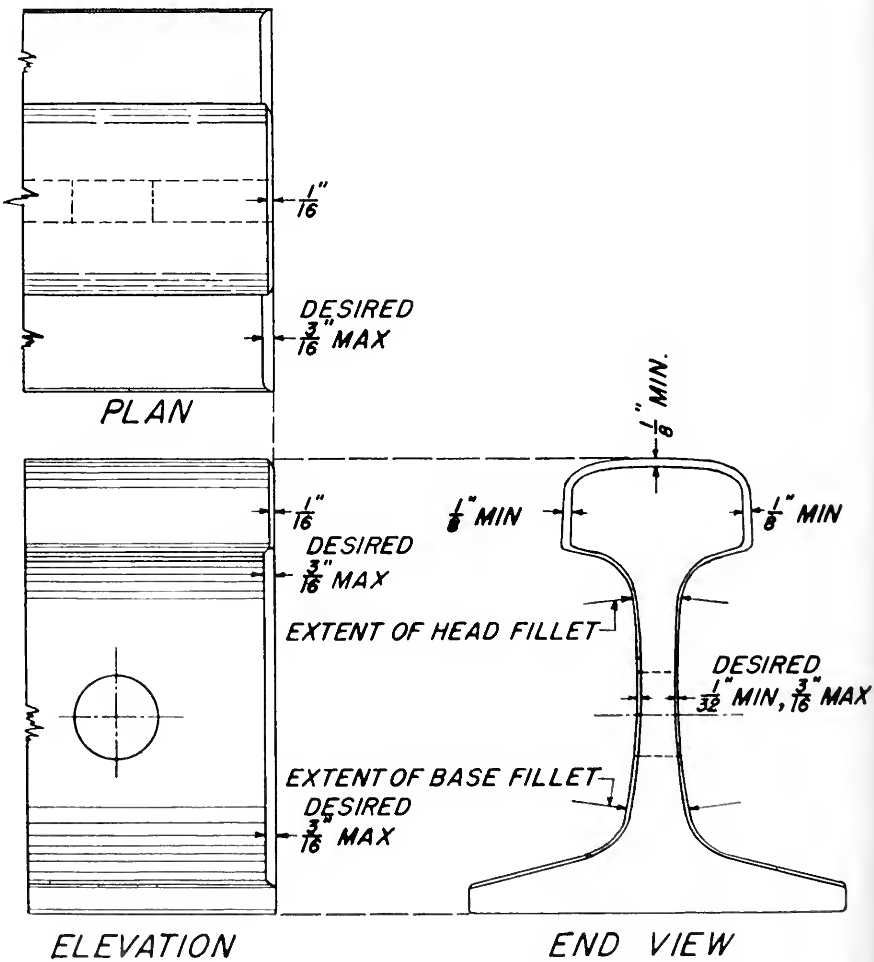


Fig. 1—Beveling of rail ends.

that all concerned may have ample opportunity to study the subject before adoption as Manual material, a drawing showing the proposed bevelling is included as information for publication in the Proceedings, but not for inclusion in the Manual.

Future test work should include a study of the maximum easement length and depth permissible that will not materially shorten the fatigue life of the bar; this information to serve as a guide when grinding out cracks on the top fishing surface at bars mid-length. Preliminary tests on 112-lb bars conducted at the University of Illinois have indicated that a maximum ground area 2 13/16 in. in length and 9/32 in. in depth required to eliminate an existing crack did not shorten the fatigue life of the bar.

Appendix 7–a

Eleventh Progress Report of the Rolling-Load Tests of Joint Bars

By R. S. Jensen

Research Assistant Professor of Engineering Materials, University of Illinois

Introduction and Acknowledgment

This report covers test of joint bars conducted during the past year in the Talbot Laboratory, University of Illinois, as a part of the work of the Engineering Experiment Station in cooperation with the American Railway Engineering Association Committee on Rail, under its Assignment 7, Joint Bar Wear and Failures; Revision of Design and Specifications for New Bars and Bars for Maintenance Repairs. E. E. Chapman, mechanical assistant to general manager, mechanical, Atchison, Topeka and Santa Fe Railway, is chairman of the subcommittee handling this assignment. The work is sponsored and financed by the Association of American Railroads.

Acknowledgment is made of the services of James Bryant and Elmer Hunt, mechanicians in the Talbot Laboratory shops, and Joseph Borrino, student test assistant.

Testing Machines and Test Specimens

Joint bar tests were made in three 33-in stroke rolling machines similar to the one described in the AREA Proceedings, Vol. 40, 1939, page 649. The dimensions of the test joint and method of loading are described in the Proceedings, Vol. 44, 1943, page 587. In all tests, the maximum bar bending stresses are obtained with the wheel load at the joint gap, and are 50 percent in value and reversed in sign with the wheel load at the cantilever end of the stroke. The criterion for bar failure is taken to be the number of cycles of loading to propagate a fatigue crack to one-half of the bar height.

Results of Rolling-Load Tests

Twenty-eight tests on joint bars have been completed since the last annual report was published, including 18 tests on 132 RE, headfree, 36-in, 6-hole bars and 10 tests on 112 B53, headfree, 36-in, 6-hole bars.

The 132 RE bars were part of a group of bars set aside for special heat treatment from heat 11629 with the following chemical composition:

C —0.41, Mn —0.70, P —0.016, S —0.030, Si —0.10

Included are 3 tests on bars oil quenched from 1550 deg F and tempered 1 hr at 800 deg F, 3 tests on bars water quenched from 1550 deg F and tempered 1 hr at 1000 deg F, and 12 tests on bars oil quenched below the critical temperature at 1350 deg F.

The 112 B53 bars, which were from 1939 rollings, were selected from a group of bars being reformed and reheat-treated by the Chicago, Milwaukee, St. Paul, and Pacific Railroad, after grinding out the cracks on the top bar surface at mid-length. Data on these 28 joints are tabulated in Table 1, and the physical properties as determined from tensile specimens cut from the bars after failure are listed in Table 2.

Hardness Tests on Joint Bars

Both Brinell and Rockwell B hardness readings were taken on upper and lower fishing surfaces of all bars before testing. For the 6 bars oil quenched from 1550 deg and tempered at 800 deg the Brinell hardness on the surface ranged from 196 to 254, with an average of 217, while the Rockwell B readings converted to equivalent Brinell averaged 25 points lower.

For the 6 bars water quenched from 1550 deg and tempered at 1000 deg, the Brinell hardness on the surface ranged from 196 to 255, with an average of 225, while the Rockwell B readings converted to equivalent Brinell averaged 27 points lower.

For the 12 pairs of bars oil quenched below the critical temperature at 1350 deg F the Brinell hardness on the surface ranged from 146 to 156, with an average of 150, while the Rockwell B readings converted to equivalent Brinell averaged 7 points lower.

The 10 pairs of reheat-treated 112 B53 bars ranged from 217 to 292 Brinell on the surface, with an average of 254, while the Rockwell B readings converted to equivalent Brinell averaged 17 points lower.

The majority of bars showed higher Brinell hardness on the surface than on the tensile specimens taken from the center of the head of the bars.

Rolling-Load Tests of 132 RE Oil-Quenched and Tempered Bars

Results of 3 tests of 132 RE bars oil quenched at 1550 deg F and tempered 1 hr at 800 deg are given in Table 1. The three fractures are shown in Fig. 1. All of the failures occurred from the top bar surface, the cracks starting in gouge marks caused by rail ends.

The average cycles for failure was 573,100 cycles for the 3 joints. This is considerably lower than the 934,290 cycle average for 12 joints tested last year using 132 RE oil quenched bars, although 1 joint, No. 241, ran for 970,000 cycles.

Magnaflux examination revealed additional cracks on the top fishing surfaces of each of the failed bars in or near the gouge marks, the cracks ranging in length from 3/8 in to 1 1/8 in. The 3 companion bars were also found to contain cracks 1/2 in to 1 1/4 in. in length on the top surfaces in gouge marks.

Fig. 2 shows micrographs taken from each failed bar. A fine grain sorbitic structure is revealed for each specimen, and depths of decarburization of 0.009 and 0.011 in are shown for Bars 240S and 242S.

Since tightening of the bolts was noted to bend the bars laterally at mid-length, lateral deflection readings were taken on upper and lower bar flanges before bolting, after bolting, and at regular intervals during the progress of each test. The amount of lateral bending varied with individual bars, and since unbroken bars recovered to their original shape upon release of bolt tension, it was apparent the bending was elastic.

Lateral deflection readings on the bars indicated that at 100,000 cycles the centers of the bars were bowed from 0.014 in inward to 0.011 in outward, with an average of 0.001 in inward for the upper flanges. Bending on the lower flanges ranged from 0.002 in to 0.36 in inward, with an average of 0.015 in inward.

Out-to-out measurements, that is, the distance between outer bar flanges, indicated that at 100,000 cycles the lower flanges had moved inward 0.042 in average at the center

Table 1—Rolling-Load Tests of Joint Bars

Maximum Positive Bending Moment for 112B53 Bars: 44,400-lb load—400,000 in lb
Maximum Positive Bending Moment for 132 RE Bars: 55,500-lb load—500,000 in lb
Maximum Negative Bending Moment is 50 Percent of Positive Moment
Bolt Tension 15,000 lb Bolts 1 in Diameter, Heat Treated, Prestressed

Joint No.	*Cycles for Failure*	*Bar Failure* *N = North S = South*	*Surface Hardness Failed Bar B H N*	*Hardness on Cross Section B H N*	*Depth of Decarb. from Micrograph Inches*	*Rail Ends* *H = Hot Sawed C = Cold Sawed*	*Pinching from Hot Sawed Rails on Failed Bar Inches*	
							Top	*Bottom*
		Bars: 132 RE HF 36 in Serial 2 Oil Quenched from 1550 deg F, Tempered at 800 deg F for 1 hr						
240	384,000	S. Top—Rail End	196	204	0.009	H	0.005	0.003
241	970,000	N. Top—Rail End	254	215	Slight	H	0.010	0.002
242	365,400	S. Top—Rail End	219	200	0.011	H	0.005	0.003
		573,100 Cycles: Average of 3 Joints						
		Bars: 132 RE HF 36 in Serial 2 Water Quenched from 1550 deg F, Tempered at 1000 deg F, for 1 hr						
243	248,600	S. Top—Rail End	205	231	0.008	H	0.000	0.002
244	387,300	N. Base—2 in from rail end	215	218	Slight	H	0.001	0.003
245	460,000	Both: N. Top—Rail End	N-240	222	Slight	H	N-0.006	0.004
		S. Base—Rail End	S -244	218	Slight	H	S -0.003	0.002
		365,300 Cycles: Average of 3 Joints						
		Bars: 132 RE HF 36 in Serial 2 Oil Quenched Below Critical Temperature at 1350 deg F						
246	77,500	Both Top—Rail Ends	N-148	136	Slight	H	N-0.004	0.003
			S -151	142	Slight	H	S -0.011	0.008
247	75,100	Both Top—Rail Ends	N-148	142	Slight	H	N-0.011	0.004
			S -149	140	Slight	H	S -0.007	0.002
248	65,900	N. Top—Rail End	147	144	Slight	H	0.012	0.005
249	61,700	S. Top—Rail End	153	138	Slight	H	0.017	0.007
250	103,700	S. Top—Rail End	149	142	Slight	H	0.001	0.003
251	59,500	Both Top—Rail Ends	N-148	149	Slight	H	N-0.003	0.005
			S -156	152	Slight	H	S -0.013	0.007
252	75,100	Both Top—Rail Ends	N-152	154	Slight	H	N-0.006	0.006
			S -155	149	Slight	H	S -0.008	0.003
253	59,000	Both Top—Rail Ends	N-147	157	Slight	H	N-0.003	0.004
			S -150	154	Slight	H	S -0.012	0.004
254	86,400	Both Top—Rail Ends	N-149	157	Slight	H	N-0.002	0.004
			S -150	154	Slight	H	S -0.011	0.004
255	72,500	Both Top—Rail Ends	N-156	161	Slight	H	N-0.012	0.007
			S -149	158	Slight	H	S -0.004	0.001
256	62,000	Both Top—Rail Ends	N-148	155	Slight	H	N-0.004	0.002
			S -151	148	Slight	H	S -0.012	0.006
227	57,700	S. Top—Rail End	149	154	Slight	H	0.012	0.001
		71,400 Cycles: Average of 12 Joints						

TABLE 1—Continued

Joint No.	Cycles for Failure	Bar Failure N = North S = South	Surface Hardness Failed Bar B H N	Hardness on Cross Section B H N	Depth of Decarb. from Micrograph Inches	Rail Ends H = Hot Sawed C = Cold Sawed	Pinching from Hot Sawed Rails on Failed Bar Inches	
							Top	Bottom
Bars: 112 B53 HF 36 in Reheat-treated after grinding out cracks								
258	513,900	N. Base—Rail End	255	243	Slight	C	----------	----------
259	410,800	N. Top—Rail End	239	233	0.002	C	----------	----------
260	491,700	S. Top—Rail End	269	240	0.004	C	----------	----------
261	491,100	S. Top—Rail End	228	227	0.015	C	----------	----------
262	2,000,000	No Failure	N-273 S-277	N-252 S-240	N-0.006 S-0.009	C	----------	----------
263	785,800	N. Top—Rail End	232	244	Slight	C	----------	----------
264	536,400	S. Top—Rail End	255	230	0.007	C	----------	----------
265	2,000,000	No Failure	N-280 S-264	N-231 S-225	N-0.011 S-0.011	C	----------	----------
266	680,300	S. Base—Rail End	284	248	0.006	C	----------	----------
267	616,600	N. Base—Rail End	231	229	0.010	C	----------	----------
		852,660 Cycles: Average of 10 Joints						

TABLE 2—PHYSICAL PROPERTIES OF JOINT BARS

Bar Type	*Joint No.*	*Surface Hardness BHN*	*Hardness on Tensile Specimen BHN*	*Yield Point Psi*	*Tensile Strength Psi*	*Reduction of Area Percent*	*Elongation 2-in Gage Length Percent*
132 RE HF Oil Quenched at 1550 deg F: Tempered at 800 deg F 1 hr	240S	196	204	67,900	102,800	54.7	23.0
"	241N	254	215	71,300	111,000	52.6	20.0
"	242S	219	200	65,900	101,800	55.3	23.0
132 RE HF Water Quenched 1550 deg F: Tempered at 1000 deg F 1 hr	243S	205	231	79,800	115,800	54.8	20.0
"	244N	215	218	74,600	109,500	59.0	21.5
"	245N	240	222	76,000	110,500	57.5	21.0
"	245S	244	218	73,200	109,800	55.7	21.0
132RE HF Oil Quenched Below Critical at 1350 deg F	246N	148	136	45,700	77,000	51.4	28.5
"	246S	151	142	47,300	79,200	50.0	28.0
"	247N	148	142	45,800	78,700	48.0	27.5
"	247S	149	140	46,500	78,000	50.5	27.5
"	248N	147	144	47,300	80,800	48.0	27.0
"	249S	153	138	46,700	77,400	50.7	28.0
"	250S	149	142	45,800	80,200	49.7	27.5
112 B53 HF Reheat-treated	258N	255	243	81,100†	118,000	25.2	12.0
"	259N	239	233	78,300†	115,200	27.4	14.0
"	260S	269	240	79,500†	116,300	26.4	14.0
"	261S	228	227	79,900†	118,000	26.2	13.0
"	262N	273	252	85,500†	125,500	36.8	14.5
"	262S	277	240	84,800†	124,600	36.6	15.0
"	263N	232	244	79,200†	117,200	30.0	13.5
"	264S	255	230	79,500†	117,200	30.8	14.0
"	265N	280	231	78,500†	114,000	29.6	14.0
"	265S	264	225	78,800†	115,200	26.8	13.5
"	266S	284	248	86,000†	126,200	34.5	14.0
"	267N	231	229	79,000†	116,000	27.0	14.0

†No well defined yield point—values are yield strength.
AREA Specifications: Tensile Strength, Min 100,000 Psi
Yield Point, Min 70,000 Psi
Elongation in 2in, Min 12 percent
Reduction of Area, Min 25 percent

of bar length and 0.018 in average at the ends of the bars. The upper flanges averaged 0.004 in movement at the center and 0.002 in at the ends.

The physical properties of the 3 failed bars, as indicated in Table 2, met the AREA specification of 100,000 psi tensile strength, and 1 bar, No. 241N, met the AREA specification of 70,000 psi yield point.

Rolling Load Tests of 132 RE Water-Quenched and Tempered Bars

Results of 3 tests of 132 RE bars water quenched at 1550 deg F and tempered 1 hr at 1000 deg F, are given in Table 1. Four bars from the 3 joints failed, 2 from the top surface at a gouge mark caused by a rail end, and 2 from the bottom surface, 1 at a gouge mark from a rail end and the other in an area of heavy bearing 2 in from the rail end.

The average cycles for failure for these 3 joints was 365,300 cycles.

Magnaflux examination revealed additional cracks 3/16 in to 1 in. in length on the top fishing surfaces in gouge marks on the 4 failed bars, and cracks 5/8 in to 1¾ in. in

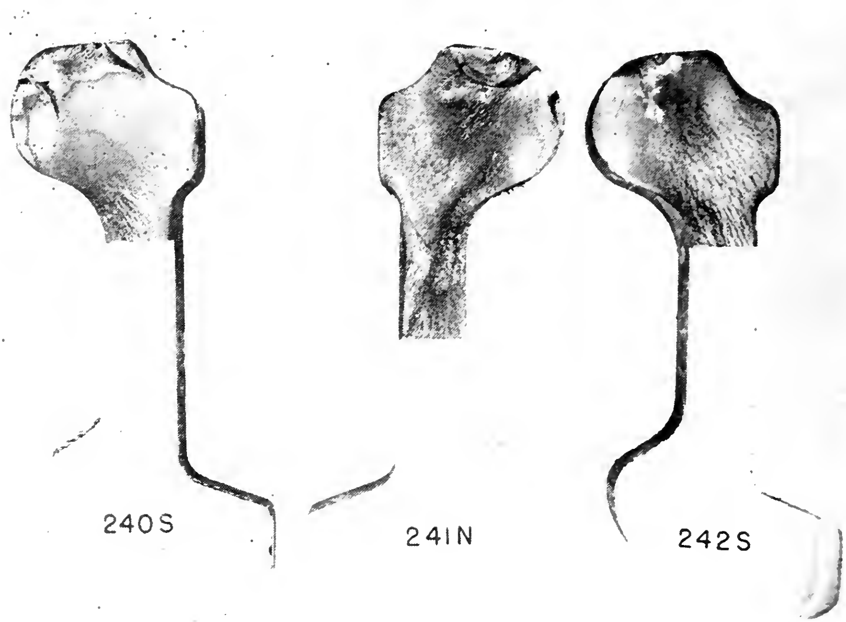


Fig. 1—Fatigue failures of 132 RE HF bars.

These bars were oil quenched at 1550 deg F and tempered 1 hr at 800 deg F.

length on the top fishing surfaces in gouge marks on the 2 companion bars which did not fail.

Fig. 3 shows micrographs from 3 of the failed bars, revealing a fine grain sorbitic structure with specimen 243S showing about 0.008 in depth of decarburized surface.

Lateral deflection readings on the bars indicated that at 100,000 cycles the centers of the bars were bowed from 0.028 in inward to 0.036 in outward, with an average of 0.007 in inward for the upper flanges. Bending on the lower flanges ranged from 0.020 in outward to 0.050 in inward, with an average of 0.024 in inward.

Out-to-out measurements indicated that at 100,000 cycles the lower flanges had moved inward 0.038 in average at the center of bar length and 0.016 in average at the ends of the bars. The upper flanges averaged 0.007 in movement at the center and 0.002 in at the ends.

The physical properties as shown in Table 2 were all well above the AREA specifications.

Rolling-Load Tests of 132 RE Bars Oil Quenched Below Critical Temperature

Results of 12 tests of 132 RE bars oil quenched below the critical temperature at 1350 deg F are given in Table 1. In 8 of the 12 tests, both bars of the joint failed, all of the bar failures starting on the top fishing surface at a gouge mark caused by a rail end.

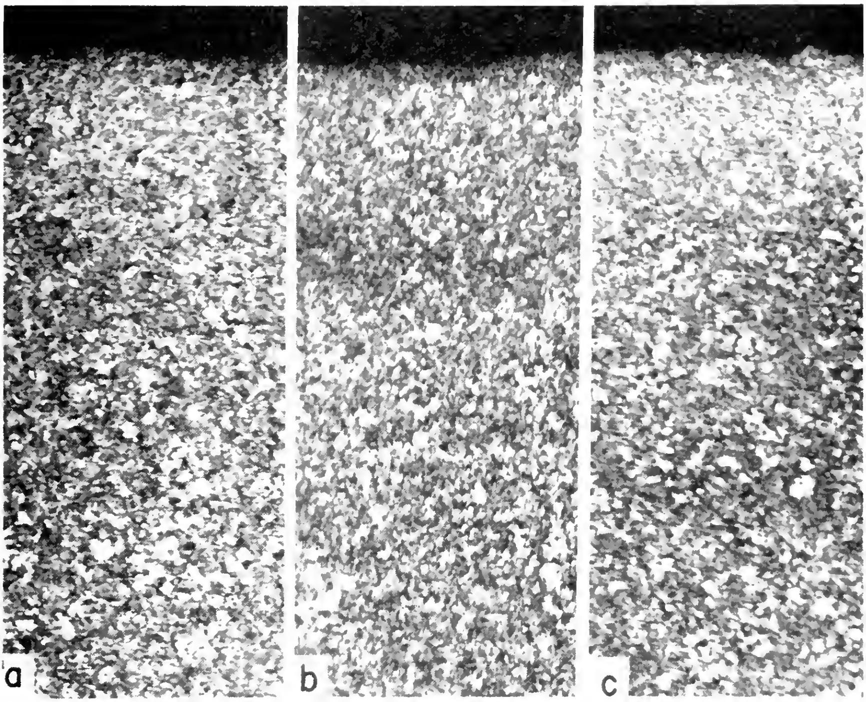


Fig. 2—Micrographs from oil-quenched and tempered bars.
Magnification—about 60X; Etch—2 percent nital.
a. Bar 240S; b. Bar 241N; c. Bar 242S.

The 12 joints averaged 71,400 cycles, which is slightly less than the average of 78,750 for 4 joints using bars not oil quenched, made last year. The physical properties listed in Table 2 for 7 of the failed bars were not greatly different from the physical properties of non-heat-treated bars. The average yield point for these 7 specimens was 46,440 psi, as compared to 41,060 psi average yield point for 8 specimens from non-heat-treated bars reported last year. The average tensile strength for these bars was 78,750 psi, compared to 76,610 psi for the non-heat-treated bars.

Magnaflux examination revealed additional cracks on 6 of the 20 failed bars on the top fishing surfaces in gouge marks, the cracks ranging in length from 3/8 in to 1 in. The 4 unbroken companion bars all contained cracks ranging in length from 3/4 in to 1 1/2 in. in gouges on the top surfaces.

Micrographs from 3 of the failed bars, revealing large amounts of ferrite throughout the structure, are shown in Fig. 4.

Lateral deflection readings on the bars indicated that at 30,000 cycles the centers of the bars were bowed from 0.031 in inward to 0.022 in outward, with an average of 0.001 in inward for the upper flanges. Bending on the lower flanges ranged from 0.005 in outward to 0.045 in inward, with an average of 0.016 in inward.

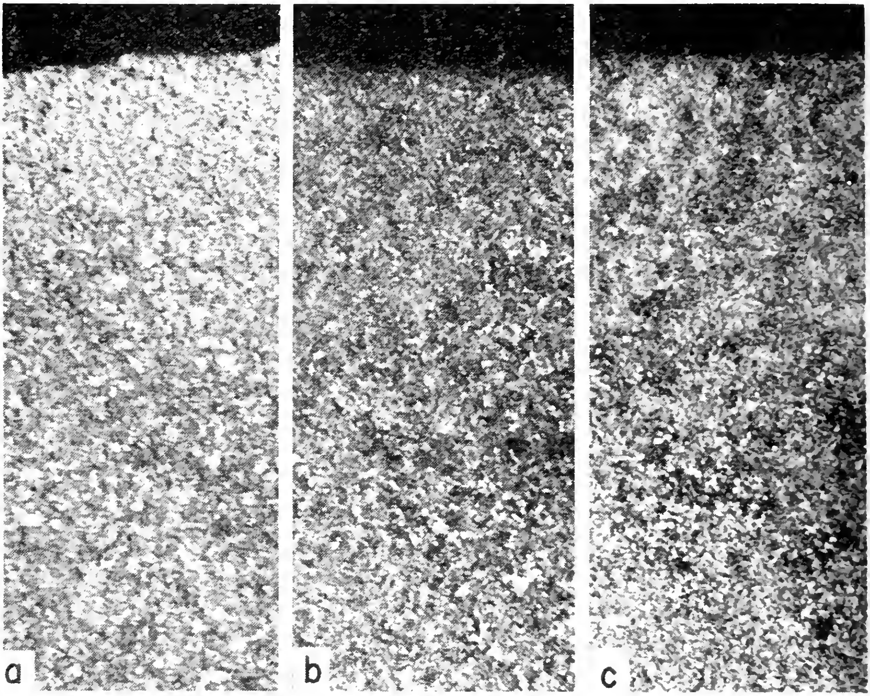


Fig. 3—Micrographs from water-quenched and tempered bars.
Magnification—about 60X; Etch—2 percent nital.
a. Bar 243S; b. Bar 244N; c. Bar 245N.

Out-to-out measurements indicated that at 30,000 cycles the lower flanges had moved inward 0.045 in average at the center of bar length and 0.018 in average at the ends of the bars. The upper flanges averaged 0.004 in movement at the center and 0.001 in at the ends.

Rolling-Load Tests of 112 B53 Headfree Bars

Ten pairs of 112 B53 headfree 36-in bars were furnished from a group of bars which had been reformed and reheat-treated by the Chicago, Milwaukee, St. Paul and Pacific Railroad after grinding out the cracks on the top fishing surface at bars mid-length. Since the grinding to eliminate cracks extended rather deeply into some of the bars, it was thought desirable to make rolling-load tests on several joints in which the grinding on the bars was excessive; consequently, these bars were selected. The ground areas on the bars ranged from 2 in to 2 13/16 in. in length and from 3/16 in to 9/32 in. in depth.

Results of the 10 tests on these bars are given in Tables 1 and 2. Three of the fractures are shown in Fig. 5.

Two of the joints ran to 2,000,000 cycles with no failure. Of the remaining 8 joints 3 failed from the base at a gouge mark caused by a rail end, and 5 failed from the top, the crack originating on the under side of the head of the bar about 1 in below the fishing surface at the junction of an inner rib with the head of the bar.

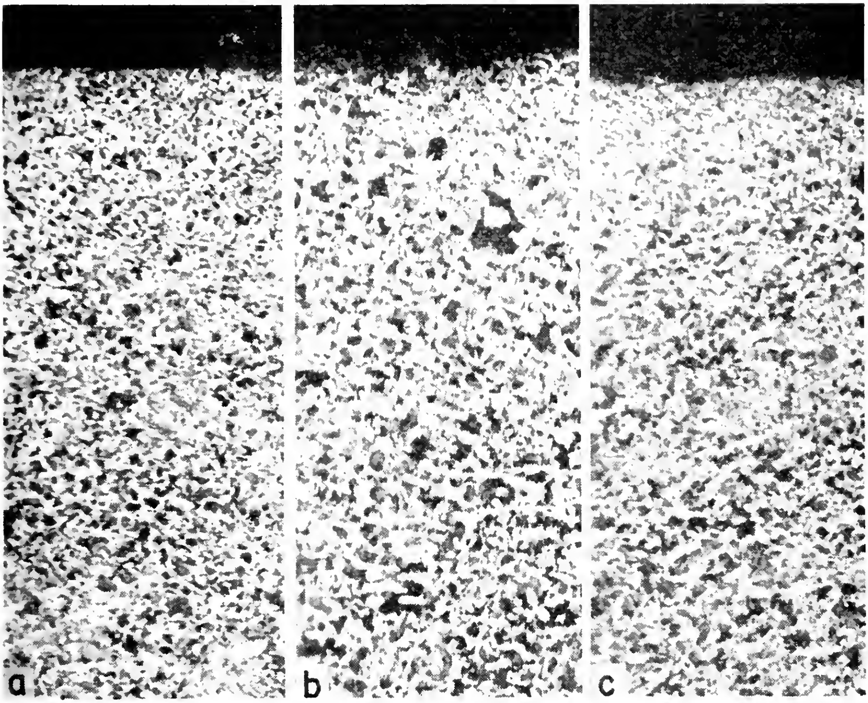


Fig. 4—Micrographs from bars oil quenched below critical temperature.
Magnification—about 60X; Etch—2 percent nital.
a. Bar 246N; b. Bar 247N; c. Bar 252N.

The average cycles for failure was 852,660 cycles for the 10 joints, which compares favorably with the average of 748,500 cycles for 12 tests made last year on 115 K4 headfree 36-in bars.

No additional cracks were detected on the failed bars or companion bars, although they were subjected to Magnaflux examination. The large ground areas on the top of the bars acted effectively as easements to eliminate gouging by the rail ends and apparently did not materially shorten the fatigue life of the bars.

Lateral deflection readings on the bars indicated that at 100,000 cycles the centers of the bars were bowed from 0.013 in outward to 0.051 in inward, with an average of 0.021 in inward for the upper flanges. Bending on the lower flanges ranged from 0.013 in outward to 0.053 in inward, with an average of 0.024 in inward.

Out-to-out measurements indicated that at 100,000 cycles the lower flanges had moved inward an average of 0.028 in at the center of bar length and 0.011 in average at the ends of the bars. The upper flanges averaged 0.047 in inward movement at the center and 0.039 in at the ends.

Brinell hardnesses and physical properties, as indicated in Table 2, were above average for these bars, and micrographs taken on specimens from each failed bar revealed a fairly fine grain structure for most bars. Depths of decarburization ranged from less than 0.001 to 0.015 in on the failed bars. No apparent correlation existed between depth of decarburization and cycles for failure.

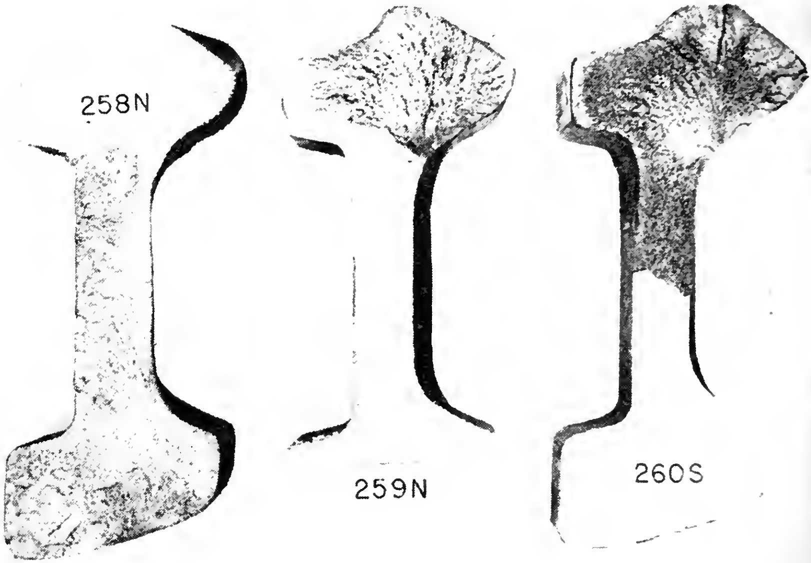


Fig. 5—Fatigue failures of 112 B53 bars.

Fig. 6—Top surface of failed bars from service showing cracks in gouges.

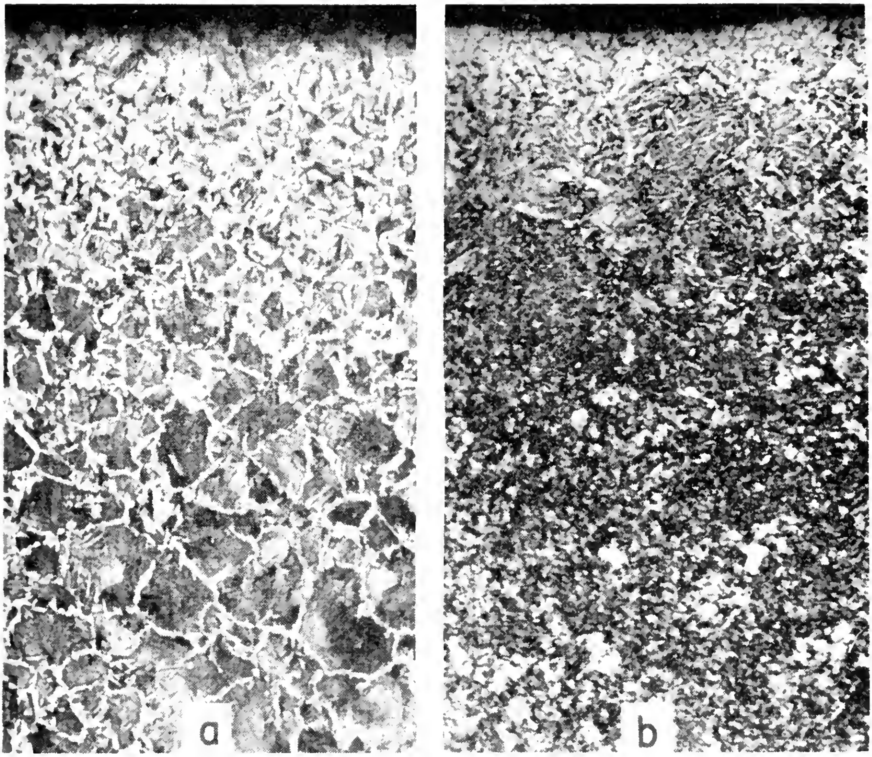


Fig. 7—Micrographs of failed bars from service.
Magnification—about 70X; Etch—2 percent nital.
a. Bar N36; b. Bar N42.

Failed Bars from Service

Eighty-five failed bars from service received for examination and testing are covered in this report. All were 36-in, 6-hole, RE headfree bars, 31 for 115-lb rail section and 54 for 132-lb rail section, and represented 23 heats from 2 mills, 1947, 1949, 1950 and 1951 rollings.

Six of the bars failed from cracks originating on the base at gouge marks caused by the rail ends, and the remaining 79 bars failed from the top surface from cracks starting in gouge marks. On 3 of the bars which failed from the top, the crack progressed to an oval bolt hole. Fig. 6 shows the top surface and gouge marks of 2 of the failed bars.

Brinell hardness measurements were taken on all of the failed bars after removing $\frac{1}{16}$ in of surface metal. A tensile specimen was cut from each failed bar and the hardness values and physical properties obtained from the tensile tests are given in Table 3. Eighteen of the 85 specimens tested, or 21 percent, passed the yield point specification of 70,000 psi, and 42 of the 85, or 49 percent, passed the tensile strength specification of 100,000 psi.

Micrographs were taken on specimens from all failed bars and, in general, revealed a coarser grain structure for specimens from bars below 200 Brinell hardness than for

TABLE 3—BRINELLS AND PHYSICAL PROPERTIES OF FAILED BARS FROM SERVICE

Lab. No.	*Bar Type*	*Hardness Near Top Surface BHN*	*Hardness On Tensile Specimen BHN*	*Yield Point Psi*	*Tensile Strength Psi*	*Reduction of Area Percent*	*Elongation 2 in G.L. Percent*
K1	115 RE	228	195	51,700	92,000	50.3	23.0
K2	115 RE	197	176	48,400	87,600	50.1	24.0
K3	115 RE	247	195	67,500	104,800	51.7	21.5
L1	132 RE	173	161	43,800	89,400	40.7	23.0
L2	132 RE	213	183	51,400	97,800	37.4	Broke outside G.L.
L3	132 RE	208	184	48,900	97,800	42.5	21.5
L4	132 RE	210	180	51,500	98,000	42.0	21.0
M1	115 RE	223	216	66,800	110,500	46.0	19.0
M2	115 RE	233	237	69,000	115,200	42.5	17.0
M3	115 RE	222	208	66,400	105,600	47.4	22.5
M4	115 RE	220	221	69,000	112,000	49.0	19.0
M5	115 RE	278	246	80,300	125,000	48.0	18.5
M6	115 RE	228	226	68,500	111,800	48.5	20.0
M7	115 RE	238	217	68,500	111,200	48.0	19.0
M8	115 RE	225	221	66,500	108,000	50.5	20.0
M9	115 RE	249	225	71,500	114,200	50.8	19.0
M10	115 RE	253	227	75,200†	115,000	41.5	17.0
N1	132 RE	252	221	71,200	113,600	49.4	20.5
N2	132 RE	224	203	52,700	103,200	34.6	Broke outside G.L.
N3	132 RE	245	248	75,300	126,500	38.8	16.0
N4	132 RE	175	166	43,100	86,200	47.5	25.0
N5	132 RE	219	222	71,100	117,800	47.5	19.0
N6	132 RE	253	223	72,300	115,500	44.1	18.0
N7	132 RE	216	211	65,800	110,800	49.5	21.0
N8	132 RE	203	193	49,700	97,400	41.2	Broke outside G.L.
N9	132 RE	232	200	55,400	106,000	40.0	20.5
N10	132 RE	212	193	52,500	101,200	39.4	20.5
N11	132 RE	254	229	74,500†	116,000	24.8	14.0
N12	132 RE	180	166	44,700	89,000	45.2	23.5
N13	132 RE	246	216	67,200	111,000	45.7	18.0
N14	132 RE	261	229	73,200	117,800	43.9	19.0
N15	132 RE	176	174	45,400	89,100	46.6	Broke outside G.L.
N16	132 RE	167	160	43,700	85,000	47.9	26.0
N17	132 RE	191	174	44,300	89,000	44.4	Broke outside G.L.
N18	132 RE	186	182	49,400	94,500	40.5	Broke outside G.L.
N19	132 RE	174	151	43,300	79,800	51.9	27.0
N20	132 RE	245	228	69,000	113,000	44.8	18.0
N21	132 RE	167	176	44,300	90,000	42.5	22.0
N22	132 RE	177	165	41,300	85,300	46.9	26.0
N23	132 RE	240	226	67,500	108,000	44.2	19.5
N24	132 RE	249	222	75,000†	114,700	44.0	17.5
N25	132 RE	181	184	45,200	92,100	44.7	Broke outside G.L.
N26	132 RE	253	221	66,800	110,500	45.0	18.0
N27	132 RE	251	221	68,800	111,200	45.7	20.0
N28	132 RE	254	212	67,400	112,500	45.6	19.5
N29	132 RE	172	157	44,700	86,000	45.8	15.5
N30	132 RE	273	238	75,000	119,000	46.0	19.0
N31	132 RE	258	226	71,500	113,200	48.0	20.5
N32	132 RE	179	181	56,300	100,500	42.0	22.5
N33	132 RE	185	183	57,000	99,100	43.4	22.0
N34	132 RE	179	179	46,100	91,300	43.4	22.0
N35	132 RE	188	174	45,000	89,600	47.0	24.0
N36	132 RE	175	174	43,500	89,700	42.3	22.5
N37	132 RE	227	230	68,700	110,800	48.5	20.0
N38	132 RE	177	192	52,100	98,400	44.0	22.0
N39	132 RE	256	231	70,800	114,200	46.3	19.0
N40	132 RE	237	228	67,700	113,200	43.3	18.0
N41	132 RE	169	175	47,800	91,000	44.6	Broke outside G.L.
N42	132 RE	247	223	71,800	114,000	47.8	20.5
N43	132 RE	180	166	44,500	86,500	48.1	22.5
N44	132 RE	258	230	76,500	119,200	44.0	17.5
N45	132 RE	170	178	50,600	98,200	38.0	Broke outside G.L.
N46	132 RE	168	171	44,000	88,900	42.0	23.0
N47	132 RE	165	174	46,500	90,000	46.8	25.0
N48	132 RE	265	238	75,000	119,500	45.0	18.0
N49	132 RE	196	172	45,500	89,000	45.6	24.0
N50	132 RE	235	222	71,500	114,200	46.1	19.5

TABLE 3—Continued

Lab. No.	*Bar Type*	*Hardness Near Top Surface BHN*	*Hardness On Tensile Specimen BHN*	*Yield Point Psi*	*Tensile Strength Psi*	*Reduction of Area Percent*	*Elongation 2 in G.L. Percent*
P1	115 RE	189	171	48,500	90,000	50.8	25.0
P2	115 RE	210	192	59,100	98,500	53.7	24.0
P3	115 RE	206	194	60,000	99,200	53.5	23.5
P4	115 RE	229	217	67,800	107,000	50.7	21.0
P5	115 RE	253	204	66,100	105,800	51.2	21.0
P6	115 RE	198	168	48,600	89,500	51.5	24.0
P7	115 RE	257	232	75,000†	114,000	37.0	16.5
P8	115 RE	187	161	48,100	86,000	52.5	25.5
P9	115 RE	167	151	42,000	80,400	48.4	27.0
P10	115 RE	239	215	68,400	108,000	52.7	21.0
P11	115 RE	169	161	49,700	86,000	49.0	26.0
P12	115 RE	164	158	46,600	84,000	50.1	27.0
P13	115 RE	165	155	45,200	84,600	49.8	27.0
P14	115 RE	171	143	41,400	79,100	49.8	26.5
P15	115 RE	174	146	41,000	80,700	50.6	27.5
P16	115 RE	176	174	46,500	89,000	50.2	24.0
P17	115 RE	197	172	48,100	91,100	49.3	23.5
P18	115 RE	226	192	62,500	97,500	57.7	25.0

†No well defined yield point—Value is yield strength.
AREA Specifications: Tensile Strength, Min 100,000 psi
Yield Point, Min 70,000 psi
Elongation in 2 in, Min 12 percent
Reduction of Area, Min 25 percent

specimens from bars above 200 Brinell. Fig. 7 shows micrographs from two failed bars which are representative; part a, showing bar N36 with a Brinell hardness of 174, reveals a much coarser grain structure than part b for bar N42 with a Brinell hardness of 223. The micrographs indicated various depths of decarburization for individual bars, ranging from less than 0.001 in to 0.026 in.

The yield point and tensile strength values of the failed bars from service are plotted against the Brinell hardness on the tensile specimen in Fig. 8. A few of the laboratory tested bars are included for comparison. In general, the plot of Fig. 8 indicates that for a specimen to meet the yield point specification of 70,000 psi it should have a Brinell hardness of 218, and to meet the tensile strength specification of 100,000 psi it should have a Brinell hardness of 193; these are the intersections of the lines through the plotted points with the 70,000 psi and 100,000 psi stress lines.

Future Work

Tests are in progress on 12 joints using 132 K44, headfree, 36-in, 6-hole, long-toe bars. Tests are planned on 132 RE bars with both ground and pressed easements; both oil-quenched bars and oil-quenched and tempered bars will be included in the tests.

Summary

1. Three tests of 132 RE headfree bars specially oil quenched from 1550 deg F and tempered 1 hr at 800 deg F averaged 573,100 cycles. All of the failures started on the top bar surface at a rail end.

2. Three tests of 132 RE headfree bars specially water quenched from 1550 deg F and tempered 1 hr at 1000 deg F averaged 365,300 cycles. Four bars failed, 2 from the top and 2 from the base. Physical properties of these bars were all above AREA specifications.

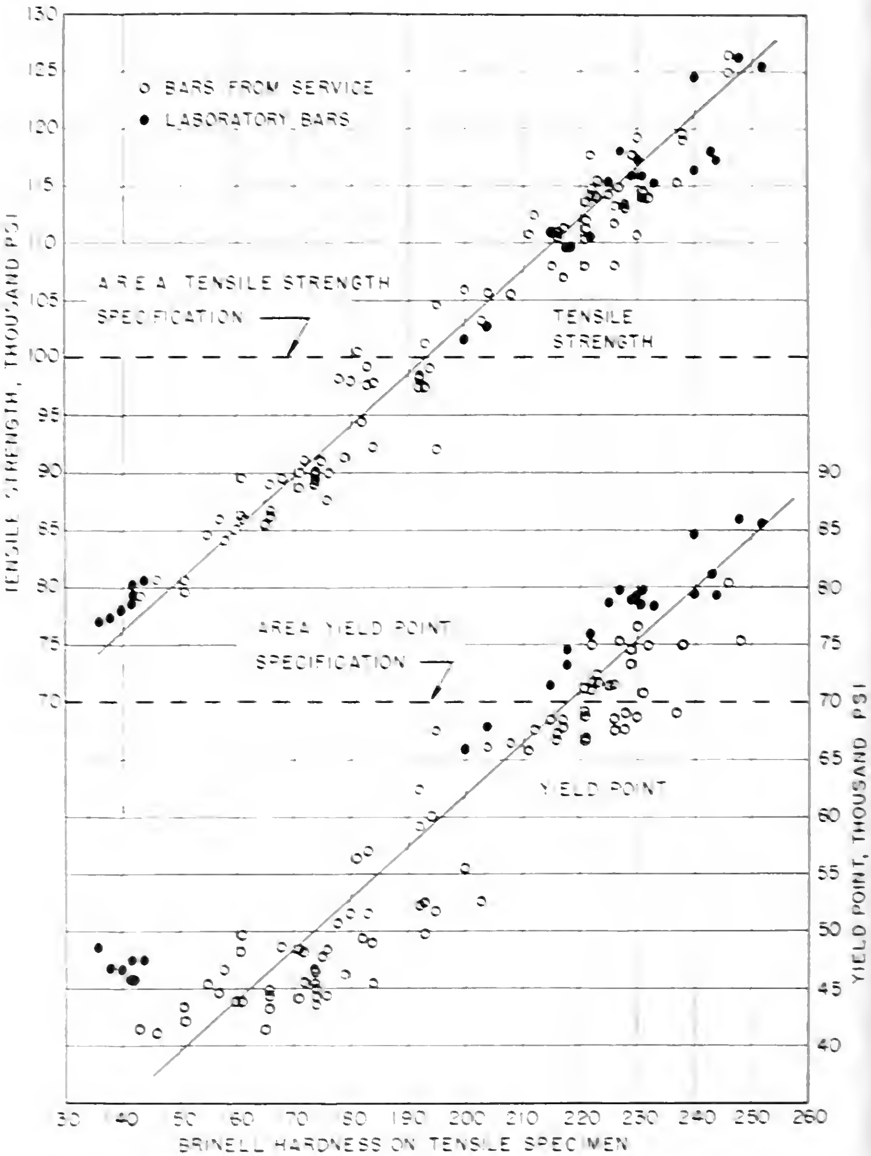


FIG. 81. PHYSICAL PROPERTIES VS BRINELL OF FAILED JOINT BARS

3. Twelve tests of 132 RE headfree bars specially oil quenched below the critical temperature at 1350 deg F averaged 71,400 cycles. Twenty bars failed, all from the top surface at rail ends. Physical properties of these bars were only slightly above the physical properties of non-heat-treated bars.

4. Ten tests of reheat-treated 112 B53 headfree bars with large ground areas on the top fishing surface (where cracks had been removed by grinding) averaged 852,660 cycles; apparently the ground areas did not materially shorten the bar life.

5. Tensile tests on 85 specimens from failed bars from service revealed that 21 percent passed the yield point specification of 70,000 psi and 49 percent passed the tensile strength specification of 100,000 psi.

6. Micrographs on specimens from failed bars, both from service and laboratory tested bars, indicated depths of decarburization from less than 0.001 in to 0.026 in. In general, the grain structure was coarser for bars with hardness below 200 Brinell than for bars above that hardness.

Appendix 7–b

Service Tests on the Burlington Railroad near Fort Morgan, Colo., of Joint Bars of Different Metallurgies

In the Proceedings, Vol. 47, 1946, page 411, a description was given of the test installation of joint bars of various metallurgies placed in the single-track main line of the Chicago, Burlington & Quincy, near Fort Morgan, Colo., in July 1939. The joint bars were applied at the time new 112 RE rail was laid. This rail was control cooled, but not end hardened. The purpose of the test was to compare the service performance, and, in particular, the resistance to developing fatigue cracks at the top mid-length, of joint bars with higher strength steel, and bars of the AREA specification chemistry and heat treatment. This particular location was selected for the tests because of past difficulty with joint bar cracks.

The test installation included 5 test sections of 100 pairs of joint bars, each in tangent track. All of the joint bars of one type were installed out-of-face on both rails. The installation begins at MP 460 with bars of type 1, and extends west.

Types of Bars Tested

All of the joint bars are 24 in. in length, with four 1-in diameter heat-treated bolts and triflex springs. The test bars are the Rail Joint Company's designs. A description of the chemistry and heat treatment of the test bars is given in the report referred to above. Types 1 to 4, incl., are the B-34-1 head-contact section, and type 5 is the B–53 headfree section. The test observation on type 5 had to be discontinued because these bars were replaced in track by mistake in connection with a general joint bar replacement through this area.

Joint Wear

Since the bars are at the end of their service life and will be replaced in the near future, measurements were made in October 1952. These measurements were similar to those previously reported to compare the change in out-to-out distance of the joint bars and the sag or dip of the rail ends at the joints. The amount of decrease in out-to-out distance is an indication of the amount of joint bar and rail fishing surface wear. The results are shown in Table 1, and represent the average of measurements made at both top and bottom ribs at each end, and at the center, of 10 joints in each test section, except as noted.

Because the available take-up or pull-in of the new head-contact joint bars before they contact the rail web is 0.38 in, the decreases shown in Table 1 are significant in showing the rate at which the service life of the bars is being expended. The average pull-in of the four types of head-contact bars to October 1952, varied from 0.15 to 0.19 in. At this stage of the investigation, the harder bars show more resistance to wear, which may be a factor in increasing the life of the bar. A badly worn pair of type 2 bars was replaced in 1948.

Table 1—Decrease in Out-to-Out Distance of Joint Bars (November 1939 to October 1952) Reading in Inches

Type	October 1952		Averages of Top and Bottom Readings Taken on					
	Top	Bottom	Oct. 1952	Sept. 1951	Oct. 1950	Oct. 1948	Nov. 1946	Nov. 1945
1. HC ordinary chemistry	0.190	0.183	0.186	0.176	0.158	0.139	0.105	0.092
2. HC hardened top center	0.189	0.140	0.165	0.153	0.145	0.129	0.095	0.082
3. HC water quenched, drawn	0.154	0.136	0.145	0.137	0.132	0.121	0.078	0.075
4. HC rail steel, oil quenched, drawn	0.165	0.139	0.152	0.131	0.127	0.120	0.071	0.053

Joint Droop

The amount of sag or dip at the rail end is important as an indication of how well the joint bars are supporting the rail ends. Table 2 shows the average sag or dip in the rail surface profile at the joints, as measured at a point ½ in from each rail end with reference to a 36-in straight edge placed along the center of rail head with its midlength over the joint gap. The measurements shown are an average of readings taken on 20 joints in each test section, except as noted. Because the rail ends on all four test sections were built up by welding in the summer of 1947, the value of this particular measurement was largely destroyed.

Table 2—Rail End Sag of Joint at ½ In from Rail Ends, Reading in Inches

Type	Oct. 1940	Oct. 1941	July 1943	Nov. 1945	Nov. 1946	Nov. 1948	Nov. 1950	Sept. 1951	Oct. 1952
1	0.004	0.006	0.011	0.023	0.023	0.012	0.015	0.020	0.021
2	0.002	0.006	0.016	0.024	0.026	0.016	0.039	0.037	0.044
3	0.002	0.006	0.012	0.031	0.028	0.015	0.026	0.027	0.039
4	0.003	0.007	0.012	0.031	0.030	0.018	0.020	0.023	0.030

Joint Bar Failures

Five cracked bars have been observed in the test to date. One occurred in 1950 on type 2 bars, which were of ordinary chemistry and heat treatment, subsequently flame hardened at the top center portion. The next three were observed in 1951 on type 4 bars, which were rail steel, oil quenched and drawn. One cracked bar was observed among type 1 bars, which were bars of ordinary chemistry.

The bars in this test section may be removed by the railroad before the next inspection date. It is planned to inspect carefully all bars for cracks at the time of the removal and to make measurements of wear.

Acknowledgement

The committee and the Association are indebted to the Burlington for making the installation and providing assistance in taking the field measurements.

Report on Assignment 8

Causes of Shelly Spots and Head Checks in Rail: Methods for Their Prevention

L. S. Crane (chairman, subcommittee), T. A. Blair, B. Bristow, E. E. Chapman, C. M. Chumley, C J. Code, W. J. Cruse, J. C. DeJarnette, Jr., R. A. Emerson, F. Fahland, E. L. Gosnell, J. L. Gressitt, C. B. Harveson, S. R. Hursh, K. K. Kessler, C. C. Lathey, W. B. Leaf, E. E. Mayo, Ray McBrian, B. R. Meyers, L. T. Nuckols, R. E. Patterson, G. A. Phillips, J. G. Roney, I. H. Schram, W. D. Simpson, J. S. Wearn, E. Wise, Jr., J. E. Yewell.

This is a progress report, presented as information.

This investigation is conducted by five task groups. The work of Group 1 is handled directly by the subcommittee; that of Group 2 by the research staff of the Engineering Division, AAR; that of Group 3 by the University of Illinois; that of Group 4 by Battelle Memorial Institute; and that of Group 5 by Prof. M. M. Frocht of the Illinois Institute of Technology.

The AAR provides funds for the work conducted by Group 2 and the AAR and AISI jointly provide funds to support the work of Groups 3, 4 and 5.

A small administrative committee comprising members selected by the subcommittee and by the rail manufacturers has met regularly during the past year with the research investigators at the University of Illinois, Battelle Memorial Institute, and Prof. Frocht for the purpose of reviewing and guiding the conduct of the research work.

The research work conducted to date has failed to reveal any positive solution for this problem. Gage corner contour design improvements made on the 115, 132 and 133 RE sections have assisted in retarding the onset of shelling but have not prevented its eventual occurrance. The use of heat-treated and chrome-vanadium alloy rail is effective in extending the period of time until gage corner shelling will occur where the expense of this type of rail may be economically justified.

Group 1

The committee has continued to follow the performance of various installations of heat-treated rail. A summary of the performance of these test installations follows:

CHESAPEAKE & OHIO RAILWAY

Service Test of 132 RE Heat-Treated Rail

This test was installed near Martha, W. Va., on the Logan Subdivision of the Huntington Division, on a 3-deg 6-min curve, both low and high side. Twelve heat-treated (oil quenched) and 12 end-hardened rails from the same heat, all control cooled, were laid on May 2, 1949. The heat-treated rails were laid on the receiving end of the curve followed by the end-hardened rails. Six rails of each type were laid on the high and low sides.

This curve was inspected on May 5, 1952, after the test rails had accumulated approximately 93,000,000 tons of traffic. Visual examination of the rails revealed the following surface condition:

On the low side of the curve the six heat-treated and six end-hardened control-cooled rails are in excellent condition. There is a very slight amount of metal flow of the rail head to the field side and this flow is more evident on the control-cooled than on the heat-treated rails.

On the high side of the curve the six control-cooled rails all show some evidence of gage corner flaking or light incipient cracks. Two of the heat-treated rails on the high side of the curve are entirely clear, while the other four heat-treated rails show some evidence of the light incipient cracks on the gage corner, which are thought to precede the light flaking conditions.

The rolling-load test results at the University of Illinois on companion samples of these rails show the following results:

Control Cooled, Cycles	*Heat Treated, Cycles*
900,000	3,232,000
1,206,000	5,022,000*
1,667,000	5,032,000*

* Specimen did not fail. Test stopped.

PENNSYLVANIA RAILROAD

Service Test of 155-Lb Heat-Treated Rail

This test was installed in the No. 1 eastbound track, Middle Division, near Forge, Pa., No. 11 curve, 6 deg, in the high side only. Twelve oil-quenched, heat-treated rails and 12 end-hardened rails, all control cooled, from the same heat, were laid on January 19, 1949.

The test rails were laid in the following sequence, beginning at the receiving end of the curve, high side only: 2 end-hardened rails, 2 heat-treated rails, 2 end-hardened rails, 2 heat-treated rails, etc.

The last inspection of this test curve was made on May 2, 1952; the accumulated tonnage as of that date was approximately 172,000,000 gross tons.

Compared to the previous year's inspection, an increase was noted in the amount of flaking, black spots and shelling which had occurred on both the heat-treated and the end-hardened, control-cooled rails. The greatest amount of flaking, black spots and shelling has developed at the receiving end of the curve and has diminished progressively toward the leaving end of the curve. However, when the heat-treated rails are compared with the adjacent end-hardened, control-cooled rails, in each case, the heat-treated rails show greater resistance to the development of gage corner flaking, black spots or shelling, but they have not prevented this deterioration from eventually occurring.

The rolling-load test results at the University of Illinois on companion samples of these rails showed the following:

Control Cooled, Cycles	*Heat Treated Cycles*
350,000	4,764,000
782,000	5,000,000*
831,000	

* Specimen did not fail. Test stopped.

NORFOLK & WESTERN RAILWAY

Service Test of 132 RE Heat-Treated Rail

This test was installed in the main line, westbound track, M.P. Na 6, west of the station at Kermit, W. Va., west of the tunnel exit in a 6-deg curve on both the high and low side. Twenty-three heat-treated, oil-quenched rails and 24 end-hardened rails from the same heat, all control cooled, were laid on May 3, 1949.

Ordinary rails were laid through the tunnel and at the exit end; 6 end-hardened test rails on both high and low sides, followed by 12 and 11 heat-treated rails on the high and low sides, respectively, followed by 6 end-hardened rails on both the high and low sides.

This curve was inspected October 15, 1952, after the test rails had accumulated 150,000,000 tons of traffic.

Visual examination of these test rails revealed the following surface condition: On the low side of the curve 8 of the 12 control-cooled, end-hardened rails had been removed from service due to excessive metal flow and chipping on the field side of the rail head. Two of the remaining 4 end-hardened rails are badly flowed and will shortly be removed. The remaining 2 are in satisfactory condition. The 11 heat-treated rails on the low side of the curve were in good condition, except for some engine burns and "Skid Burns".

On the high side of the curve 1 of the 12 control-cooled rails was removed by the Sperry detector car. Examination of this rail subsequently revealed that the defect was a detailed fracture from a shell spot. The remaining 11 control-cooled rails all had developed flaking throughout their entire lengths; 9 rails had black spots and 3 rails had shelly spots. Compared to the control-cooled rails, the 12 heat-treated rails on the high side are in relatively good condition. Eight of these heat-treated rails on the high side of the curve are clear of any defects, 1 has incipient crack on the gage corner, 4 exhibit small shell spots, and 1 has a black spot which has cracked out on the gage corner.

Rolling-load test results at the University of Illinois on companion samples of these rails showed the following:

Control Cooled, Cycles	*Heat Treated, Cycles*
900,000	3,232,000
1,206,000	5,022,000*
1,667,000	5,032,000*

* Specimen did not fail. Test stopped.

Service Test of 132 RE Alloy Rail

This test was installed on the Scioto Division, Kenova District, M. P. 481.4, westbound track, and M. P. NA 17.1. The test rails were installed in both the low and high side of the curves in both locations. Thirty-two alloy rails were installed on the curve at M. P. 481.4, and 92 rails were installed in the curve at M. P. NA 17.1. No control-cooled rails were installed for comparison since it is believed that the control-cooled rails installed at M. P. Na 6 will serve as a satisfactory control for these test rails.

The analysis of the steel from which these rails were made is as follows:

Carbon	0.74%	Chromium	0.90%
Manganese	1.30%	Vanadium	0.12%
Silicon	0.25%		

For the purpose of identification this chrome-vanadium alloy steel rail has been termed C–V rail.

This rail was visually examined on October 15, 1952, after it had accumulated approximately 80,000,000 gross tons of traffic.

All of the rails on the high side of the curve near M. P. 481.4 were in very good condition, except for one rail which revealed the presence of three small shell spots. All of the rails on the low side of the curve were in very good condition and exhibited very little flow.

All of the rails installed on the high side of the curve near M. P. NA 17.1 were in very good condition, except for 3 rails, each of which exhibited one small black spot, and one rail which exhibited light flaking. All the rails on the low side of this curve were in very good condition and exhibited very little flow or wear.

Rolling-load test results at the University of Illinois on companion samples of these rails are as follows:

Sample	*Cycles*
1136A	8,117,000
1137A	5,152,000
1136B	9,635,000
1137B	6,152,000

Standard carbon steel rails average about 1,000,000 cycles in the same type of rolling-load test.

GREAT NORTHERN RAILWAY

Service Test of 115 RE Heat-Treated Rail

This test was installed on the eastbound track near M. P. 33, east of Carlton, Minn. Two identical curves, each of 4 deg curvature, are located immediately adjacent to each other. Eighty-eight heat-treated rails were installed on both the low and high sides of the first curve, and 88 control-cooled, end-hardened rails were installed on the low and high sides of the adjacent curve.

Inspection of these test rails was made on June 3, 1952, after the test rails had accumulated approximately 56,000,000 tons of traffic. Visual examination of the first curve, which is the heat-treated rail installation, revealed one rail had developed light flaking. The balance of the rails exhibited light incipient cracking near the gage corner. The second curve, laid with the end-hardened, control-cooled rail, was beginning to exhibit gage corner flaking, and 2 rails, 1 with heavy flaking and 1 with light shelling, were observed.

Rolling-load test results at the University of Illinois on companion samples of these rails showed the following:

Control Cooled Cycles	*Heat Treated Cycles*
1,565,000	9,625,000
	9,625,000

Group 2

The Engineering Division research staff has continued to assist the committee in the direction of the research work and the field studies.

Group 3

The third portion of the assignment is covered by a report prepared by Prof. R. E. Cramer, which follows as Appendix 8–A.

Group 4

The fourth portion of the assignment is covered by a report prepared by the Battelle Memorial Institute, which follows as Appendix 8–B.

Group 5

Prof. M. M. Frocht of the Illinois Institute of Technology has completed construction of the replica samples of rail and wheel required for the three dimensional photoelastic analysis which he will conduct. Preliminary test loadings of the specimens have begun and it is hoped that a progress report will be made in the near future.

Appendix 8–a

Eleventh Progress Report on Shelly Rail Studies at the University of Illinois

By R. E. Cramer

Research Associate Professor of Engineering Materials, University of Illinois

Organization and Acknowledgment

The shelly rail investigation at this laboratory is a cooperative study financed under the same research contract as explained under a report on "Failures in Control Cooled Rails." Previous reports have been published annually in the Proceedings of the AREA, which describe the rolling machines used and give the results of laboratory tests on 163 rail specimens of different composition and heat treatments. This report is a continuation of the investigation.

Acknowledgment is made of the part-time help of K. B. Meurlott, R. Berkovitz, and C. F. Chen, student test assistants. Marion Moore, mechanic, has operated the rolling machines and rebuilt two cradles during the past year.

Repeat Test on Heat-Treated Rail

When the Oct. 1, 1951, report was written, only one rolling-load test had been made on the heat-treated 115-lb rail supplied by the Great Northern Railway. This rail is Laboratory Number 1139 and gave 9,625,000 cycles on the first rolling-load test. Test of a second specimen of this rail was started in December 1951 and was stopped in June 1952 at 9,068,000 cycles when a crack in the web made it impossible to continue the test. The rail had not developed a shelling failure in this long test.

Completion of Tests of Flame Hardened Rails

In the last report rolling-load tests were reported on three rails experimentally flame hardened by the Union Carbide and Carbon Research Laboratories. There were four specimens left which had been given different heat treatments during th flame-hardening procedure. Rolling-load tests were made on these specimens and the results of all tests on this group of flame-hardened rails are reported in Table 1. The flame-hardening process only hardened a thin layer on the rail tread, which ranged from 340 to 450

Brinell hardness. There is no correlation between the cycles for failure and the hardness of the specimens because the shelling cracks developed in the rail heads considerably below the hardened area and near the gage corner of the rails, as shown in Fig. 1. Only one specimen ran over two million cycles in the rolling-load test. This was specimen 31, flame hardened by the standard Oxweld process of immersing the rail in water the full height of the web and using no other quenching or drawing of the heated area. This specimen had the lowest hardness of 340 Brinell and gave 4,068,000 cycles in the test;

TABLE 1—METHOD OF FLAME HARDENING AND ROLLING-LOAD TESTS

Specimen Number	*Description of Flame-Hardening Treatment*	*Brinell Hardness Obtained*	*Cycles for Failure 50,000 lb Wheel Load*
	115-Lb Rails Treated by Union Carbide Research Laboratory		
25	Heated and Quenched to Martensite—Tempered to 450 Brinell	446	1,478,000
28	Heated and Quenched to Martensite—Tempered to 380 Brinell	364	554,000
29	Heated and Quenched to Martensite—Tempered to 350 Brinell	342	960,000
30	Heated and Quenched to Martensite—Tempered to 480 Brinell	450	1,893,000
31	Immersed in Water—Standard Oxweld Method—350 Brinell	340	4,068,000
32	Immersed in Water—Standard Oxweld Method—350 Brinell	368	1,990,000
33†	Immersed in Water—Standard Oxweld Method—350 Brinell	370	1,055,000
	†No. 33 also had both sides of the rail flame hardened		
	132-Lb Rails Commercially Treated by Weir Kilby Corp.		
U12A	Flame Hardened by Weir Kilby Corp.	345	1,008,000
U12B	Flame Hardened by Weir Kilby Corp.	345	875,000
U34A	Flame Hardened by Weir Kilby Corp.	364	930,000
U34B	Flame Hardened by Weir Kilby Corp.	364	767,000

however, the head flowed a large amount, as shown in Fig. 1. Since other specimens treated by the same process failed below two million cycles, this one high value must be considered an exception. In general the tests of these flame-hardened rails did not give laboratory test results comparable with fully heat-treated rails or alloy rails which have been previously reported.

Rolling-Load Tests of Commercially Flame-Hardened Rails

The advisory committee of the Shelly Rail Investigation arranged to obtain two specimens of commercially flame-hardened rails from the Weir Kilby Corporation, Cincinnati, Ohio. Two tests on each specimen, U12 and U34, are included in Table 1. These rails had a treated area across the rail tread about ¼ in. in depth, as shown in Fig. 2. The Brinell hardness at the surface of the rails was 345 and 364. None of the specimens gave rolling-load tests of over one million cycles, the average for unhardened standard rails. Fig. 2 also shows the shelling cracks produced in these rolling-load tests. These tests even indicate that with a ¼-in depth of the hardened area 50,000-lb wheel load sets up stresses at a depth in the specimen that is less able to withstand the stress than a standard rail which is not flame hardened. There is probably a stress concentration effect at the boundary between the hardened and unhardened areas in the steel. The 50,000-lb wheel load used in rolling-load tests is almost twice the average wheel load used in service. Therefore, these tests should not be interpreted as applying to track conditions. Only track tests should be considered as final tests for determining their life under service conditions. The flame-hardened rails definitely show less flow of the rail heads in the rolling-load tests, and under the lighter wheel loads used in service the higher stresses may not penetrate to the lower edge of the flame-hardened area.

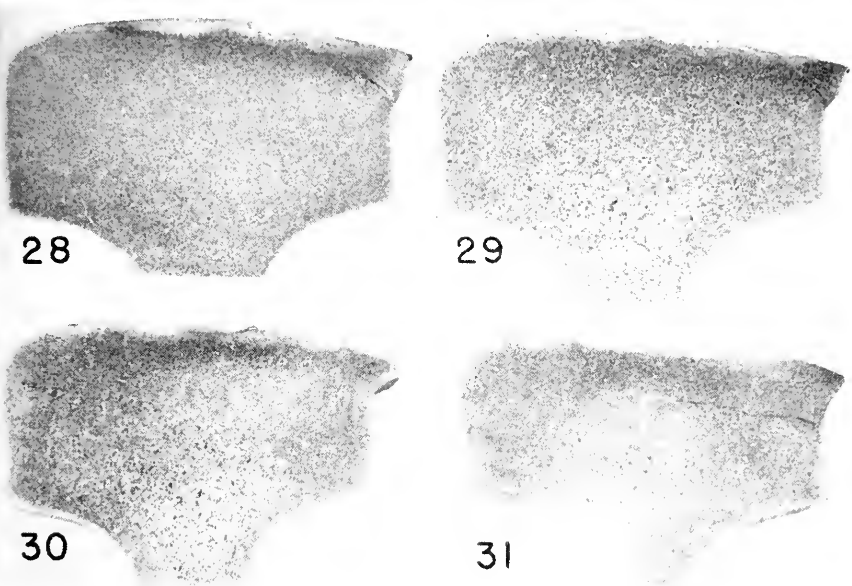


Fig. 1—Etched slices of flame-hardened rails.
Etched in hot 50 percent hydrochloric acid

	Brinell Hardness	Cycles for Failure
No. 28—Quenched and tempered	364	554,000
No. 29—Quenched and tempered	342	960,000
No. 30—Quenched and tempered	450	1,893,000
No. 31—Standard Oxweld	340	4,068,000

Rolling-Load Tests to Develop Detail Fractures

Previous rolling-load tests to develop detail fractures from shelling had been made with a slot cut in the rail web 5.7 in long and 5 in below the rail tread. In these tests the shelling cracks had developed too fast in relation to the detail fractures. To produce more bending and less tendency to develop shelling several combinations of length of slot and wheel load were tried. These tests are listed in Table 2. It was found that with a longer slot the rail base would bend, and this was overcome by welding stiffners to the top of the rail base. The fractures produced in these tests are shown in Figs. 3 and 4. Best results have been obtained with a combination of 50,000-lb wheel load and a slot 6 in. in length. As would be expected, the combination of flow of the metal by heavy wheel loads to produce shelling cracks and high bending stresses to produce detail fractures results in a wide scatter in the type of failure produced.

Stress Relief of Specimen During Rolling-Load Tests

Stress relaxation tests were made at Battelle Memorial Institute by Messrs. D. R. Jenkins and H. J. Grover. These tests were made by cutting strips from a 152 lb railroad rail and producing a given stress by bending the strips in clamps, and the stress was relieved by annealing the clamped strips. These tests showed that the stress produced

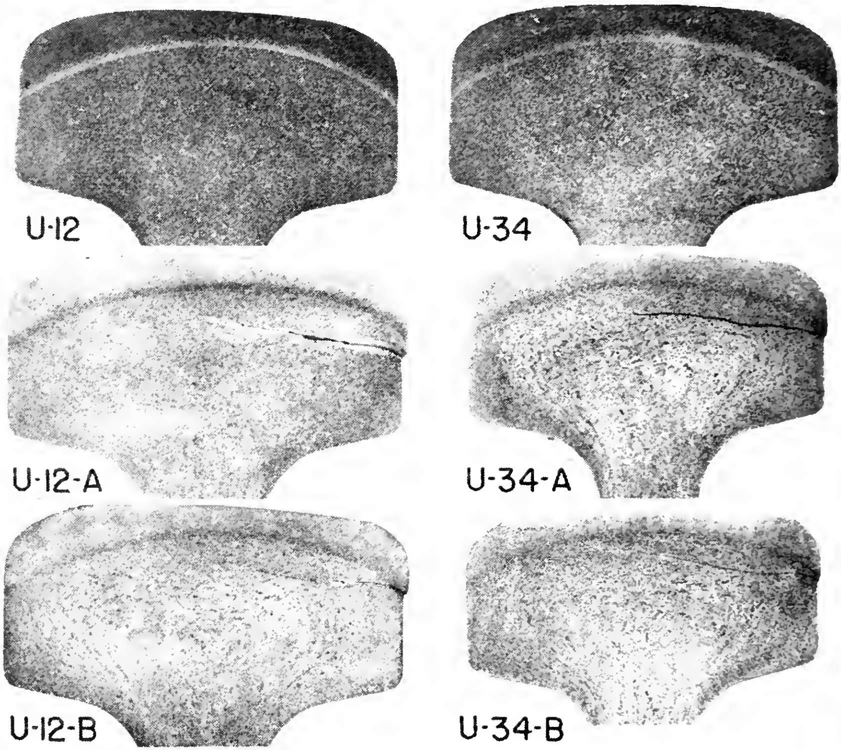


Fig. 2—Weir Kilby Corp. flame-hardened rails before and after testing.

Top row—Before testing. Etched with amonium persulfate which darkens flame-hardened area.

Lower two rows—After testing. Etched in hot 50 percent hydrochloric acid.

Specimen No.	*Type of Specimen*	*Average Brinell Hardness*	*Cycles in Rolling Machine*
U12A	132-lb rail, flame hardened	345	1,008,000
U12B	132-lb rail, flame hardened	345	875,000
U34A	132-lb rail, flame hardened	364	930,000
U34B	132-lb rail, flame hardened	364	767,000

in the bent strips was relieved by stress-relief heat treatments. The final recommendation based on these tests was that the stress in rail steel was best relieved by annealing the steel at 1000 deg F. Based on these tests the Shelly Rail Joint Contact Committee decided that stress relief tests should be made on full section rails after they had been rolled in laboratory rolling machines for various portions of their expected life before shelling.

The first standard rail was stress relieved at 1000 deg F for 1½ hr at both ½ million and 1 million cycles, and developed a shelling crack at 1,228,000 cycles. A repeat test using the same stress-relief cycles failed at 1,193,000 cycles. A specimen of this standard

TABLE 2—ROLLING-LOAD TESTS TO PRODUCE DETAIL FRACTURES

(All slots were cut in rail webs 5 in below rail tread)
(All specimens were from the same 132-lb standard rail)

Specimen No.	*Method of Stiffening Rail Base*	*Avg. Brinell Hardness*	*Length of Slot in Web, In*	*Wheel Load, Lb*	*Cycles in Rolling Machine*	*Remarks on Failure*
828E	No Stiffener Used	273	6.7	40,000	3,316,000	Base bent; Shelling crack only
828F	No Stiffener Used	273	6.7	45,000	1,989,000	Base bent too much to continue test
828G	Stiffeners Welded to Rail Base	273	6.7	45,000	2,632,400	Shelling crack and 25% detail fracture
828H	Stiffeners Welded to Rail Base	273	6.7	50,000	1,350,000	20% detail fracture from gage corner
828I	Stiffeners Welded to Rail Base	273	6.7	45,000	2,580,000	Shelling crack and 10% detail fracture
828J	Stiffeners Welded to Rail Base	273	6.2	50,000	1,201,000	Small shelling crack and 20% detail fracture
828K	Stiffeners Welded to Rail Base	273	6.0	50,000	1,630,000	Large shelling crack and 10% detail fracture
828L	Stiffeners Welded to Rail Base	273	6.0	50,000	1,903,600	Small shelling crack and 40% detail fracture
828M	Stiffeners Welded to Rail Base	273	6.0	50,000	767,600	Small shelling crack and 20% detail fracture

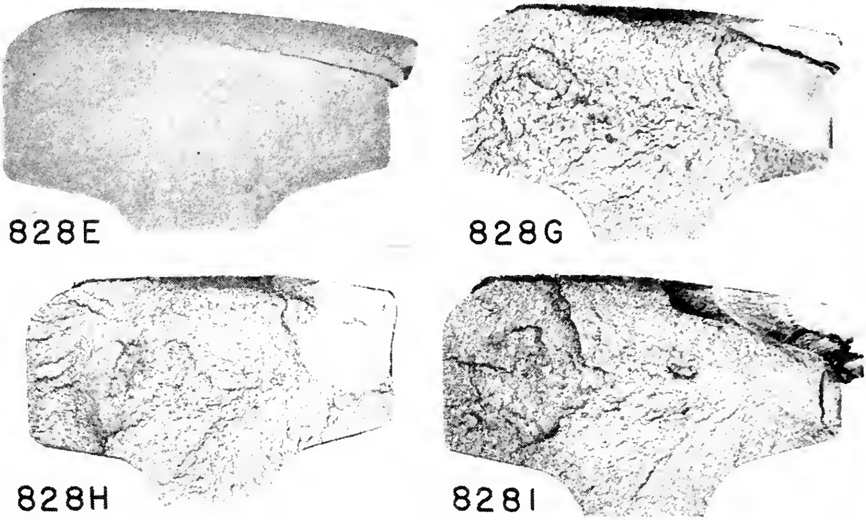


Fig. 3—Specimens tested to produce detail fracture.

Specimen No.	*Description of Fracture*	*Cycles for Failure*
828E	Etched slice showing shelling crack only	3,316,000
828G	25 percent detail fracture from shelling crack	2,632,000
828H	20 percent detail fracture from gage corner	1,350,000
828I	10 percent detail fracture from shelling crack	2,580,000

rail 828 was then rolled without stress relief and failed at 1,135,000 cycles. These tests indicated that the stress-relief treatment had very little if any effect on the development of the shelling crack as all three failures occurred within the spread usually obtained in rolling-load tests of standard rails.

A third specimen was stress relieved using the same time and temperature at 250,000 cycles and 500,000 cycles and failed at 626,800 cycles, which was a significant drop in cycles due to the more frequent stress-relief treatments.

These tests indicated that the effect of stress relief may be different on rail steel which had been flowed by wheel loads than strips which had been bent to produce the stress. Some study has been started on the changes in metallographic structure produced by the stress-relief treatments, but the results are inconclusive at present. Due to a failure of the rolling machine cradle, it has become necessary to rebuild the cradle and driving mechanism of the rolling machine used in the stress-relief tests.

Summary

1. A repeat rolling-load test on a heat-treated 115-lb rail ran 9,068,000 cycles without developing a shelling failure. The test was stopped due to a web crack.

2. Seven rolling-load tests were made on experimentally flame-hardened rails furnished by Union Carbide and Carbon Research Laboratories. Four specimens ran to 1½ million cycles, but do not compare favorably with previous tests of heat-treated or alloy rails.

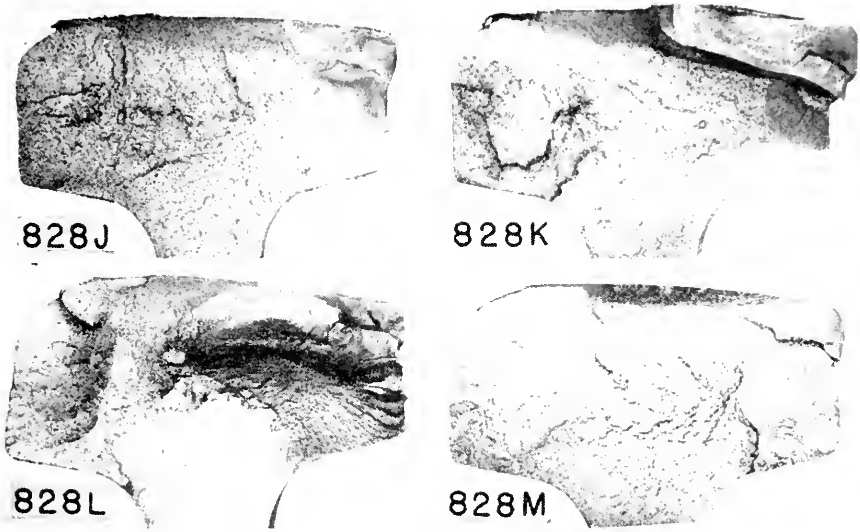


Fig. 4—Specimens tested to produce detail fractures.

Specimen No.	Description of Fracture	Cycles for Failure
828J	Small shelling crack and 20 percent detail fracture	1,201,000
828K	Large shelling crack and 10 percent detail fracture	1,630.000
828L	Small shelling crack and 40 percent detail fracture	1,903,600
828M	Small shelling crack and 20 percent detail fracture	767,600

3. Four rolling-load tests were made on commercially flame-hardened rails furnished by Weir Kilby Corporation. None of these specimens gave tests better than standard carbon steel rails.

4. Nine rolling-load tests were made to develop detail fractures from shelling. There was a large variation in cycles for failure and the type of failure produced.

Appendix 8-b

Summary of Progress on Studies of Stress Relaxation in Rail Steel and of Deformational Behavior of Rails

By W. S. Hyler and H. J. Grover,
Battelle Memorial Institute

Introduction

Investigations aimed toward a better understanding of shelling and detailed fractures in rails have proceeded along two lines.

First, the use of stress-relieving heat treatments[1], to delay or prevent the local damage resulting in such failures, was further studied. Results of tests in this phase of the investigation did not indicate beneficial effects of the stress-relieving treatments used. Accordingly, effort was directed toward other methods of studying the mechanism involved in rolling-load failures.

[1] See progress report in AREA Proceedings, Vol. 53, 1952, pp. 916-920.

The methods currently being explored involve the use of model materials which go beyond usual photoelastic materials in affording information at stresses beyond the elastic limit. Some work has been done with two types of material: (1) low-carbon steels sensitive to the Fry "strain-etch" technique, and (2) silver chloride, which has an unusual combination of optical properties and metal-like mechanical behavior.

Stress-Relaxation Studies

Bending fatigue tests of rail-steel specimens were run to investigate if a subcritical thermal treatment might heal progressive fatigue damage.

The specimen was 0.20 in wide and 0.125 in thick at the test section. Each specimen was subjected to reversed bending at a level producing maximum nominal surface strain of 1500 microinches per inch. The speed of load reversal was about 1750 cycles per minute.

Tests were run on four specimens without relaxation to afford a base lifetime for evaluating any effect of relaxation. Subsequent tests were run on specimens periodically stress relieved after one-half, after one-fourth, and after one-tenth of the mean lifetime. The stress-relieving treatment, 1 hr at 1100 F, was chosen on the basis of previous work (AREA report cited) as affording high probability of stress relaxation. Results are shown in the following table:

Specimen Number	*Fractional Lifetime Prior to Stress Relief*	*Maximum Strain, Microinches*	*Cumulative Cycles to Failure*	*Average Lifetime, Cycles*
1	----------	1500	187,000	
4	----------	"	234,000	
5	----------	"	541,000	
6	----------	"	163,000	297,000
7	½	"	282,000	
9	"	"	316,000	
10	"	"	284,000	294,000
11	¼	"	208,000	
12	"	"	256,000	
14	"	"	199,000	221,000
16	1/10	"	133,000	
17	"	"	127,000	
18	"	"	162,000	141,000

The data apparently show that stress-relief treatment at successively shorter increments of average lifetime decreases the cumulative lifetime to failure. There is some reason to believe that the range in average lifetime is within the limits of scatter inherent in tests of this kind.[1] However, examination of the microstructure showed that some decarburization at the surface occurred. Conceivably,this could mask any healing that might have been accomplished by the stress relief. Some additional tests of this kind could be made with stress relief carried out in an atmosphere to prevent decarburization. The question of healing fatigue damage might be answered by such tests.

[1] E. Epremian and R. F. Mehl, final report, NACA Contract NAw-5782, "Investigation of the Statistical Nature of Fatigue Properties", April 1931, Metals Research Laboratory of the Carnegie Institute of Technology.

It may be expected that the cumulative plastic deformation and resultant local stress in a rail under rolling load differs from the behavior of outer fibers of a bending fatigue-test specimen. Accordingly, it seemed desirable to examine the effects of stress-relaxing heat treatments on specimens under rolling loads.

As mentioned in the previous report, small-scale rolling-load tests were tried. These small-scale rolling-load tests were continued somewhat beyond the extent described previously. In addition to tests with plain disks and with disks having transverse holes (to accentuate bending), flanged disks (to accentuate transverse loading) were tried. In every case, failure appeared by shallow pitting of the surface. These failures in the small-scale tests may have been basically similar to shelling of rails; however, the appearance was so different that it could not be concluded that the failures were closely related. For this reason, further work along this line was suspended.

It was suggested that full-scale rolling-load tests with stress-relieving heat treatments be tried at the University of Illinois. These are discussed in the report (Appendix 8–a) by Professor Cramer.

Deformation Studies

When a cylindrical body rolls over a plane body, triaxial stresses are induced in the plane body. These stresses are such that the maximum shearing stress, resulting from the stress field, increases in magnitude with depth to a certain depth, z, and decreases thereafter. If the contact loads are great enough, the shearing stress may be large enough to cause plastic deformation at depth z. Thomas and Hoersch[1] have shown that the maximum shearing stress. S_s and depth of maximum shearing-stress location, z, are given by:

$$S_s = K_1 \sqrt{\frac{P}{Rh}}, \qquad (1)$$

$$z = K_2 \sqrt{\frac{PR}{h}}, \qquad (2)$$

where

K_1 and K_2 are functions of the elastic constants of the material,
P is the wheel load,
R is the radius of the wheel,
h is the thickness of the wheel.

The theoretical solution of Thomas and Hoersch and the rail problem may not be entirely compatible; the former treats a case of elastic behavior, and the latter case is known to result from plastic deformation. However, the theoretical solution might provide a base line for understanding the rail problem.

It was suggested that one approach to the problem might be through the use of materials other than rail steel. In this way, certain specific properties of the simulating materials may be used to advantage (where such properties are alien to rail steel). Two materials were agreed upon for consideration: low-carbon steel, and silver chloride. In the former material, plastic deformation is an inhomogeneous process. Yield wedges that may be formed internally may be developed on a properly sectioned sample treated with Fry's reagent or some similar reagent. The progress of progressive plastic deformation under rolling load may be studied with this material.

[1] H. R. Thomas and V. A. Hoersch, "Stresses Due to the Pressure of One Elastic Solid Upon the Other", University of Illinois, Engineering Experiment Station Bulletin No. 212, July, 1930.

Silver chloride, on the other hand, although an ionic crystal, exhibits mechanical properties much like common metals. In addition, its unusual optical properties suggested that it may have considerable usefulness in this study.

Studies With Low-Carbon Steel

All low-carbon-steel analyses do not react with the Fry reagent. Apparently, nitrogen content is a critical variable. Of five heats of low-carbon steel submitted by the Bethlehem Steel Company for this work, nitrogen content varied from about 0.003 to 0.016 percent. Preliminary screening tests showed heat 3 to be most receptive to the Fry reagent. Composition of heat 3 was: 0.08 percent C; 0.46 percent Mn; 0.095 percent P; 0.048 percent S; 0.03 percent Si; 0.016 percent N_2. Unfortunately, this steel showed particularly severe banding. The following treatment homogenized the structure and resulted in a grain size of about ASTM 6 or 7:

(1) Heat at 2350 F for 10 hr, air cool;
(2) Heat at 1800 F for 1 hr, water quench;
(3) Heat at 1700 F for 1 hr, air cool.

All subsequent test specimens have been given this treatment.

Tests were run to determine optimum strain-aging conditions and etching conditions. It appeared that strain aging (following plastic deformation) at 700 F for 1 hr was the best treatment. Etching was at room temperature for about 15 to 20 secs.

Calculations using equations 1 and 2 were made to determine a range of wheel diameters which might result in an appreciable range in depth of maximum shearing stress. As a result, wheels (or sections of wheels) of 4-in, 8-in, and 12-in radius are being fabricated. Depth of shearing stress will range from about 0.02 to 0.06 in. Rails of rectangular cross section are being machined from the low-carbon steels. Some of these will be loaded statically through the wheels; others will be loaded with repeated rolling loads. For each wheel and loading, loads will vary over a range to produce stresses ranging from elastic to inelastic. Effects will be studied following strain aging and sectioning of rails.

Studies With Silver Chloride

Ingots of AgCl were centrifugally cast and hot rolled initially at 200 C to effect breakup of large columnar crystals. Further rolling was done at room temperature to form plates ¼ in thick. Bars, approximately $\frac{3}{16}$ in by ½ in by 4 in, machined from the plates, were recrystallized at 175 C for 15 min and were polished and lightly etched with a solution of Kodak Acid Fixer.

Bars were rolled repeatedly with either a 4-in diameter wheel and 3.5-lb load, or an 8.75-in diameter wheel and 6.7-lb load. According to equations 1 and 2, slip, if observed, should occur in the bar rolled with the large wheel at a depth about twice that found in the bar rolled with the small wheel.

During the course of the tests, slip lines were developed on the transverse face of the bars. These slip lines increased in density and in depth with repeated rolling. At comparable lifetimes, slip in the bar rolled with the large wheel always extended to depths greater than that observed in the bar rolled with the small wheel. Tests were terminated after about 64,000 cycles in each case. In the case of the bar rolled with the large wheel, slip extended to an average depth of about 0.04 to 0.045 in. The bar rolled with the small diameter wheel showed depth of slip averaging about 0.028 to 0.033 in.

Although the observed behavior is in the direction indicated by theoretical considerations, the actual behavior emphasizes that real material is not homogeneous nor isotropic and that the prediction of mechanical behavior by the theory of elasticity must be tempered by other considerations.

The silver chloride bars tested in this work were not of sufficient purity or clarity to permit full advantage of the optical properties of the material. Commercially pure, silver chloride bars have been ordered from the Harshaw Chemical Company. Tests on these bars will duplicate and extend previous work on silver chloride.

Future Work

Work with the two model materials will be continued with the objective of obtaining information about the effect of plastic deformation upon cracking and shelling of rails under rolling loads.

Report on Assignment 9

Recent Developments Affecting Rail Section

W. J. Cruse (chairman, subcommittee), E. L. Anderson, T. A. Blair, C. B Bronson, W. J. Burton, E. E. Chapman, H. R. Clarke, C. J. Code, L. S. Crane, P. O. Ferris, C. J. Geyer, E. L. Gosnell, S. R. Hursh, K. K. Kessler, L. R. Lamport, C. C. Lathey, Ray McBrian, B. R. Meyers, W. G. Powrie, R. B. Rhode, J. C. Ryan, G. L. Smith, Edward Wise, Jr., H. F. Whitmore, S. P. Winton.

This is a progress report, presented as information.

The topics being pursued under this assignment are:

(a) Study of the stresses developed around the bolt hole of a rail with the joint in tension.

(b) Redesign of 100 RE rail and joint bars.

(c) Study of rail web bolt hole finish in regard to fatigue failure.

(d) Study of the proposal for the adoption of the 140 PS rail section as an AREA standard.

(a) The report of the Engineering Division research staff, presented herewith as Appendix 9-a, covers stress measurements around the bolt holes of a rail with the joint in tension.

(b) In regard to the redesign of the 100 RE rail and joint bar the stress measurements in the fillet area of the present design will be made this winter at the Central Research Laboratory.

(c) The study of rail web bolt hole finish in regard to fatigue failure is being carried out at the Central Research Laboratory. A Sonntag fatigue testing machine has been purchased and installed and is being used to make a comparison between rail web sections having defective bolt holes, such as gouges and burred conditions, and a rail web section having properly drilled bolt holes. Other rail web sections are being investigated, some with the bolt holes having the edges peened and others with the bolt holes having a $\frac{1}{16}$-in chamfer.

(d) A survey of the proposal for the adoption of the 140 PS rail section as an AREA standard is now in progress.

Appendix 9-a

Stresses Around a Bolt Hole of a Rail With the Joint in Tension

At the request of the committee the research staff has studied the stresses developed around a bolt hole when, due to contraction of the rail, the bolt comes into contact with the margin of the hole. The work has been carried out at the Central Research Laboratory under the direction of G. M. Magee, director of engineering research, by Kurt Kannowski, metallurgist, and M. F. Smucker, assistant electrical engineer.

This report is presented as information. Seven rail joints using 132 RE rail were assembled with 132 RE headfree 36-in, 6-hole bars. The following are the dimensions of the various hole spacings and diameters of bolts and holes:

	Bolt Hole Spacing Inches	*Diameter of Hole Inches*	*Diameter of Bolt Inches*
Joints 1, 4, 5	6–6–3½–3½–6–6	1 3/16	1 1/16
Joints 2, 6, 7	6–6–3½–3½–6–6	1 3/16 (note 1)	1 1/16
Joints 2, 6, 7	6–6–3½–3½–6–6	1 5/16 (note 2)	1 1/16
Joint No. 3	6–6–2½–2½–6–6	1 5/16	1 1/8

Note 1—Diameter of holes 1, 2, 5, 6.
Note 2—Diameter of holes 3, 4.

The rail ends used in these joints were machined at one end into a tongue 6 in long and 2 in wide, and of the thickness of the web as shown in picture 3. These tongues were then placed in the grips of the Baldwin testing machine to produce tension in the joint as shown in picture 5. The strains were measured by means of resistance wire strain gages (SR–4) attached to the web of the rail as close to the hole as possible, as shown in pictures 1 and 2. In order to investigate the effect of bending moment on the joint, as well as the effect of tension, wedges were driven into the rail joint gap until the SR–4 gages indicated a contact of the bolt with the edge of the hole. The joint was then supported at each end of the joint bars and loaded in the center, as shown in picture 6.

The major static stresses are produced in a rail joint by the bolts at the point of contact in the bolt hole when the rail contracts. To simulate this condition the joint assembly was put in tension with various loadings, as shown on Table 2.

In order to determine the maximum strains and their direction produced by the bolt bearing on the hole with the joint in tension, SR–4 gages were placed around the bolt hole next to the rail end, as shown in pictures 1 and 2 and in Fig. 1. These gages were located 45 deg apart around the bolt hole on both sides of the web. The results of this determination are shown in Table 1. From this table it can be seen that the major stresses were produced in direct line with the bolt bearing. This determined the location of the SR–4 gages for the next step of the investigation. The location of these gages is shown on picture 4.

The effect of the different hole spacing on the stresses in the rail web was investigated with two joint assemblies with hole spacings of 6–6–3½–3½–6–6 in, and 6–6–2½–2½–6–6 in. The results are shown in Table 2. To determine the effect of increasing the diameter of the holes next to the rail end by ⅛ in, a joint assembly with a hole spacing of 6–6–3½–3½–6–6 in was used.

After analyzing the results from this test procedure it was decided to check the location of the gages by applying Stress-Coat to rail joint assemblies and subjecting them to tension. Joint 1S was stress-coated and assembled with a bolt tension of 15,000 psi. Joint 2S was stress-coated but not assembled. The stress-coating on both joints was then permitted to dry. Joint 1S was subjected to 101,000 lb tension. Joint 2S was assembled with a bolt tension of 15,000 lb. This tension was released and the stress pattern due to the bolt tension was marked as shown on picture 7. This joint was then reassembled and subjected to 105,000 lb tension. The location of the major stresses, as indicated by the stress-coating for Joint 1S, is shown on picture 8, and for Joint 2S on picture 9.

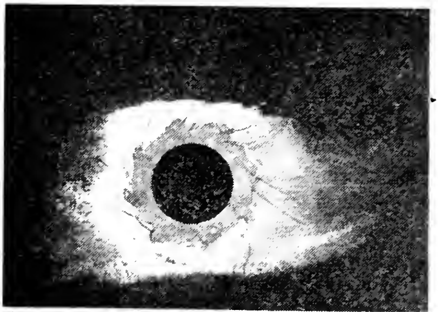
The results, as indicated on pictures 7, 8, and 9, showed that SR–4 gages should be located 15 deg below the horizontal, rather than on the horizontal directly through the center line of the bolt holes. Four more joint assemblies marked 4, 5, 6 and 7 were prepared with the SR–4 gages at a similar location, as shown on picture 4, but 15 deg below the horizontal. Joint assemblies 4 and 5 had $1\frac{3}{16}$ in diameter bolt holes and joint assemblies 6 and 7 had $1\frac{3}{16}$ in diameter bolt holes on all but the two nearest rail ends. These two bolt holes had $1\frac{5}{16}$-in diameters. These joint assemblies were subjected to various loadings, as shown on Table 4.

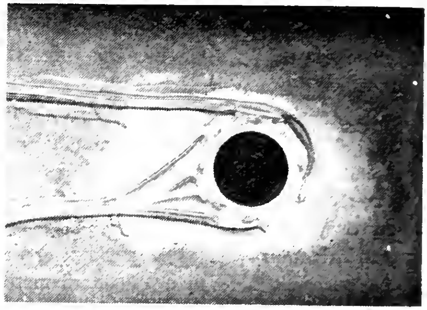
In attempting to simulate track conditions a joint assembly with a 6–6–3½–3½–6–6-in hole spacing was put in tension by driving wedges in the rail joint gap to approximate the tension on the bolts and holes caused by contraction. This joint was then supported at each end of the joint bars. It was loaded as a beam, as shown on picture 6 and Fig. 4. The results are given in Table 3.

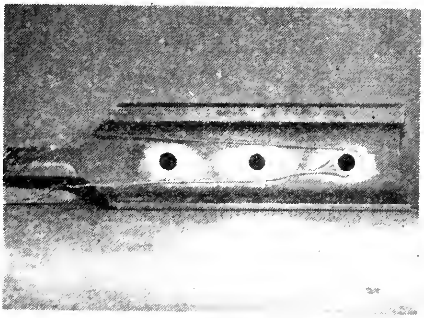
During the investigation it was noted that the bolts did not bear on the side of the hole for the full thickness of the rail web. This can be noted by the difference in the stresses on the two sides of the web for the same location in all of the data. This occurred in all cases in spite of careful lining up and seating of the joint bars. This same unequal bearing has also been noted on a considerable number of bolt-hole failures in track. The major stresses appear to be on the hole in line with the tension. The effect of the friction between the joint bars and the rails, as well as the variation of the bolt-hole spacing within the tolerances of the specification, introduce unknown factors which make the stress measurements inconclusive. A trend towards the reduction of the stresses around the bolt hole next to the rail end can be noted in the case where the diameter of this bolt hole is larger than that of the rest of the holes. The stresses seem to decrease as the distance from the end of the rail increases. This is shown on Table 2 with bolt-hole spacings of 3½ in and 2½ in from the end. The data on Table 3, obtained from the joint assembly under a horizontal loading, indicate that the major stresses are in the same direction as the tension and not at a location of 45 deg from the horizontal where bolt-hole cracks occur.

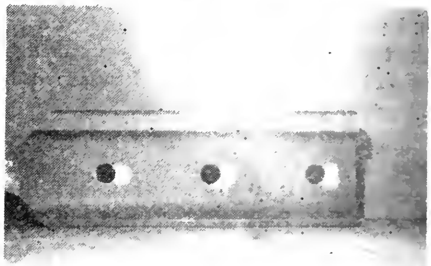
Conclusions

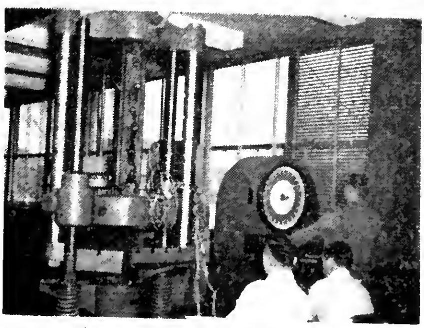
Tensile stresses are developed around most of the circumference of the bolt hole when the bolt comes to a solid bearing as a result of rail contraction in cold weather. These stresses are a maximum directly at the point of bolt bearing and may exceed the yield point. They diminish rapidly each way from this point and become zero or even compressive directly opposite. Although of moderate intensity at 45 deg from the horizontal, they may be a factor in the development of bolt hole cracks which normally occur at this location.

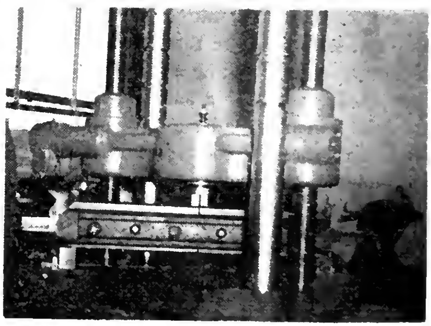

Picture 1. Eight 1/4 in. SR-4 gages around a bolt hole.


Picture 2. SR-4 gages with leads attached.

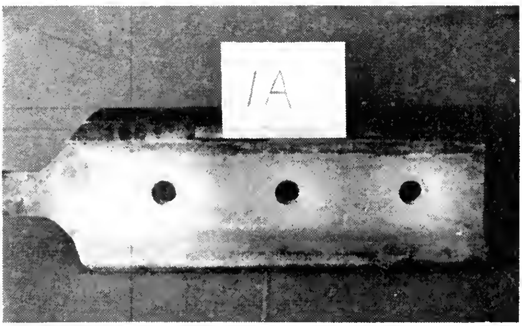

Picture 3. Rail end with SR-4 gages around first bolt hole .


Picture 4. Rail end with SR-4 gages on three bolt holes.

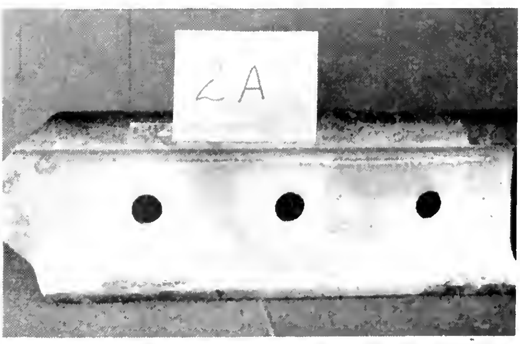

Picture 5. Rail joint in tension.


Picture 6. Rail joint with horizontal loading.

Picture 7. Stress coat pattern around bolt hole of rail end of joint 2S, B side. Pattern outlined with black line due to bolt tension only. Remainder due to tension on entire joint.



Picture 8. Stress coat pattern around bolt holes of rail end of joint 1S, A side due to tension on entire joint.



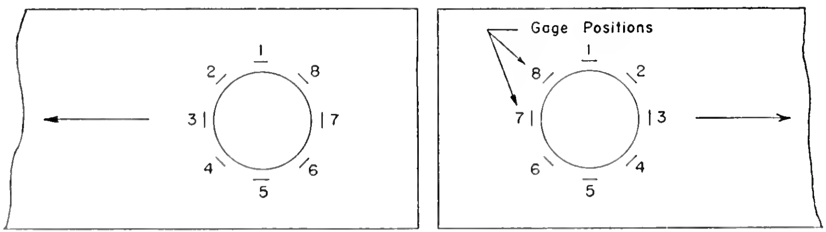
Picture 9. Stress coat pattern around bolt holes of rail end of joint 2S, A side due to bolt tension and tension on entire joint.

TABLE 1

STRESSES AROUND FIRST BOLT HOLE OF A RAIL WITH THE JOINT IN TENSION
(In 1000 P S I)

132 lb RE Rail, 6-6-3½-3½-6-6" Spacing, 1 3/16" Dia. Hole, 1 1/16" Dia. Bolt.
15000 lb Bolt Tension

Gage No.	No Load "A" Side of Web	No Load "B" Side of Web	30000 lb Load "A" Side of Web	30000 lb Load "B" Side of Web	35000 lb Load "A" Side of Web	35000 lb Load "B" Side of Web	40000 lb Load "A" Side of Web	40000 lb Load "B" Side of Web
1	1.8	-	11.4	-	13.8	-	9.9	-
2	1.8	4.2	5.4	5.1	3.3	5.7	.6	9.9
3	5.7	5.1	.9	.3	.9	-.3	-.6	5.1
4	4.8	-.9	12.6	.3	7.5	.3	6.9	3.0
5	-1.2	-.6	4.2	7.5	12.3	9.3	11.4	9.9
6	00	6.3	9.9	11.7	12.3	12.6	2.1	14.4
7	9.0	4.2	38.4	13.8	39.6	15.0	33.9	19.5
8	8.7	-4.2	17.1	2.7	19.5	3.6	15.3	6.6



Side "A" Rail Web Elevation Side "B"

FIG. 1

TABLE 2

STRESSES AROUND BOLT HOLES OF RAILS WITH JOINTS IN TENSION SIMULATING CONTRACTION IN TRACK.

(In 1000 P S I) 15000 lb Bolt Tension

	Bolt No.	No load Odd Gage	No load Even Gage	60000 Load Odd Gage	60000 Load Even Gage	70000 Load Odd Gage	70000 Load Even Gage	80000 Load Odd Gage	80000 Load Even Gage	90000 Load Odd Gage	90000 Load Even Gage	100000 Load Odd Gage	100000 Load Even Gage	110000 Load Odd Gage	110000 Load Even Gage
Test No. 1															
132# RE rail	1	8.7	5.1	6.6	2.4	76.2	3.6	111.6	4.8	152.7	7.2	197.7	9.6		
6-6-3½-3½-6-6"	2	-10.8	3.9	-11.4	3.6	-5.1	2.7	3.6	3.0	52.5	4.2	85.2	5.1		
hole spacing	3	17.1	18.9	15.3	20.4	13.5	31.2	15.0	35.1	16.8	38.7	19.5	41.4		
1 3/16" diam. hole	4	28.2	.9	24.9	-.6	24.3	1.2	25.2	3.6	28.8	5.4	34.2	6.0		
1 1/16" diam. bolt.	5	20.1	-.6	19.2	-.3	18.9	-.6	17.1	4.5	15.3	.9	16.5	-1.8		
	6	19.2	3.9	13.2	-.6	6.3	7.8	8.5	15.6	143.1	34.5	203.4	47.7		
Test No. 2															
132# RE rail	1	25.2	3.0	24.9	-.9	35.4	-1.5	44.4	-2.4	55.5	-1.5	64.5	-1.5		
6-6-3½-3½-6-6"	2	17.4	6.9	16.2	6.3	17.1	4.8	50.1	0	20.4	-1.5	212.4	-3.0		
hole spacing	3	19.2	18.3	19.5	17.4	21.3	15.3	23.4	42.6	24.0	11.7	24.0	12.3		
No. 1, 2, 5, 6	4	25.5	5.4	23.1	9.6	21.6	6.3	21.9	6.3	21.9	6.0	22.2	6.0		
holes - 1 3/16" diam.	5	10.2	6.3	9.6	6.0	13.8	1.5	10.5	12.9	9.0	29.7	8.7	84.3		
No. 3, 4 holes 1 5/16" diam.	6	5.4	13.2	1.2	7.8	33.3	-3.0	-64.8	5.7	-111.6	-10.8	-125.7	-14.1		
Test No. 3															
132# RE rail	1	13.5	6.0	10.2	4.8	17.7	3.9	54.6	1.8	104.4	-1.8	1957.5	-2.4	2482.5	-.3
6-6-2½-2½-6-6"	2	.6	12.6	2.1	13.5	3.0	13.2	4.2	12.6	1.2	11.4	19.2	12.0	40.5	12.3
hole spacing	3	10.5	28.2	21.9	27.9	31.5	26.4	76.5	24.9	65.4	23.4	72.3	24.0	93.9	21.3
1 5/16" diam. holes	4	7.8	19.8	6.9	22.5	36.6	53.1	10.5	23.1	7.5	20.7	4.8	15.9	2.7	-.3
1 1/8" diam. bolt.	5	5.1	7.2	7.8	10.8	7.8	10.8	9.0	10.8	9.6	10.5	10.5	10.8	11.7	10.5
	6	15.0	9.6	15.6	7.5	9.9	24.0	18.0	19.5	7.5	62.1	11.1	161.1	12.9	2476.5

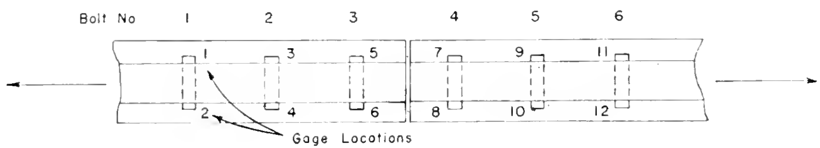


FIG. 2

TABLE 3

STRESSES AROUND BOLT HOLES OF RAILS WITH JOINTS IN TENSION SIMULATING CONTRACTION IN TRACK AND HORIZONTAL LOADING

132# RE Rail
6-6-3½-3½-6-6" Hole Spacing
1 3/16" Dia. Hole 1 1/16" Dia. Bolt
(In 1000 P S I)

Bolt No.	Gage No.	No Bolt Ten. 55500 lb Load on "A"	No Bolt Ten. 55500 lb Load on A + B	15000 lb B.T. No Load	15000 lb B.T. 55500 lb Load on A	15000 lb B.T. 55500 lb Load on A + B	No B.T. No Load with Wedge	No B.T. 55500 lb Load on A with Wedge	No B.T. 55500 lb Load on A + B with Wedge	15000 lb B.T. No Load with Wedge	15000 lb B.T. 55500 lb Load on A with Wedge	15000 lb B.T. 55500 lb Load on A + B with Wedge
	5	6.3	-2.4	13.6	9.6	10.8	-9.3	43.8	48.9	33.6	30.0	29.7
	6	.9	6.6	10.5	13.8	12.3	53.4	100.8	139.8	145.5	154.2	121.5
3	5A	6.3	0	4.8	3.0	1.8	-.3	15.9	14.4	6.9	8.7	5.7
	6A	-5.4	-1.5	7.2	2.7	1.8	6.6	-2.1	0	9.9	3.9	6.3
	7A	-2.1	3.3	1.5	9.9	11.4	.3	12.3	9.0	16.2	13.5	15.3
4	8A	-1.8	6.0	-4.8	-9.6	-9.0	3.0	-.9	-2.1	2.4	.3	2.7
	7	-1.5	-1.5	24.9	-5.1	-8.1	-1.8	12.6	36.0	-2.7	-5.7	-.6
	8	-1.8	4.5	-4.5	-1.5	-4.8	1.8	-2.1	11.4	18.0	18.3	15.3

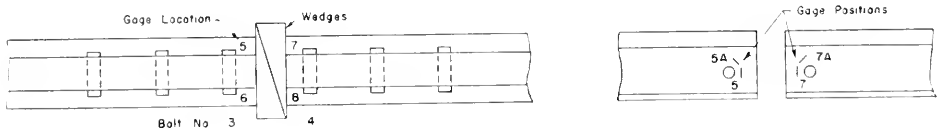


FIG 3

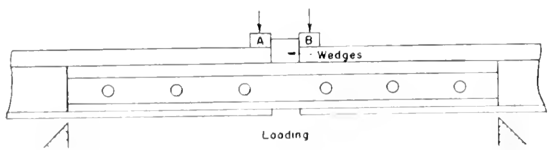


FIG 4

TABLE 4

STRESSES AROUND BOLT HOLES OF RAILS WITH JOINTS IN TENSION SIMULATING CONTRACTION IN TRACK

(In 1000 psi) 15000 lb Bolt Tension

	Jt. No.	Bolt No.	No Load Odd Gage	No Load Even Gage	30000 Load Odd Gage	30000 Load Even Gage	45000 Load Odd Gage	45000 Load Even Gage	50000 Load Odd Gage	50000 Load Even Gage	60000 Load Odd Gage	60000 Load Even Gage	70000 Load Odd Gage	70000 Load Even Gage	80000 Load Odd Gage	80000 Load Even Gage	90000 Load Odd Gage	90000 Load Even Gage	100000 Load Odd Gage	100000 Load Even Gage
		1	20.9	9.0					13.7	27.8	10.7	48.3			8.9	78.1	10.1	103.8	14.6	133.8
		2	16.7	-6.0					18.2	30.5	25.1	37.4			44.6	45.2	69.6	53.1	96.5	59.7
	4	3	15.5	-1.5					14.3	-.3	14.9	-.2			12.8	13.1	11.3	54.2	9.8	103.1
		4	7.2	2.4					8.1	-1.2	4.2	3.3			31.5	1.8	110.0	.6	178.5	-.9
132 lb RE rail		5	19.2	-1.2					14.7	-1.5	94.1	-.6			100.6	.2	120.6	.6	131.7	.8
6-6-3½-3½-6-6" hole spacing		6	17.4	11.9					14.6	12.5	15.3	12.8			124.8	8.6	196.8	4.8	252.6	7.2
1 3/16" diam.hole		1	24.0	-6.6			23.6	32.7			20.9	227.5	22.2	**	25.8	**	30.0	**	38.1	**
1 1/16" diam.bolts		2	20.0	-10.4			21.3	-13.1			14.7	5.1	15.8	14.0	19.5	21.6	27.9	27.3	40.4	32.7
	5	3	25.2	-7.5			24.9	-8.1			24.9	-8.6	24.6	-8.7	24.3	-8.3	23.6	-5.3	22.7	-8.3
		4	-5.4	6.8			-3.6	7.7			155.7	2.6	**	.8	**	2.6	**	4.8	**	7.7
		5	3.5	9.5			8.1	12.8			16.1	8.6	29.4	5.8	46.7	5.0	62.0	5.7	75.6	8.6
		6	4.1	20.4			5.1	5.8			102.2	14.4	149.0	15.6	183.3	15.8	214.8	15.9	**	16.2
		1•	12.9	-2.3	14.9	-3.5					12.0	**	22.1	**	40.4	**	80.4	**	127.8	**
		2•	10.1	-4.7	12.2	-5.1					26.7	99.3	44.0	98.4	61.7	98.0	84.9	97.7	105.3	100.5
	6	3•	16.8	-.9	15.6	.8					15.0	1.5	14.6	1.5	14.6	1.5	14.4	1.5	14.6	1.1
132 lb RE rail		4•	5.3	6.3	9.8	3.2					8.1	2.9	7.7	3.0	7.7	3.3	7.5	3.6	6.2	4.4
6-6-3½-3½-6-6"		5•	6.6	-.8	10.4	-3.3					123.6	-7.7	156.6	-7.1	179.1	-4.7	**	1.4	**	7.7
hole spacing No. 1,2,5&6 holes		6•	10.8	11.7	12.2	9.0					135.6	9.3	**	10.4	**	14.3	**	19.8	**	23.7
1 3/16" diam.		1	9.3	5.6					7.5	4.4	8.3	3.9	6.5	-16.7	5.6	-16.2	5.4	-2.0		
No.3 & 4 holes		2	.8	3.6					1.4	4.7	2.7	4.5	-2.6	135.3	-4.2	**	.8	**		
1 5/16" diam.	7	3	6.2	9.3					6.9	10.4	8.2	10.5	7.5	10.6	7.8	11.1	8.1	11.6		
1 1/16" diam.bolts		4	3.2	9.0					-1.2	13.2	-1.2	14.0	-1.5	14.6	-2.6	15.5	-2.9	16.2		
		5	.2	6.5					.3	8.1	.2	12.5	-.6	12.8	-1.2	11.3	-2.1	14.6		
		6	-3.8	9.2					4.8	10.2	1.7	10.7	28.4	11.4	103.4	11.6	**	15.6		

• Bolt tension 11,500 lb.

** Gage out, stressed beyond its range.

Report on Assignment 10

Service Performance and Economics of 78-ft Rail

Collaborating with Committee 5

L. R. Lamport (chairman, subcommittee), E. L. Anderson, T. A. Blair, B. Bristow, C. B. Bronson, B. Chappell, C. J. Code, J. C. De Jarnette, R. A. Emerson, C. J. Geyer, J. L. Gressitt, C. B. Harveson, S. R. Hursh, N. W. Kopp, Ray McBrian, B. R. Meyers, E. E. Oviatt, R. E. Patterson, G. A. Phillips, R. B. Rhode, E. F. Salisbury, I. H. Schram, A. A. Shillander, W. D. Simpson, A. P. Talbot, Edward Wise, Jr., R. P. Winton, J. E. Yewell.

This is a progress report, presented as information.

This is the first of a series of reports to be submitted covering the service tests of 78-ft rail. Initial measurements were made of rail surface profile, joint camber, and out-to-out distances on bars for determining the rate of rail-end batter, joint droop, and fishing surface wear. Similar measurements were taken on adjoining 39-ft rail sections to serve as a comparison for the 78-ft rail. These initial measurements will provide a reference for data accumulated with each succeeding year of track service.

The field work, analysis of data and report of measurements were carried out by the Engineering Division research staff of the Association of American Railroads, under the direction of G. M. Magee, director of engineering research, and K. H. Kannowski, metallurgist.

The test section for the 115 RE rail is on the eastbound main track of the Chicago and North Western Railway near Calamus, Iowa. The 78-ft rail test section is located between M.P. 32 and 33; the 39-ft rail test section between M.P. 28 and 29.

The test section for the 133 RE rail is on the eastbound main track of the Pennsylvania Railroad between Hamlet and Hanna, Ind. The 78-ft rail test section is between M.P. 400 and 401; the 39-ft rail test section between M.P. 399 and 400.

Both test locations are on tangent track. The 115 RE section has headfree type joint bars, and the 133 RE section has head-contact type bars. The 78-ft rail sections are two 39-ft rails pressure butt-welded by the Oxweld process.

Tests of Joint Impact Effects

It was thought that it might be helpful in evaluating the economics of 78-ft rail to develop some fundamental information on the impact effects of rail batter, joint gap, and the rail joint itself on joint ties compared to the load on the ties elsewhere in the rail length and not subjected to these impact effects. Accordingly, arrangements were made with the Chicago and North Western Railway for the Association research staff to make tests to evaluate the added loading on joint ties and to measure accelerations and vibrations of the joint ties, and to compare these values with those for ties away from the rail joint effect. A test location was selected about 4 miles east of Clinton, Iowa, on the westbound main line on tangent track where speeds up to 90 mph could be obtained. The test program was arranged so that the tie loading and tie vibration would be determined under six conditions, as follows:

1. Little batter, tight fitting joint bars and no joint gap.
2. Little batter, tight fitting joint bars and ⅜-in joint gap.
3. Heavy batter, tight fitting joint bars and no joint gap.
4. Heavy batter, tight fitting joint bars and ⅜-in joint gap.
5. Heavy batter, loosely fitting joint bars and no joint gap.
6. Heavy batter, loosely fitting joint bars and ⅜-in joint gap.

Strain gages were placed on the tie plates at the joint ties to determine the tie plate loading, and an accelerometer was placed on one joint tie to determine the accelerations and vibrations of the tie. The tests were made at two rail joints with 39-ft rails, and after they were completed the two 39-ft rails for each joint were replaced with 78-ft rails and the tests were repeated at both locations on the same ties but with the continuous rail over them so all of the effects of the rail joint would be eliminated. Measurements were made under regular service trains, and in addition a special test train was provided consisting of a diesel locomotive and three box cars which were outfitted for use in head-end passenger service and were thus suitable for high-speed runs. One of the three cars was empty, the second was half loaded, and the third was fully loaded to give a maximum wheel load of approximately 15,000 lb. These tests were run during October and November 1952, and it is planned that the test data will be analyzed and the report included in the Rail committee report next year.

Conclusions

Since these are the first measurements, and since no data for comparison are available, results will be published next year after further data have been obtained.

Installations of 78-ft Rail

Presented herewith as a part of this report is a table listing installations of 78-ft rail on American railroads, exclusive of short stretches through highway crossings, along station platforms, over ballasted-deck bridges, etc. This table corrects and brings up to date a similar table presented by the committee last year (see Proceedings, Vol. 53, 1952, page 943.) The table is shown on page 1264.

INSTALLATIONS OF 78-FT RAIL

Railroad and Location		Length Miles	Weight of Rail Lb per Yd	Year Installed	Type of Traffic Pass.-Frt.	Annual Gross Tons Pass. and Frt.	Train Speeds MPH Pass.	Frt.	Welded or from Mill in 78-ft Lengths	Joint Stagger	Type of Ballast	Subgrade Conditions
C. RR. of N. J.												
Near Bayonne, N. J.	4 Trks	8.0	131	1943 and subsequent	" "	18,000,000	70	45	Welded	19'-6"	Stone	Solid
C. & N. W. RY.												
Near Waukegan, Ill.	E.B.	1.5	115	1950	" "	10,200,000	100	60	"	"	"	Unstable
" " "	W.B.	1.5	115	1950	" "	10,300,000	100	60	"	"	"	"
" Wheatland, Ia.	E.B.	3.0	115	1948	" "	14,500,000	90	60	"	"	Slag	"
" Marshalltown, Ia.	E.B.	1.4	112	1947	" "	14,000,000	90	60	"	"	"	"
" "	W.B.	1.4	115	1950	" "	12,600,000	90	60	"	"	"	"
" Crescent, Iowa	W.B.	2.0	112	1946	" "	11,400,000	90	60	"	"	Gravel	"
" " "	E.B.	2.0	115	1948	" "	13,000,000	90	60	"	"	"	"
" Mondamin, Iowa	Sgl.	2.0	112	1943	" "	7,900,000	65	45	"	"	"	Grouted
" " "	Sgl.	2.0	112	1944	" "	7,900,000	65	45	"	"	"	"
" River Sioux, Ia.	Sgl.	5.0	112	1945	" "	7,900,000	65	45	"	"	"	"
" Blencoe, Iowa	Sgl.	5.0	112	1945	" "	7,900,000	65	45	"	"	"	Unstable
" Ashippun, Wis.	E.B.	4.0	115	1948	" "	9,500,000	95	50	"	"	"	"
" " "	W.B.	4.0	115	1949	" "	7,100,000	95	50	"	"	"	"
GRAND TRUNK WESTERN R.R.												
Near Stillwell, Ind.	E.B.	5.1	115	1950	" "	9,000,000	75	60	"	"	Stone	Good
KANSAS CITY SOUTHERN RY.												
Near Grandview, Mo.	Sgl.	1.0	127	1937	" "	10,500,000	78	50	From Mill	39'-0"	Chat	Good
PENNSYLVANIA R. R.												
Near Hamlet, Ind.	No. 1 E.B.	1.0	133	1950	" "	20,000,000	75	50	Welded	19'-6"	Stone	Sandy - Some Clay
" Coshocton, O.	No. 1 E.B.	1.0	140	1950	" "	25,000,000	70	50	"	"	"	Sand and gravel
" Ryde, Penn.	No. 2 E.B.	1.0	155	1950	" "	35,000,000	50	50	"	"	"	Sand and gravel
UNION PACIFIC R. R.												
Near Bryan, Wyoming	W.B.	1.0	133	1950	" "	31,000,000	79	50	From Mill	39'-0"	"	Good

PROCEEDINGS

Program

Fifty-Second Annual Meeting

Palmer House, Chicago

TUESDAY, MARCH 17

Morning Session—Grand Ballroom—9:45 to 12:15

Address of President C. J. Geyer, Vice President—Construction & Maintenance, Chesapeake & Ohio Railway

Report of the Secretary—Neal D. Howard

Report of the Treasurer—A. B. Hillman

Greeting from the Signal Section, AAR, R. W. Troth, Chairman

Greetings from the Electrical Section, AAR, C. A. Williamson, Chairman

Address—Planning Is Always in Season, by J. H. Aydelott, Vice President, Operations and Maintenance Department, AAR

Address—Research Review, by G. M. Magee, Director of Engineering Research, Engineering Division, AAR

Report of Committees	Bulletin Numbers
14—Yards and Terminals	504
16—Economics of Railway Location and Operation	504

Address—Improved Transit Time for Freight Shipments, by Dr. L. K. Sillcox, Vice Chairman of Board, New York Air Brake Company

Afternoon Session—Grand Ballroom—2:00 to 4:45

Report of Committees	Bulletin Numbers
25—Waterways and Harbors	504
9—Highways	504
24—Cooperative Relations with Universities	506

Address—The Manpower Situation, by O. W. Eshbach, Dean, Northwestern Technological Institute

20—Contract Forms	504

Address—Two Essentials of Engineering Science—Mathematics and Agreements, by W. R. Swatosh, Assistant to Superintendent of Construction, Erie Railroad

11—Records and Accounts	506
13—Water, Oil and Sanitation Services	504

WEDNESDAY, MARCH 18

Morning Session—Red Lacquer Room—9:00 to 12:00

Report of Committees — Bulletin Numbers

7—Wood Bridges and Trestles 506

28—Clearances 505

29—Waterproofing 505

Address—Tests on Waterproofing Coatings for Concrete Surfaces, by J. B. Blackburn, Research Engineer, Engineering Experiment Station, Purdue University

30—Impact and Bridge Stresses 505

8—Masonry 505

Address—Repeated Loading Tests on Prestressed Concrete Beams, by Professor W. J. Eney, Head of Department of Civil Engineering and Mechanics, Lehigh University

15—Iron and Steel Structures 506

Association Luncheon, Grand Ballroom, 12:00 Noon

Announcement of Results of Election of Officers

Address—by Dr. Francis Gaines, President, Washington and Lee University
Subject: Hand and Spirit

Afternoon Session—Red Lacquer Room—2:30 to 5:15

Report of Committees — Bulletin Numbers

17—Wood Preservation 505

Address—Controversial Issues, by Dr. Walter Buehler, Technologist, Wood Preservation, School of Forestry, University of Florida

6—Buildings 504

27—Maintenance of Way Work Equipment 505

22—Economics of Railway Labor 505

Address—Reducing Maintenance Man-Hours, by H. E. Kirby, Cost Engineer, Chesapeake & Ohio Railway

1—Roadway and Ballast 507

Motion Picture—Earthquake Damage and Repairs—with comments by W. M. Jaekle, Assistant Chief Engineer, Southern Pacific Company

THURSDAY, MARCH 19

Morning Session—Grand Ballroom—9:00 to 12:30

	Bulletin Numbers
Report of Committees	
3—Ties	505
Address—Progress in AAR-NLMA Cross Tie Research Project, by G. M. Magee, Director of Engineering Research, Engineering Division, AAR	
5—Track	507
Address—Prolonging the Life of Ties Through the Use of Pads vs Hold-Down Fastenings, by G. M. Magee, Director of Engineering Research, Engineering Division, AAR	
Special Committee on Continuous Welded Rail	507
4—Rail	507
Address—Rail Problems in the Moffat Tunnel, by Ray McBrian, Engineer of Standards and Research, Denver & Rio Grande Western Railroad	
Address—Rail Failures and Shelly Rail Investigation, by R. E. Cramer, Special Research Associate Professor, University of Illinois	

Closing Business

Installation of Officers

Adjournment

Report of the Tellers

Presented Wednesday Noon, March 17, 1953

We, the Committee of Tellers, appointed to canvass the ballots for officers and for members of the nominating committee, find the count of ballots as follows:

For President

C. G. Grove 1577

*For Vice-President**

G. M. O'Rourke 1571

For Directors (four to be elected)

E. S. Birkenwald 1021
F. G. Campbell 871
B. R. Meyers 868
G. E. Robinson 860
H. B. Christianson 857
A. B. Hillman 621
F. R. Smith 617
J. F. Marsh 543

For Members of Nominating Committee (five to be elected)

L. T. Nuckols 1079
C. H. Sandberg 1007
E. L. Anderson 960
W. H. Giles 821
L. H. Laffoley 741
M. S. Norris 701
J. L. Beckel 690
C. J. Code 622
G. E. Martin 619
L. F. Racine 507

Eight other miscellaneous votes were cast for the various officers listed above.

THE COMMITTEE OF TELLERS

R. A. BARDWELL, *Chairman,*
D. F. APPLE
COL. H. AUSTILL
S. H. BARNHART
B. W. DEGEER
W. M. S. DUNN
J. J. DWYER
C. E. DYSART
C. S. GRAVES
E. M. HASTINGS, JR.
T. L. HENDRIX
T. W. HISLOP
W. C. KING
L. D. LANGHAM
H. S. LOEFFLER
J. DE N. MACOMB
T. D. MASON
RAY MCBRIAN
H. L. MCMULLIN
G. F. METZDORF
C. B. PORTER
B. J. RICHARDS
J. P. RODGER
J. F. SCHELL
H. M. SCHUDLICH
J. M. SHORT
R. M. STIMMEL
W. R. SWATOSH
D. C. TEAL
R. H. TIMMINS
C. B. VOITELLE
J. E. WIGGINS
H. F. WHITMORE
A. R. WILSON

* Under the provisions of the constitution, G. W. Miller advances automatically from junior vice president to senior vice president.

PROCEEDINGS

Running Report of the Annual Meeting of the American Railway Engineering Association, March 17–19, 1953, Palmer House, Chicago, Including Abstracts of All Discussion, All Formal Action on Committee Presentations, Specific Papers and Addresses Presented in Connection with Committee Reports, and Other Official Business of the Association

Opening Session—March 17, 1953

The opening session of the fifty-second annual meeting convened at 9:45 am, President C. J. Geyer* presiding.

President Geyer: As we are about to begin the fifty-second annual meeting of this Association, I would like to have all the past presidents come to the platform and take seats on my right. We would also like to have the current vice presidents, the secretary, the treasurer, and the Board of Direction come to the platform and take seats on my left.

The fifty-second annual meeting of the American Railway Engineering Association, and the concurrent annual meeting of the Construction and Maintenance Section of the Engineering Division, Association of American Railroads, will please come to order.

Before proceeding with the business of our opening session, I should like to present to you those sitting at the speaker's table.

(The past presidents introduced to the convention included T. A. Blair, chief engineer system, Santa Fe Railway; H. S. Loeffler, assistant chief engineer, Great Northern Railway; F. S. Schwinn, assistant chief engineer, Missouri Pacific Lines; Armstrong Chinn, president, Terminal Railroad Association of St. Louis; J. B. Akers, chief engineer, Southern Railway System; and A. R. Wilson, retired engineer of bridges and buildings, Pennsylvania Railroad.

Also introduced were Neal D. Howard, secretary of the Association; C. G. Grove, chief engineer, Western Region, Pennsylvania Railroad, and senior vice president, AREA; G. W. Miller, engineer maintenance of way, Eastern Region, Canadian Pacific Railway, and junior vice president, AREA; R. P. Hart, chief operating officer, Missouri Pacific Lines, director; W. J. Hedley, assistant chief engineer, Wabash Railroad, director; L. L. Adams, chief engineer, Louisville & Nashville Railroad, director; Ray McBrian, engineer of standards and research, Denver & Rio Grande Railroad, director; A. B. Hillman, chief engineer, Chicago & Western Indiana, and Belt Railway of Chicago, treasurer; M. H. Dick, editor, Railway Track and Structures, director; A. N. Laird, chief engineer, Grand Trunk Western Railroad, director; and R. J. Gammie, chief engineer, Texas & Pacific Railroad, director.)

President Geyer: On your extreme right, at the long table, are the chairmen of the standing and special committees of this Association. They are the people who do the work, steering their committees along the proper channels. I would be glad if they would stand. (Applause)

* Vice president construction and maintenance, Chesapeake & Ohio Railway.

At this time I want to call on Mr. C. G. Grove, our incoming President, for a special message.

C. G. Grove: I wish to give a tribute to Herbert Rentoul Clarke.

A Tribute to Herbert Rentoul Clarke

By C. G. Grove
Chief Engineer, Western Region, Pennsylvania Railroad

We are all saddened this morning because of the absence among us of one who for many years has been in constant attendance at our deliberations and conventions—One who has been our dear friend and counselor. I refer to Herbert Rentoul Clarke, Past President, Member of the Board for many years, Honorary Member, constant and tireless worker on many committees, eminent engineer, loving husband and father, a staunch and active member of his Church, a citizen of the highest order, and a Christian gentlemen. This Association was so dear to his heart and so much a part of his daily life that he lived it every hour. During his recent illness, one thought uppermost in his mind was to get well so that he could attend this convention. But that was not to be. He passed away at his home in LaGrange, Ill., on February 18, 1953. Thus we see that "Man proposes and God disposes."

It is difficult to understand why, in the Providence of God, Mr. Clarke had to be called Home at this time. He had been retired as chief engineer from the service of the Burlington Lines for less than two months. Thus he was active to the end of his engineering career. Of him, who stood as a "sturdy oak" through the years, always seeking after the truth, it can be truly said, "He had fought a good fight, he had finished the course, he had kept the Faith."

We take this moment to honor his memory. At times such as these, words are hollow. It is difficult to express what we feel, but as an association of engineers we feel deeply the passing of this fellow member, this great and good man. We shall miss him. He was always ready to go the second mile. When a difficult assignment was in the offing he could be counted on to say "Here am I, send me." His life was an inspiration to those of us who worked with him in this Association. It will long continue a guiding star as we chart the course of the future.

In thinking of Mr. Clarke, we are reminded of Abraham Lincoln's tribute to Washington at Springfield, Ill., on his birthday in 1842, when he said, "To add brightness to the sun, or glory to the name of Washington, is alike impossible. Let no one attempt it. In solemn awe pronounce the name; and in its naked, deathless splendor, leave it shining on."

During the past year other faithful and honored members have "Gone Home." In addition to Mr. Clarke, we have lost Past President and Charter Member Edwin F. Wendt, Past President George L. Sitton, Charter Member Andrew D. Schindler, and some forty others. We are grateful to these men for their unselfish and consecrated service through the years. Their efforts and example spur us on to perpetuate and enlarge the knowledge that they have given to us.

In the words of Henry Wadsworth Longfellow—

Lives of great men all remind us,
We can make our lives sublime,
And, departing leave behind us,
Footprints on the sands of time.

Will you please rise and stand in solemn tribute?

(The membership arose for a moment of respectful silence.)

President Geyer: Thank you, Mr. Grove.

At this time I would like to introduce some other guests here at our speaker's table.

It is a great pleasure to recognize our brother associations in the railroad field, and we are honored this morning to have with us Mr. R. W. Troth, chairman of the Signal Section of the Association of American Railroads. Mr. Troth.

R. W. Troth: Mr. President, members of the AREA, and guests, it is my pleasure and privilege, as its chairman, to bring you at this opening of your fifty-second annual meeting, greetings from the Signal Section, Engineering Division of the Association of American Railroads.

We seem always to have a number of problems of mutual interest before us, and so the collaboration between your committees and our respective organizations is of the utmost importance to the railroads of this country. In the past this collaboration has been 100 percent, and we can see no reason why it should not continue as such in the years to come.

If there is anything that we in the Signal Section can do to assist you in your committee work—or, for that matter, in any way—we hope that you will call on us, and you can be assured we will do likewise.

On behalf of the Signal Section, I extend to you our very best wishes for a most successful meeting, and also extend to each of you a cordial invitation to attend our annual meeting, to be held this year at the Hotel Chase in St. Louis, Mo., on September 28–30. Thank you.

President Geyer: Thank you, Mr. Troth. It is a very great pleasure for us to have you here, and we appreciate your kind invitation to your meeting in St. Louis.

We are also pleased to have with us Mr. C. A. Williamson, chairman of the Electrical Section of the Association of American Railroads. Mr. Williamson.

C. A. Williamson: Mr. President and members of the AREA, it is a pleasure for me to bring you greetings from the AAR Electrical Section. Representing the Electrical Section, I wish you the best of success in this convention and in all your undertakings. I am sure they will be successful, because, as a member of the General Committee of the Engineering Division, I have been greatly impressed as I have reviewed the results of your extensive and valuable work.

I would like to take a moment to tell you that the Electrical Section is now a solid consolidation of what were previously two electrical sections, one representing the fixed properties and the other representing rolling stock. There are 17 actively working committees.

We offer you our full cooperation, and suggest that full advantage be taken of the benefits of close collaboration in all phases where our work is interrelated. We welcome an opportunity to be of service.

And now I wish to thank you for the invitation to be here with you this morning.

President Geyer: Thank you very much Mr. Williamson. We appreciate your being with us.

The first order of business of the annual meeting is consideration of the minutes of our last annual meeting. These minutes have been printed in Vol. 53 of the AREA Proceedings for 1952, a copy of which has been furnished to each member. Accordingly, unless I hear some objection, we will dispense with the reading of the minutes of the 1952 annual meeting.

(The minutes of the 1952 meeting were approved.)

It is now the duty of the president to report to you.

Address by President C. J. Geyer

Fellow members of the American Railway Engineering Association—ladies and guests:

I am honored today in reporting to you as the president of your great Association on this occasion of its 52nd Annual Convention.

It has been a great pleasure during the past year to work with your Board of Direction and other officers of your Association. I take this opportunity to acknowledge their diligent service and cooperative loyalty to your Association and to me. I thank each of them for this support.

Association Departments

You should also know about the job being performed by your office staff and research department. Secretary N. D. Howard and his staff at the Association offices, 59 East Van Buren St., are currently handling all the business of your Association coming under their jurisdiction, and this handling is of the highest quality.

Director of Engineering Research G. M. Magee and his staff of engineers at the Association research laboratory, 3140 South Federal St., are doing excellent work on the complicated problems you submit through your standing committees and Board of Direction.

You have seen the reports on some of these problems in our past publications, and I am sure you will find future reports of equally high quality. We have $364,100 appropriated for research in 1953. You may be assured this money will be spent to the greatest advantage, and that the results will add greatly to our engineering knowledge and return a substantial profit to our railroads.

On behalf of our entire Association, I thank the personnel of these two departments for their good work and support of the traditions of the engineer.

Progress of Association

Your Association has shown its usual progress during the past year. It is physically and financially sound. I will not report here the many details because they are included in the secretary's report which is a part of our program to follow.

Importance of Committees

The backbone of our Association is the twenty-two standing committees, and the special committees appointed for particular studies outside of assignments to the standing committees.

The value of the Association reports depends primarily upon the ability and diligence of our committee chairmen and committee members. Subjects for study originate from many sources. They are submitted to the Board of Direction for disposition. The Board then determines whether they are proper, timely, and merit consideration. If so, they are assigned to the committees handling pertinent matters. Here is the start of a report that may mean much or little to railroad engineering knowledge. It all depends on the committee workers.

Railroads and AREA

Our Association is unique from other railroad associations in that its recommended practices and standards are not facilities or methods affecting interline railroad operation. Their use is not mandatory on any railroad, nor will such use interfere with the free interchange of traffic. This fact makes it unnecessary for railroad management to control AREA activities as a corporate matter. The individual member is free to express and support his own ideas or those of other Association members.

Committee Work and Personnel

The committees are the groups upon whom we principally depend for the successful handling of the various assigned studies. These committees are composed of officers from the president to the youngest subordinate officers of railroads, allied industry, college professors and private engineering consultants, who are admitted to membership under our constitution. Can you conceive of a group better qualified to handle a railroad problem, particularly with a free rein to each member?

These are approximately 1000 Association members on committees. These men have knowledge and experience in the subjects assigned to their respective committees. They are practical men studying railroad construction and maintenance problems as individuals. They wisely provide alternates or a range in latitude, where possible, to permit the practical application for the varying conditions of all railroads.

There is an old "saw" that every problem has three sides—"Your side, my side, and the right side." Our committee's product is the solving of problems, therefore, a well balanced personnel should develop the "right side" in all our problems.

I suggest to you committee chairmen a review of your committee personnel with the objective of a well rounded committee of railroad officers, college professors, industry representatives, and consulting engineers. Get the outside point of view added to that of the expert in training and experience in handling the problem day after day. We have of the convention. This procedure covers the greater part of criticism that otherwise all of these people on our membership rolls, so get them distributed to the standing committees on an equitable basis.

In my opinion, your Association, under this system, has developed in the past, and will develop in the future, the finest standards, methods and practices that can be devised for railroad purposes in the engineering field.

Convention Floor Discussions

A guest attending our convention and not familiar with its proceedings may be surprised at the apparent lack of comment from floor by members to the reports and recommendations submitted and voted on by the Association members. Comment from the floor is desirable and encouraged, however, it is not strange that very little comment or criticism originates from the floor at the time a committee report is submitted in convention.

It must be understood that the reports and recommended action here submitted are not the ideas and work of a single individual. They express the thoughts and experience of many AREA members on committees. Each committee is composed of men skilled in the subject at hand and interested in that subject, else they would not be on the committee. Many meetings for discussion and exchange of correspondence have taken place before each report is finally agreed upon, and then it is published in our Bulletins to Association members for study and comment by correspondence in advance would come from the floor during convention proceedings.

Right here, however, is a good place to inject a word of warning to any complacent committee members and to non-members of committees. If we are to submit the very highest quality work of which we are capable, it is necessary that every member study the reports in which he has special knowledge and write the committee chairmen, or discuss from the convention floor, any point in the committee reports with which he does not agree or has an idea for improvement. Only in this way can we work as a team and develop our best work. I urge each member to so help the committees on their assigned subjects.

AREA Value to Railroads

Now I want to speak a word to top management of the railroads on the value to the railroad corporations of the AREA recommended practices. Many of you are not AREA members or familiar with the potential savings to your road if it uses the standards set forth as recommended practices in the AREA manual.

Earlier in this report, I pointed out that it was not mandatory on the part of any railroad to use AREA standards. Because of this fact, many railroads, for one reason or another, have not adopted these standards, at least in a great many respects.

I believe every railroad on the North American continent is represented in this Association by at least one officer. If top management is not familiar with AREA values to their railroad, I urge it to become familiar with these values through its officer member or members of this Association.

Manual Revision

An organization of any kind cannot stand still. It is either going forward or backing up. Our Association is wide awake and moving forward. Through our standing committees and our Board of Direction, we have a well organized plan for review of our constitution, our Manual of Recommended Practices, and our policies for Association conduct. These matters are kept current to keep our organization abreast with progress.

During the past year every committee has revised its material in our Manual of Recommended Practices, and during this convention we will have presented and will act upon revisions and additions thought to be necessary by our committees.

Our Manual has been overhauled from cover to cover. Taking advantage of all the new developments in railroad practices since the last complete revision about ten years ago, your committees have assembled a manual on railroad construction and maintenance that is unequaled by any other reference of its kind. It will go to the printer as soon after this convention as changes can be made to record the actions of this convention. It should be available for distribution this fall.

Vitality

And now what is the life blood that keeps any organization moving ever forward to greater and better achievements? It is the young person just crossing the threshold of business with the vigor and inquisitiveness of youth, mixing with the experience of an older generation, both working together, if wise, and thereby improving the knowledge of each succeeding generation.

Our Junior grade member is our source of energy. We have 261 members in that grade and the class has been steadily increasing. For the Association, I welcome you Juniors into our counsel and urge you to express freely your ideals and to ask questions. You will be the Association of tomorrow, and it will be a sore disappointment to your predecessors if you do not make it more useful than the Association of which we are so justly proud today.

Our next order of business is the report of our secretary, Neal D. Howard.

Secretary's Comment

Since we meet here today both as the American Railway Engineering Association and the Construction and Maintenance Section of the Engineering Division of the Association of American Railroads, I report to you as secretary of both groups. Incidentally, as so many of you well know, the relationship of these two groups is a most happy one. The AREA is not only preeminent in its own right, but, in my estimation, is doing an outstanding job as the Construction and Maintenance unit of the AAR. Mutual respect and cooperation have been complete, and the work goes on with the greatest harmony, to the advantage of both groups, to you men individually, to your separate railroads, and to the railroad industry as a whole. Together, you can and are doing many things which could not be done as well or as economically working independently.

If I might digress for a moment, I should like to pay my respects to the operating head of the AAR—Mr. J. H. Aydelott, vice president, Operations and Maintenance Department—for the splendid cooperation which he has always given to the AREA and your secretary; and to Mr. G. M. Magee and his staff for the fine way in which they work with our committees in research matters; and further, to the Signal and Electrical Sections, AAR, for the splendid relationship which we have with them as sister groups in the Engineering Division.

Conceivably, a year could come when your secretary would not be able to make a completely favorable report. It has happened in the past, under conditions beyond the control of either the Association or the secretary. But the past year was not one of those years.

Thanks to the continuing interest of you members, individually and working on committees, and to the diligent efforts of your officers, your Association is "doing all right." In many respects, as some Democrats tried to tell us not so long ago, "things was never so good." As President Geyer so well said in this address—"Our Association is wide awake and moving forward."

The detailed secretary's report appears in the March Year Book of the Association—Bulletin 508—which was mailed to members during the past week, and a copy of which I hold in my hand. I do not need to tell you that I'm not going to read it, but I would like to point out a few facts, particularly for the benefit of those of you who may not find time to read the report in full.

Contrary to the concern that existed in some quarters that the membership of the Association would fall off following the big membership drive in 1948, immediately preceding the Golden Anniversary Year of the Association, in 1949, when 852 new members were taken in—and who wasn't concerned—our membership has continued to grow each succeeding year, including the past year, when a total of 272 new memberships were added to the Association, including 66 Juniors. Of course, many members were removed from the rolls due to deaths, resignations and other causes, so that the net gain in membership was only 47, but the total membership as of February 1, 1953, stood at 3237—an all-time high.

Just this further word about memberships. It has been highly gratifying to see the interest taken by many higher officers among our members in encouraging the younger technical men on their staffs to join the Association and thus early in their experience gain the benefits to be derived through Association activity. On the other hand, it is a little disappointing to realize that there are still many qualified men on the railroads who are not availing themselves of the benefits of Association membership, and that a considerable number hold off joining up with us until they have attained years of seniority.

Herein lies further opportunities for the growth of the Association and the extension of its benefits.

Just a word about the work of our committees—and I mean work. This past year has been one of intensive activity if we ever had one. At present we have a total of 986 members serving in 1119 places on our 23 standing and special committees—an all-time record. Our committees held a total of 79 meetings in 1952, while considering some 200 assigned subjects. The extent of their work is reflected in the size of the Bulletins which you have been receiving in recent months, which, together, include some 1600 pages of reports—400 more than in the previous year, and more than 600 more than two years ago.

Even more significant is the volume of work which has been done by committees during the past year in reviewing and revising Manual material. The impact of this will be reflected continuously throughout this Annual Meeting, when you will be asked to pass upon recommendations affecting some 500 documents in our Manual. This has called for great effort on the part of your committees, and especially on the part of committee and subcommittee chairmen, looking to the complete reprinting of the Manual this year—and I take my hat off to them for what they have done.

We in the secretary's office are so enthusiastic about this work and the resulting improvement that will be reflected in the new Manual that it is difficult to refrain from talking at length about this new volume, but I shall, except again to congratulate your committees and to thank their members for the cooperation which they have given to the secretary's office in connection with every detail of this effort.

Mr. President, I have touched upon only a few of the things brought out in the secretary's report. Other features will, no doubt, be commented on by others. Besides, it's all recorded in the published report for those who are interested.

I trust that the membership will accept this report with a high degree of satisfaction to itself, and with full appreciation of the efforts of those many active, hard-working officers and members of the Association who have made such a favorable report possible. Thank you.

President Geyer: Thank you, Mr. Howard. I am sure that the condition of our books under your direction is very satisfactory to all of the members of the Association.

It is now time to receive our treasurer's report. Mr. A. B. Hillman, chief engineer of the Belt Railway of Chicago, and the Chicago & Western Indiana, was elected our treasurer last July to fill the position formerly held by Mr. J. D. Moffat, now retired, formerly chief engineer of the Western Region of the Pennsylvania Railroad. Mr. Hillman, will you please present your report at this time.

Treasurer's Report

Mr. President and members of the American Railway Engineering Association: Your treasurer's report appears in the March Bulletin—No. 508—and you may all study it at your leisure.

I will not, therefore, burden you at this time with statistics on assets and liabilities. Both the receipts and expenditures of the Association were substantially greater in 1952 than in 1951, but for reasons readily explainable the excess of receipts over disbursements was considerably smaller than in 1951, amounting to only $550.37.

That there was any excess of receipts over expenditures in 1952 in view of the amount expended account of Manual reprinting, and generally increased costs, gives the year a very favorable comparison with past years.

Your Finance committee and Secretary Howard and his staff are to be commended very highly for a job well done.

President Geyer: Thank you, Mr. Hillman.

As your treasurer reported, we didn't have much money left, but our usual surplus has been well spent on revision of our Manual—which is our bargain. You have heard quite a little bit about the Manual already, and you will hear a lot more about it through the rest of the meeting, because this has been one of our big jobs during the past year. But I would like to have Past President Loeffler—who is chairman of the Board committee on Manual—tell you briefly just what is being accomplished in this regard. Mr. Loeffler.

Reprinting of the AREA Manual

By H. S. Loeffler

Assistant Chief Engineer, Great Northern Railway

It has been my privilege during the past year to serve the Association as chairman of the Board Committee on Manual. The other members of the committee are:

A. N. Laird, chief engineer, Grand Trunk Western Railroad
R. J. Gammie, chief engineer, Texas & Pacific Railway, and
M. H. Dick, editor, Railway Track and Structures

Inasmuch as the time available for holding this annual meeting is quite closely scheduled, I shall take only a few minutes to present some pertinent data concerning the reprinting of the AREA Manual, and to inform you with respect to the present status of this project.

A substantial amount of detailed information on the reprinting of our Manual is contained in a series of four articles appearing in recent issues of the AREA News; namely, the issues for November and December 1952, and for January and March 1953. I recommend that you read these articles at your convenience.

It may be of interest to know that the AREA Manual first appeared in bound book form in 1905, and that it was reprinted in bound form in 1907, 1911, 1915, 1921 and 1929. The Manual first appeared in loose-leaf form in 1936, and subsequently has been maintained in such form. The Manual first appeared in its present two-volume loose-leaf form in 1945.

During 1951 the Board Committee on Manual, under the direction of Chairman Schwinn, together with the assistance of Secretary Howard and his office staff, developed a very comprehensive and substantially complete set of rules to govern the reprinting of the AREA Manual in an up-to-date, streamlined fashion to satisfy the current requirements of the railway engineering profession. During the latter part of 1951 and early in 1952 the chairmen of all AREA standing committees were advised of the Association's plans for the reprinting of the Manual and were furnished copies of the above mentioned rules.

In March 1952 the Association's Board of Direction adopted this most excellent set of rules, and subsequently authorized funds in the amount of $5000 to cover preliminary costs in the secretary's office to handle this project during 1952.

Within a short time after the close of the March 1952 annual meeting, arrangements were made for all of the AREA standing committees to review thoroughly the material in the Manual chapters under their supervision, and to submit their recommendations for the revision and rearrangement of such Manual material so as to conform with the recently adopted set of rules for the reprinting of the Manual.

The response and prompt action taken by the Association's committees has been most gratifying. The revised Manual material is included in the various committee reports to be submitted for consideration at the annual meeting now in progress. Secretary Howard and his staff have carefully edited this revised material to the extent that the last of it can be forwarded to the printer within about 30 days after the close of the present annual meeting.

The new Manual will be issued in two-volume loose-leaf form, similar to the present Manual. Each chapter will be provided with a table of contents applying to the particular chapter concerned. It is being produced entirely at the expense of the Association at a total cost of approximately $30,000. Members of the Association who presently hold copies of the Manual will be furnished, free of charge, a complete set of new Manual pages consisting of about 2300 pages. Such members then can remove and destroy their present Manual pages, and insert the new pages in their present Manual binders. Libraries which hold copies of the present Manual will be treated likewise.

Railway Companies and also non-member holders of the Manual (who have purchased Annual Supplements in recent years) will be offered complete sets of new Manual pages at approximately actual cost. which is expected to be quite reasonable. Complete new Manuals, with binders, will be offered to members and others at a scale of price yet to be determined.

It behooves me, as a representative of the Board of Direction of the American Railway Engineering Association, to thank each and every member of our Association who has assisted in this Manual reprinting project; to express appreciation to all of the committee chairmen and committee members for their cooperative efforts; and to congratulate Secretary Howard and his staff for the prompt, accurate and efficient service performed in the handling of this highly important project.

In accordance with the present schedule it is anticipated the new Manuals will be distributed during December of this year.

President Geyer: Thank you, Mr. Loeffler.

It is readily evident that under the direction of Mr. Loeffler and his able committee, the work of revision of the Manual has gone forward most effectively.

As you know, the American Railway Engineering Association acts as the Construction and Maintenance Section of the Association of American Railroads. We have been very fortunate in past years in having the head of the Operations and Maintenance Department of the Association of American Railroads—Vice President J. H. Aydelott, from Washington—bring us a message at our convention, and we are to have him with us again this year. He did miss last year's meeting, because of a threatened or actual strike on railroads, which required that he stay in Washington to keep in close touch with the situation, but fortunately, we do not have a repetition of that situation this year, and Mr. Aydelott is with us.

Previous to assuming his present highly responsible position with the Association of American Railroads, Mr. Aydelott served for a number of years as an operating officer on the Burlington Lines. As the result of that experience and, in more recent years, his contacts with all railroad problems, he always brings us an important and stimulating message.

He is so well known to railroad men throughout the country that he does not need any introduction, particularly to this audience. I am very happy to present to you this morning Mr. J. H. Aydelott, who will talk to us on "Planning Is Always in Season."

Planning Is Always in Season

By James H. Aydelott

Vice President, Operations and Maintenance Department, Association of American Railroads

You may infer from the title given this paper that I am a believer in long-range planning in behalf of the railroad industry—and that would be a correct assumption. I have endeavored to demonstrate this belief by giving wholehearted support to research activities from the time that I first occupied my present position with the Association of American Railroads. I feel we are now progressing research in behalf of the railroads in a manner which befits an industry whose future must be a concern of all our people. Without adequate planning some railroads may encounter serious difficulty if there is even something less than a full scale transition from a war-time to a peace-time economy. Our industry is particularly fortunate in that most of its members have a staff of engineers well qualified by experience to carry out long-range planning activities such as will point to lower costs of operation and maintenance and more acceptable service to its patrons. The traffic volume potential of the future may well be determined by the efficiency of railroad service and whether it will meet the needs of a nation which has grown all-powerful among the nations of the world within the last decade.

National Economy Undergoing Change

The elements which go to make up our national economy are undergoing constant change. War emergencies usually see the development of new techniques in production and manufacturing and, likewise, bring new products into existence which may contribute materially to the well-being of our people. Scarcities of material, such as feature a war emergency, necessitate the development of substitutes, many of which have found public favor and are retained in usage after the emergency is over. The diversification of industrial production is widespread and is constantly expanding. Some of our oldest industries which have produced or processed a single product for many years are now putting many different products upon the market, and by this diversification some have escaped serious financial difficulties. I mention these developments only because our own industry is severely handicapped in that it has only its service to sell, and its efforts to diversify by engaging in other forms of transportation as a common carrier have thus far been unsuccessful. As an added difficulty, the railroads are closely regulated by the Federal government and by the states, and may not without approval of those agencies make any major adjustment of their charges.

The railroads made a fairly creditable showing during 1952. This was not because they handled an unusual volume of traffic as compared to other post-war years, but rather because they handled it more economically and received revenues therefrom which bore a closer resemblance to those which are necessary to offset increased taxes and ever-rising costs of materials and labor. Much of the freight handled by the railroads in 1952, as in most of the post-war years, was of commodities which cannot properly be said to belong to a peace-time economy as we have heretofore used that term to distinguish it from a war-time economy. Certainly the nature of many of the commodities, and the average length of haul involved, were not in keeping with our pre-war or normal experience. The average length of haul which was fairly high in 1952 reflects the more distant origins of military machines, equipment and supplies moving to our fighting forces overseas, and of similar shipments which are going to fulfill commitments made to friendly nations in various parts of the world. The average length of haul of freight handled by the railroads has an important bearing on their revenues. As an example, the revenue tonnage originated in 1952 created 83½ billion more ton miles with an average haul of 426 miles than would have been created had the 1941 average haul of 368 miles prevailed. The freight revenue received would have been more than one billion dollars less with the shorter haul.

Your guess is as good as mine as to how long shipments of the kind referred to will feature railroad traffic here in the United States, and thus add materially to the revenues of the carriers as occurred in 1952.

It is generally accepted that it costs more to produce in the United States many of the materials and supplies which have been sent to friendly nations than if they were to produce them themselves. Now that their own economy has greatly improved, some of these nations seem to prefer to have their future aid from the United States in the form of dollars, supplemented by the services of our specialists who are needed to assist them in their rehabilitation programs and in the further development of their own natural resources.

Competition Growing

I am sure it is apparent to all of you that competition from other forms of transportation is growing more severe. In the years since the end of World War II industry has been transporting an ever-increasing tonnage of its own products upon the waterways and upon the public highways. Pipe lines carry the greater share of petroleum products. The practicability of moving coal through pipe lines is being investigated and will be tried out experimentally in the British Isles. The use of carrier belts for the movement overland of bulk commodities, such as coal and iron ore, is being advocated as means of reducing transportation costs. There is a growing amount of freight moving by air along with a greater volume of express and passenger traffic.

The lack of flexibility in the railroad plant, such as would permit rapid adjusting to meet the shifting pattern of manufacture and distribution which is taking place, makes the problem of the railroads in a competitive field a truly serious one, particularly if there is not to be a sustaining volume of freight moving in export. Observe what happened to grain prices when foreign demand eased off. Our productive capacity has been developed to an all-time high. In this respect the railroad plant has not lagged and is capable of producing more transportation today than ever before in its history. We still remain the only all-weather surface carrier. Except for indebtedness incurred in the purchase of cars and locomotives, the financial obligations of the railroads have been under consistent reduction during the past 10 years, as well as have the carrying charges on these obligations. Obviously, the tax burden of the railroads is badly in need of adjustment.

Planning For the Future

How then are we to plan for the future which has so many elements of uncertainty which only time will clarify?

The diesel locomotive is perhaps the greatest single influence toward economy and efficiency of operations that has ever been introduced in the railroad industry. Its almost continuous availability and its versatility have revolutionized our freight and passenger service, and it has permitted the retirement of many units of fixed property and decreased maintenance expenses all down the line. It has built our train-hour production in ton miles to astronomical figures.

In contrast to the performance of this modern locomotive is that of the average freight car. The railroads secure something less than 3 hr of line haul performance from their freight cars out of each 24. These units today cost around $6000 on the average, but many cost more than $10,000, and a few of specialized design a great deal more.

The solution of this problem lies with both operating and engineering departments.

Obviously, the railroads would not have to make such a heavy investment in freight car equipment as they are doing if a lesser number, more efficiently used, could meet the maximum demands of our shippers. I am sure that few of you would expend $25,000 in a home on the premise of living in it only 6 weeks of the year, yet that is theoretically the situation as regards the use of the freight car when it is moving only 3 hr out of the 24.

Much of the excess time used by cars at terminals stems from the inadequacy of many of the older industrial layouts. These industries were built before the days of the automobile and necessarily had to be located where they could be reached conveniently by the use of public transportation, which at that time was the streetcar. Expansion of these plants has been carried on through the years, and evidently without much thought being given as to whether or not the rail carrier could perform efficient switching service or do it economically. As a result, the switching costs of serving these industries is excessive and the layouts are such as to cause delay to cars moving in and out. Where industries are grouped together, as many of them are in these over-expanded layouts, delays and costs are pyramided.

Many of the railroad freight houses were located under similar conditions and are subject to the same physical disabilities as to the performance of rail service and utility of equipment as apply to industries in the same area. The diminishing volume of less than carload freight has made the decision as to what to do with these freight terminal facilities a very perplexing one. The freight tariffs of the railroads, however, are open to the receipt of less than carload freight in practically all towns and cities, and so long as this is the case, costs of operating them being what they are, the relocation of such facilities elsewhere perhaps on a smaller scale is being undertaken by quite a number of railroads. They consider this action as necessary if they are to improve the service and lower freight-handling costs through modernization which could not be justified in the old facilities.

Many Further Opportunities for Economies

It is assumed that those railroads which have not mechanized their maintenance of way work will ultimately do so. Each succeeding year sees some new machine produced that will take the place of man power in performing certain features of roadway maintenance. Experience leads to the belief that work so handled will provide a more substantial track structure and one which will have smoother riding qualities. This rapid development, together with the results of research which have improved design and the quality of materials purchased, will insure long-range economies.

The largest single item which goes to make up the operating expenses of the railroads is that connected with transportation, which covers a wide field of activity in addition to the out-of-pocket costs of operating road and yard service. Station expense, including line as well as terminal stations, goes to make up a sizeable proportion of the cost of conducting transportation. The expense of CTC installations replacing line operators or towermen can be more readily financed today from the savings because of the higher rates of pay in effect. A continuing arrangement for the proper blocking of trains permitted by the modern freight yard and the saving in time which is possible through the operation of these yards should influence the construction of such yards to call for the most careful planning on the part of the engineer, both as to the location and the type of layout which will best fit the traffic volume without delay or congestion. Most of the new yards of this character constructed in recent years have permitted the dismantling of a great many smaller yards which did not lend themselves to efficient operation and which proved to be unneeded with the operation of diesel power.

Whatever the engineer can do to enable his railroad to operate freight trains of greater tonnage at higher sustained speeds will, of course, be reflected favorably in the cost of conducting transportation.

The development of our modern system of highways and of the motor vehicles which operate on them has seen a diminishing of the traffic volume at many inland stations, which at one time were considered important. Some railroads have shortened the distance between terminals by the relocation of lines to avoid some circuity which existed on the old alinement. Opportunities for improving the grade line are present in these relocations, and if the subdivision is more than 100 miles in length a reduction in overall mileage will permit savings in train and engine service.

It is appreciated that except as to expenditures for rolling stock, improvements must be financed out of earnings, and these will depend upon the volume of traffic handled.

Possible Shift in Industrial Production

This is a dynamic nation, and changes from any pattern which we have been following in the business world may come upon us rather suddenly. Many of our natural resources have been drawn upon very heavily because of emergency conditions of the last decade and, if this trend is not changed, an intensive search for substitute materials or for different methods of processing may be a future development. The dispersal of industry in the interest of national security may make industrial railroads out of those which have heretofore not been of that character. Our larger cities are growing larger and the smaller towns smaller. In the past 10 years our farm population decreased by more than 5 million people. Streets and highways around our larger cities are blocked to the point of congestion by motor traffic and the parking problem is one of the most serious phases in these cities. The public interest may require a reversal of this trend of the population to the larger centers and cause industrial activity to be less concentrated in and around our heavily populated areas.

The railroad engineer in his planning activities should not be unaware of this possible shift in industrial production. Some of it has already taken place. As contrasted to the situation which existed two decades ago, there are very few sections of the United States which are at a disadvantage as compared to other sections which have heretofore dominated the industrial field. Decentralization of industry may not produce the longer hauls on raw and finished materials that we are enjoying today, but it might save the abandonment of a sizeable mileage of railway lines on which patronage under present competitive conditions has about reached the vanishing point. Certainly it would seem in the public interest that the industrial planning should recognize the advantage of locations already equipped with public schools, churches, utilities, etc., but which are being reduced in population by this constant trek of its people to the larger cities. Knowing the industrial departments of the railroads and their engineering staffs as I do, I am sure that every effort will be made by them to attract new industries, the transportation of whose products might be greatly needed in the future to replace traffic which may be lost when world-wide demand for the products of our industries, our farms and our mines has slackened.

As railroad men we would be out of character if we viewed the future of our properties other than optimistically. However, I am sure that none of us wishes to live in a fool's paradise; hence, we cannot ignore the fact that deflationary forces are already at work. I am quite sure in the circumstances that you will agree that an unusual amount of long-range planning is called for.

President Geyer: Thank you very much, Mr. Aydelott. You had a very fine message, as usual, for our Association. It will be published in full in our Proceedings, and I suggest that each member analyze it carefully and see how he can apply it to improve conditions on his own railroad.

(At this point the usual photograph was taken of the convention in session)

President Geyer: As you well know, our Association—working through the research staff of the AAR—is engaged in a large program of physical research. You will hear much with respect to the individual research projects in the reports of the various committees during the next 2½ days, but we have chosen to give you a general picture of this extensive program at this time. Therefore, I want to present Mr. G. M. Magee, director of engineering research, AAR, who will tell you a little something about the work which he is conducting.

Research Review

By G. M. Magee

Director of Engineering Research, AAR

It is my purpose in this review to give you some idea of the newer developments in our various fields of research during the past year. Many of the projects necessarily must be continued for several years before they can be concluded. All of the projects are reported in detail in the research reports of that committee for which the research staff conducted the project, and I will not attempt to give any details or results in this review.

During the past year decision was made to construct a new Mechanical Research Laboratory north of the Central Research Laboratory. Although this new facility will be used entirely for mechanical research, the work will be so closely coordinated with our own activities that I feel you will be interested in knowing of this development.

The new building will be located at the north end of the one-half block which we have under lease from Illinois Institute of Technology. The building will be 72 ft wide by 192 ft long, and of similar construction to our Central Research Laboratory building. A track connecting into the trackage provided for our existing laboratory will go through the middle section of the new building for most of its length. The new building will be used primarily for certification tests of those units which must have AAR approval before they may be purchased for use on freight cars in interchange service. The draft gear drop test machine will be moved from Purdue University and placed in this building, together with other types of certification test equipment. Of particular interest is the installation of complete facilities for making tests in the laboratory of freight car journal bearings with conditions simulated for speeds of 100 mph, up to full journal loading, with a possible temperature range of — 60 deg F to + 130 deg F. Provision will also be made for research work on diesel fuels and lubricating oils. The construction of this new building will make it possible to move some of the Mechanical Division testing equipment from the basement of our present laboratory, which is already over crowded, and this will provide additional and needed room for Engineering Division research activities.

Research work on rail continued to be one of our most important activities during the past year. Of particular interest is the possibility of increasing our standard rail length from 39 ft to 78 ft. There are many problems to be confronted in mill production, principally in connection with the cooling and finishing of the rail. In order to obtain actual data on the advantages and practicability of longer rail in track, two service installations were started, one on the Chicago & North Western with 115 RE rail, and one on the Pennsylvania with 133 RE rail. In addition, tests were made on the C&NW to determine the added impact effect applied on joint ties because of the rail batter and joint gap, and to determine how much of this could be reduced if the joint were eliminated by the use of 78-ft rail. A special test train was used for these tests consisting of a diesel locomotive with one light, one medium and one heavily loaded car. Results were obtained with speeds up to 90 mph in these tests.

Shelly rail continues to be one of the most important types of rail failures, and during the year a new line of investigation on this subject was started by contractural arrangement with Prof. M. M. Frocht at Illinois Institute of Technology. Professor Frocht is one of the outstanding photoelasticians in the world, and is one of the very few, if not the only one, able to determine internal shearing stresses and principal stresses by means of three-dimensional photo-elastic models. He has prepared duplicate models of a segment of a car wheel bearing on the gage corner of the rail head. These models have been loaded in a special oven and the stress "frozen in." The models were then cut in thin sections, one transversely and one longitudinally. Photoelastic patterns are then determined for each slice, and by a very complicated mathematical procedure internal shearing stresses and principal stresses are computed. It is hoped that the knowledge from this work will give us an understanding of the internal stresses that will help us in working out a solution for rail shelling.

Another type of rail failure which is of great importance is the development of bolt hole cracks and rail end fillet cracks within joint bar limits. In fact, this type of failure, together with shelly rail failures, comprises about two-thirds of the total failures in control-cooled rail. A Sonntag fatigue testing machine was added to our laboratory equipment during the year, and tests are now being rapidly progressed with this machine to evaluate the effect of improperly drilled bolt holes on the fatigue strength, and also to evaluate various beneficial measures which may be used, such as chamfering or work-hardening the edge of the bolt hole.

On our track research the study of tie plates and hold-down fastenings to reduce tie wear is one of our most important projects. Two rolling-load machines have been installed in the basement of the laboratory and these have been in continuous operation for several months. This type of test is very slow. It requires almost three months to test one type of specimen. We are trying in these accelerated tests to learn something about the effectiveness of tie plates in preventing tie wear. This accelerated test will be helpful in cutting down the long period required to make these evaluations in service tests. Machine shop equipment has been added in the laboratory to provide the necessary facilities for servicing the various testing machines, preparing specimens, etc.

During the year two new manganese frog casting designs were tested in the McCook crossing. This crossing of the Santa Fe and Baltimore & Ohio Chicago Terminal is used as a proving ground for studying manganese crossing designs, and it is admirably suited for this purpose because of its heavy traffic and its proximity to the laboratory. One of these new designs comprised an interesting new idea in crossing construction in that the flangeways were made quite deep, with the thought of providing flexibility so that the flexural action of the casting under trains would not produce high bending stresses in the steel. Stress measurements were made with our electrical stress measuring equipment at all critical areas in both castings, and then the two types of castings were left for service observations to determine the length of service period before flangeway cracks developed.

We completed last year all of the tests to determine the tilting characteristics of passenger cars on curved track. The long travel springs used in modern designs of passenger cars have quite different tilting characteristics than the stiff type springs formerly used, and both running tests and static lean tests have been made on various modern designs of passenger cars on several different railways. This information will be used by the Track committee in deciding upon the permissible speed on curved track for modern type equipment, and also by the Committee on Clearances to determine the allowance that must be made to provide for car tilt.

Research work on bridges has comprised approximately one-third of our research activities. Of particular interest during the year was the completion of the report on the Santa Fe Topock Bridge. In this bridge, base strain gage readings on various members were established before the bridge was erected so the dead load stresses could be determined. Special consideration was given to determining the secondary stresses developed by rotation at the different joints. Live load stresses were then determined with electrical strain gage equipment. A test was also made on a new type of concrete filled steel pile trestle on the Nickel Plate Road. The use of steel piles with concrete caps in place of concrete piers offers substantial construction economies, and this test was made to verify the design calculations for this type of construction.

Tests were completed in cooperation with the Chesapeake & Ohio laboratory to determine the breaking strength of reinforced concrete culvert pipe manufactured in conformity with the new specifications developed by the Masonry committee. In these tests the pipe varied from 24 ft to 84 in. in diameter and was loaded until failure occurred—the stresses being measured both in the concrete and in the reinforcing steel during loading.

The use of high-strength bolts in lieu of rivets is a new development in structural work which offers promise of substantial economies. In addition to laboratory tests carried out in cooperation with the Research Council on Riveted and Bolted Structural Joints, our research staff has arranged for the installation of high-strength bolts for service observation on 15 different bridges located all over the United States in order to secure the extreme limits of temperature change. These installations include 1315 bolts, and are observed periodically to determine their performance.

Because of the large annual loss from timber trestle fires, work was started during the year on an investigation of fire-retardant paints. The Santa Fe Railway was working on this same subject, and as a part of its work had constructed two typical trestle bents supporting a treated timber span, at Albuquerque, N. M. This span was coated with a fire-retardant coating and was then subjected to the intense heat of burning tumble weeds. The Santa Fe very generously permitted our research staff to place thermocouples at various locations on the span and to record on an oscillograph the intensity and duration of temperatures which were developed from the tumble weed fire. From this data an ignition test was developed in the laboratory which subjects specimens to the same intensity and duration of temperatures. This ignition test is being used in conjunction with a Weather-o-meter to evaluate the effectiveness of various types of fire-retardant coatings that may be used.

Another new addition to our laboratory equipment during last year was a ballast oscillator for making accelerated loading tests to determine ballast characteristics. With this equipment tests are being made to determine the stability and durability of various types and gradations of ballast. By means of rotating unbalanced weights, a repeated load of 28,000 lb is applied to the test panel at a rate of 8 ½ rps for a period of 140 hr, which is considered to be equivalent to 3 years of heavy rail traffic.

In our research work on concrete our staff has participated with the Portland Cement Association in conducting concrete schools on various railways interested in having such schools for the purpose of educating their employees in how to make good concrete. Because of the vast amount of research being conducted by PCA, the Bureau of Standards, the Bureau of Reclamation, the Army Engineers and others, it is not our purpose to undertake any fundamental research work on cement and concrete, but rather to keep abreast of research developments and make this information available to Member Roads. These concrete schools offer an excellent means of getting latest knowledge to the man on the job. During 1952 20 schools were conducted on 12 different railroads, with a total attendance of 760. In addition, inspection has been made during the past year of several structures which have showed signs of distress.

As previously stated, the foregoing does not include all of our research projects nor the details or results for any of them. This may be found in the various committee reports. In closing, I would like to say that I think the addition of the new Mechanical Research Laboratory represents another forward step in our development, and I hope that in the near future we may see still a third step, with an Engineering Research Laboratory added in which we can further augment our laboratory facilities for making accelerated tests in the laboratory to compare the effectiveness of designs and materials more quickly and more accurately than can be done in service test installations, valuable as these installations are.

President Geyer: Thank you, Mr. Magee.

Mr. Magee has told you, very briefly, of some of the things that are being undertaken and carried to completion in our research department. That department has been growing very rapidly in the last few years and continues to produce highly effective results for our various committees.

Thank you very much, Mr. Magee, for your splendid report.

(At this point announcement was made concerning the various social functions of the convention.)

President Geyer: This completes the opening activities of our meeting. Thank you all for your attention. We especially thank our past presidents, the directors, and the visiting officers of other organizations, for their presence here on the platform. They are now excused, and we will proceed with our regular business session.

We have a heavy program this year, and in order to conserve time, it is essential that we be prompt in our attendance, and that we confine our remarks to the subjects under discussion. The privilege of the floor is extended to all members of the Association and to all interested visitors and guests. We have microphones placed in the aisles, and any speaker from the floor is urged to go to these microphones and to state his name and affiliation; or he is invited to come up here to the platform, if he so desires.

Discussion on Yards and Terminals

(For report, see pp. 501 522.)

President Geyer: Will the Committee on Yards and Terminals please come to the platform? Mr. J. E. Hoving is chairman of this committee, but since he was tied up with other work and could not be with us at this time, we have arranged for the report to be presented by the Vice Chairman J. N. Todd, superintendent of scales and work equipment of the Southern Railway System.

Mr. Todd, will you please present your report?

(President C. J. Geyer presiding.)

Chairman J. N. Todd (Southern Railway): Mr. President, the report of Committee 14 is published in Bulletin 504. We are making full report on four of our nine assignments. Work on the other assigned subjects is in progress, and we will have reports on them in due time.

At this time I regret to report the death of two members of our committee. Both of them have been noted in the AREA News for March, but it seems appropriate that further mention should be made at this time.

One was Harry H. Harsh, engineer maintenance of way of the Baltimore & Ohio Railroad at Pittsburgh, Pa., who died October 29, 1952. He was a Life Member.

The other was H. O. Hem, retired consulting engineer, Toledo Scale Company, who died November 11, 1952, at the age of 89 years Mr. Hem was a valued member of our committee, and a member of some distinction. He was a Doctor of Science from Toledo University, holder of a Franklin Institute Medal, life member of all principal engineering societies, and a member of the National Advisory Committee on Aeronautics.

We will now proceed with the reports of our subcommittees.

The first is Assignment 1—Revision of Manual. For those of you who are following the report in the Bulletin, there are two minor revisions in the text as published, and our subcommittee chairman will call your attention to them. The report will be presented by F. E. Austerman, assistant chief engineer, Chicago Union Station Company.

Assignment 1—Revision of Manual, was presented by Subcommittee Chairman F. E. Austerman (Chicago Union Station Company).

Mr. Austerman: Report on Assignment 1—Revision of Manual, will be found in Bulletin 504, pages 502 to 511, incl.

From the Manuals of 1914, 1921, 1929, and the loose-leaf Manual of the 1930's, your Yards and Terminals committee submits the following recommendations to prepare for the best Manual of them all.

If I may, I would like to thank the entire committee, and especially committee members Lyford, Mottier, Biermann, Hastings, Hedley, Giles, Foreman and Todd for their untiring work of reviewing, rearranging and revising these sections. On page 509, we recommend the following changes in your Bulletin, last paragraph of Art. 3. With Retarders—General beginning with line 13: "Where hot oil facilities and inspection pits are to be installed, they should be located at a distance in advance of the crest of the hump sufficient to permit pulling the pin for the longest cut without interference." In the first line of the second last paragraph on the same page, the word "when" should be inserted between "scale" and "installed."

I would like to call attention to Art. 252, par. (h) 4 on page 14–18.02, which has been revised to read: "Low-pressure air connections for cleaning should be spaced the same as cold water hydrants. For testing air brakes, high-pressure air connection should be provided through a double connection at the center of the track, or through a single connection at each end of each track" also, add a new section (r), page 14–18.05: "During a modernization program, consideration should be given to possibilities of overloading the existing electric, water and steam facilities. Provisions should be made to increase the capacity of these facilities to a safe level."

Under Freight Terminals, we recommend rearrangement of the sections for smoother context, and the substitute of a new Par. (b), page 14–25, reading: "The width of transfer platform should be sufficient to accommodate (a) the parking or trucking equipment at track sides, and (b) two lanes for movement of the type of equipment used in moving freight from car to car." Art. 342, page 14–25, revised to read: "(e) The factors of design for a freight house, such as tailboard frontage, floor area, width of house, platform, bridges and roadways; and in the case of the two-level house, the capacity of the elevators should be so correlated that no one factor will limit the capacity of the house."

After considerable discussion we recommend that a new paragraph be added to the section on Two-Level Freight Houses on page 14–26 to recognize the exception to present trends in one-story freight houses to read: "(a) Conditions under which a two-level freight house are required are exceptional rather than ordinary. Under certain physical and economical conditions, such as separate track and highway levels, it may provide the only solution."

The section on Locomotive Terminals, which was completely rewritten in 1951, and which covers all the latest developments, we submit for reapproval with the minor changes shown on page 503 of Bulletin 504.

Under the leadership of our new vice chairman, Fred Hess, with a small subcommittee, including Bill Giles, Bill Rudd and Ned Brown. Secs. 31, 32 and 33 on Freight Terminals have been completely rewritten as shown in Exhibit A on pages 503 to 511, incl. Secs. 31, 32 and 321 have had minor changes, some deletions, and the relocation of some of the material.

Sec. 322, Hump Yards, General—was rewritten in part and some material was added.

Sec. 323, Hump Yards with Car Retarders—was rewritten with several paragraphs deleted.

Sec. 324, Hump Yards with Retarders, General—was revised and additional material added to bring this section up to date.

Sec. 325, Hump Yards, Design of Gradients—was completely rewritten to include design data previously given in older Proceedings. We have had numerous complaints from younger members that too much reference to the older Proceedings made it difficult to obtain the necessary information easily.

Sec. 33, Receiving, Classification, Departure and Repair Yards, and Miscellaneous Tracks—was revised by eliminating parts, re-wording, adding material, and placing the entire group under "Yards, General."

The entire committee extends its thanks to Mr. Hess and his subcommittee for the excellent report they prepared.

No change is recommended in the specification for scales, except rearrangement of the sections.

Your committee recommends the adoption of all of the recommendations presented under Assignment 1, pages 502 to 511, incl., except for the two corrections, previously noted on page 509—and I so move.

I thank all those on the committee who performed the difficult task of reviewing, revising and rewriting Chapter 14 for the new Manual.

(The motion was regularly seconded, was put to a vote, and carried.)

Assignment 2—Classification Yards, Collaborating with Committee 16.

Vice Chairman Todd: One of our assignments on which we are not ready to report this year is Classification Yards, Collaborating with Committee 16. This important subject will require a comprehensive report; one has already been written, but is now being revised. Many yards are being rebuilt and modernized because of the rapidly changing requirements brought about by dieselization and technological improvements in communication. While we have no report, we wish to give you a forecast as to what this report will be like when it is ready, and such a summary will be given you now by the chairman of our subcommittee, F. A. Hess, assistant chief engineer, New York Central System.

F. A. Hess (New York Central): It is planned to have a report on this subject for the March 1954 convention. However, we felt it desirable to present a brief outline of the report which is now in a tentative form, and to mention its more important features.

We wish to emphasize that there is no ideal arrangement of a receiving, classification and departure yard (such as an end-to-end layout providing straight-line movement from one yard to the other) to cover all conditions.

The objective is to provide an arrangement whereby the functions of receiving, humping, assembling and dispatching can be performed with minimum delay to the movement of traffic and with the most efficient use of facilities and personnel. Auxiliary facilities must be considered to arrive at a final decision.

Eight basic arrangements are being considered, which are:

1. End-to-end arrangement of receiving, classification and departure yards for movement in one direction, with a separate and similar arrangement for movement in the opposite direction.

2. End-to-end arrangement of receiving, classification and departure yards to handle traffic coming from both directions; entrance to the receiving yard to be from both ends and departure from the departure yard to be from both ends.

3. End-to-end arrangement of receiving, classification and departure yards with loop tracks at the entering ends of the receiving yard and at the leaving end of the departure yard, permitting all cars to enter at a single point and to depart at a single point.

4. End-to-end arrangement of the receiving and classification yards with the departure yard adjacent to the classification yard to handle traffic from both directions; lead of the departure yard at one end more or less adjoining the leaving lead of the classification yard, and the other end of the departure yard extending back adjacent to the receiving yard. Tail tracks are provided to serve both the classification yard and the departure yard. Track connections are provided at both ends of the receiving yard for receipt of trains; trains to depart from either end of the departure yard.

5. End-to-end arrangement of receiving and classification yards, with the departure yard made a part of the classification yard. A single hump is provided. This layout is designed to handle both directions of traffic.

6. End-to-end arrangement of classification and departure yards, with a receiving yard located on each side of the classification yard and with tail tracks serving the receiving yard so as to permit the pulling back of cars and humping into the classification yard. Both directions of traffic to be handled in this arrangement.

7. The classification and departure tracks are incorporated in one yard with a receiving yard located on each side of this combined yard, and tail tracks are provided to permit the pulling back of the trains in the receiving yard and humping them over a single hump into the combined classification and departure yard. This is similar to a flat yard arrangement with hump operation. Traffic from all directions is to be handled in this layout.

8. A combined receiving and departure yard located adjacent to the classification yard, with a series of crossovers dividing the combined receiving and departure yard, so that the cars can be separated in their proper location, and a tail track provided permitting movement from the receiving end of the combined yard to the tail track, and humping into the classification yard.

The above-mentioned yard arrangements are in actual use or are under construction and represent the basic arrangements of hump yards, each one having its particular advantages and disadvantages, which will be outlined in the report.

Each one of the above-mentioned layouts will be shown in plan and described. We will then cover the following items:

1. Space required.
2. Engine requirements.
3. Receiving operations.
4. Humping operations.
5. Assembling operations.
6. Departure operations.
7. Intereference.
8. Application of the layout.

President Geyer: Thank you, Mr. Hess. Your report will be received as information.

Vice Chairman Todd: The next report is on Assignment 5—Study of Handling of LCL Freight by Conveyors. This report will be presented in summary form by the chairman of the subcommittee, C. E. Merriman, construction engineer, Santa Fe Railway. In addition to the printed report, he will give you a brief description of the very modern freight house recently put into service by his system.

Assignment 5—Study of the Handling of LCL Freight by Conveyors, was presented by Subcommittee Chairman C. E. Merriman (Santa Fe).

Mr. Merriman first summarized the report of the Committee, as presented on pages 511–514, incl., and then continued as follows:

Mr. Merriman: A new freight house was completed by the Santa Fe Railway here in Chicago a few months ago, and as it was designed for using conveyors, your committee feels that a brief description of the facility and its operation would be appropriate at this time.

The layout is 1353 ft long with 3 platforms in the shape of the letter E. The center platform is 30 ft wide for its entire length. The outer platforms are 75 ft wide where highway trucks load and unload, but narrow down beyond that point. Three stub-end tracks, each having a capacity of 27 cars, are located in each bay between the center and the outer platforms. The platforms ramp down on a 6 percent gradient to top of rail level at the open ends. At the closed end, adjacent to the cross platform, is the main office with the usual rooms for warm and cold storage, cooperage, lunch and locker rooms, toilets, etc. Small dock offices are located about mid-length on each of the outer platforms and are connected with the main office by pneumatic tubes for the handling of freight bills.

A towing conveyor of the floor type was selected for this house. It consists of a continuously moving chain housed in a chase of steel channels built into the concrete floor, leaving a slot 1 in wide. The chain has lugs or pusher dogs spaced at intervals of 15 ft, which engage a perpendicular towing pin attached to the head end of each truck. The pin is of the floating type when lowered into the slot, but can be locked in a raised position to clear the floor when a truck is removed from the line.

Two separate conveyor systems are provided. One 2389 ft long, used for inbound freight, makes a complete circuit on one of the outer platforms. The second one is 2706 ft long and is used for outbound business. It traverses the center and the other outer platform. Traveling counter-clockwise, this system descends the ramp at the open end of the center platform, turns left, crosses three tracks at grade, turns left again, ascends a ramp to the outer platform, and completes the circuit at the closed end of the house. In this way no bridges at platform level are necessary, nor is it necessary to disconnect the conveyor chain each time the house is switched. Special construction provides for the conveyor slot through the track rails.

Since the conveyor is the floor type, there are no overhead obstructions, and with the chain and drive machinery below the floor, the operation is quiet. The tow pin slot is so designed that any type of equipment can be operated over it. Brush-like fittings attached to the chain keep the chase clean by sweeping dirt or foreign particles to clean-out pits placed at intervals along the line.

The conveyor drives are of the variable-speed type. Any number of speeds, within practical limits, can be obtained by making a simple adjustment.

The entire area, including the ramps and track crossings, is roofed over.

Modern communication facilities have been provided. These include three talk-back speaker systems covering specific areas, a paging system covering the entire facility, an intercom system between the three offices, a special talk-back set-up serving a centralized checking system, two pneumatic tube systems previously mentioned, and dial telephones.

I will not go into the facilities provided for centralized checking, but those concerned with such operations might find much of interest in the new installation.

President Geyer: Thank you, Mr. Merriman. Your report will be received as information.

Assignment 7—Recent Trends in Layout and Location of Freight Houses, was presented by Subcommittee Chairman W. O. Boessneck (Erie Railroad).

Mr. Boessneck: The report of the subcommittee appears in Bulletin 504 on pages 514 to 520, incl. It is a final report submitted as information.

The nature of the assignment required the collection of information primarily through a questionnaire.

In order to keep the report as brief as possible a careful analysis was made of the replies received from the railroads and the report in the bulletin covers the important features of the subject in condensed form on pages 514 to 516, incl.

At the bottom of page 516 is a summary prepared from the preceding data, which lists the general trend in modern freight house layouts under 12 general items.

On page 517 are listed 5 questions that were asked in the questionnaire regarding conditions or features that were considered in determining the location of the new freight houses. The number of affirmative and negative replies to these questions are also shown after each question.

The report concludes with an interesting detailed description of a recently completed modern freight house which embodies practically all of the features indicated by the recent trends developed by the report.

President Geyer: Thank you, Mr. Boessneck. The report will be received as information.

Assignment 8—Stores Facilities, Including Reclamation, Scrap and Material Yards, was presented by J. E. Griffith (Southern), in the absence of Subcommittee Chairman D. C. Hastings, (Richmond, Fredericksburg & Potomac Railroad).

Mr. Griffith: In the rear of the AREA Manual chapter on Locomotive Terminals prior to its revision to include diesel electric locomotive terminal facilities, there appeared a short section on stores facilities and scrap yards. When the chapter on Locomotive Terminals was revised to include facilities for diesel electric locomotives, it was decided by your committee to omit the portion of this chapter dealing with stores facilities and scrap yards. Since these items are often most vital in a locomotive terminal and are also a vital part of the organization of any railroad, the committee decided that it was necessary to write a separate report covering such facilities.

The Purchases and Stores Division of the AAR in its Standard Reclamation Manual and other manuals covering their activities thoroughly covers practically every detail concerning stores facilities, reclamation, scrap and other material yards. Through the cooperation of this division and of various railroads, questionnaires were circulated and a report written covering such facilities in a very general manner. This report may be found on page 520 of Bulletin 504, and is submitted as information, with the idea in mind that it should be presented later as Manual material to replace that section of the Manual that was omitted, as previously indicated.

President Geyer: Thank you, Mr. Griffith. Your report will be so received.

Chairman Todd: Mr. President, that concludes the report of Committee 14—Yards and Terminals, at this time.

President Geyer: Thank you very much, Mr. Todd. Your committee is excused, with the thanks of the Association. You have done some wonderful work, and we welcome you as the new chairman of this committee.

Discussion on Economics of Railway Location and Operation

(For report, see pp. 415–426.)

(President C. J. Geyer presiding.)

President Geyer: The chairman of Committee 16, J. W. Barriger, until recently president of the Chicago, Indianapolis & Louisville Railroad, and now the executive vice president of the New York, New Haven & Hartford Railroad, is unable to be here this morning, so H. B. Christianson, Jr., vice chairman of the committee, will present the report.

Vice Chairman Christianson (Santa Fe): Mr. President and members of the AREA, our distinguished chairman, John W. Barriger, vice president of the New Haven, left Chicago last night to meet with the Transportation Council, with the Honorable Sinclair Weeks, Secretary of Commerce.

Together with Mr. Barriger, our committee is enjoying its work, we are at full strength, and we face our next assignments with confidence.

During 1952 Committee 16 worked on five assignments. We submit a progress report on Revision of Manual, and two other final reports. Another report is complete, but its presentation is being deferred because it is not yet published.

First, then, Assignment 1, by A. L. Sams of the Illinois Central.

Assignment 1—Revision of Manual, was presented by Subcommittee Chairman A. L. Sams (Illinois Central).

Mr. Sams: Mr. President, fellow members and guests: the report on Assignment 1 is published in Bulletin 504, pages 416 to 419, incl. In general, the material now appearing in Chapter 16 is submitted for reapproval with some minor changes in the language. Your attention is directed to a typographical error in the list of references appearing at the bottom of page 416. In the fifth reference, covering AAR Signal Section Proceedings, Vol. XXXVI, the year should read 1938 instead of 1937.

The committee recommends, and I move, that the material now appearing in Chapter 16 be reapproved with the suggested changes.

(The motion was regularly seconded, was put to a vote, and carried.)

Mr. Sams: Last year the Board Committee on Outline of Work requested Committee 16 to review the present Manual chapter on Complete Roadway and Track Structure, Collaborating with Committees 1, 3, 4 and 5. Mr. H. A. Aalberg, chief engineer, Burlington Lines, was appointed chairman of a special subcommittee to handle this assignment. In Mr. Aalberg's absence I will report for this special subcommittee.

This material consists of two parts. First is the Traffic Classification of Railway Main Tracks, now appearing on page CRTS–1, and the Schedule of Classes of Complete Roadway and Track Structure on page CRTS–2. It is recommended that the material on page CRTS–1 be reapproved without change, and incorporated in Chapter 16, and I so move.

(The motion was regularly seconded, was put to a vote, and carried.)

Mr. Sams: The material on page CRTS–2 consists of a schedule which makes reference to Manual pages, and will become out of date with the reprinting of the revised Manual in 1953. Therefore, it is recommended—and I move—that this document be withdrawn from the Manual, looking to its restoration at a later date when the corrected Manual page numbers can be inserted.

(The motion was regularly seconded, was put to a vote, and carried.)

That concludes the report on Assignment 1.

President Geyer: Thank you, Mr. Sams. Proceed, Mr. Christianson.

Vice Chairman Christianson: Three tasks remain with us under Revision of Manual. The subjects are: Cost of curvature, the Yager method, and life of rail. Gentlemen, we must take one of two paths. Either we withhold important formulas and indexes, for fear they are not completely correct, or we publish them and recognize their limitations. Many problems defy precise solutions. When compromise creates a formula, only good judgment should apply it. I appeal to our collaborators to help us complete these three tasks.

On Assignment 2, C. W. Sooby, our very capable secretary, will report for D. E. Brunn, subcommittee chairman.

Assignment 2—Methods for Increasing the Use of Existing Railway Facilities—Train Communication, was presented by C. W. Sooby (Union Switch & Signal Division, Westinghouse Air Brake Company) in the absence of Subcommittee Chairman D. E. Brunn (Toledo, Peoria & Western Railroad).

Mr. Sooby: The report on Assignment 2 in this case has to do with train communication, and appears in Bulletin 504, for November 1952, beginning on page 419. This report was prepared under the guidance of Subcommittee Chairman Brunn, who is unable to be with us today because of railroad business priority.

The report is submitted as information and briefly summarizes the benefits which are being obtained from space radio and inductive train communication in railroad train operations.

While communication between ends of trains and between trains and wayside stations is a comparatively new venture, such medium of transmitting information pertaining to better and safer movement has gained wide recognition and has been successfully adopted by many roads. The report specifically mentions many of the benefits thereby obtained for train operation.

Since the Communications Section of the AAR is specifically delegated the work of determining the economic benefits of various communication mediums, your committee has confined itself to citing examples of improved performance resulting from train communication installations, and to giving references to reports made by the Communications Section for such use as the individual members may wish to make of the information.

President Geyer: Thank you very much Mr. Sooby. The report will be received as information.

Assignment 3—Methods and Formulas for the Solution of Special Problems Relating to Economics of Railway Operation, was presented by Subcommittee Chairman R. L. Milner (Chesapeake & Ohio).

Mr. Milner: The problem for study is titled "Train Hour Cost and Cost of Starting and Stopping Trains, Collaborating with AAR Signal Section".

This report may be found in Bulletin 504, November 1952, pages 421–426. This is a final report, submitted as information on the current assignment.

As you can see, the present assignment covers two related but distinct subjects: Train hour cost and cost of stopping and starting trains.

Train hour cost was first studied and a report submitted in 1929, Vol. 30, wherein it was stated that "the cost per train hour, excluding wages, will vary in direct proportion to the motive power of the locomotive used and the number of locomotives per train, or, more precisely, the ratio of locomotive miles to train miles".

The train hour cost was made up of wages of trainmen and enginemen; fuel and water and lubricants and other supplies for locomotives; enginehouse expenses; train supplies and expenses; locomotive repairs; locomotive depreciation and retirement; and interest on locomotive investment.

The dangers inherent to the absolute use of a train hour cost made up in this matter were early recognized. Your committee in restudying the subject viewed the matter from the standpoint of the value of the particular train hour saved. This was due to a number of well recognized principles. For instance, crew wages vary with class of service, distances, time and with power; fuel and water expense varies with power, speed, train stops, slow orders, distance, and unit cost; lubricants and supplies vary more with number of dispatchments than with train hours or train miles; and locomotive repairs will vary with locomotive mileage, class of power and type of service. The committee's report includes many other similar observations.

It was quite obvious, therefore, that the value of a train hour saved depended very greatly upon what kind of a train hour it was.

If it was due to improvements that would effect running time, then the principal charges effected would probably be restricted to relatively few accounts, except perhaps, if the savings were due to improved power.

If the train hour saved was the result of improvements or changes reducing standing delays, then the train hour saved would include a greater number of accounts, such as fuel and water, and in some cases other accounts would be a more important consideration.

If the train hour saved was the result of improvements or changes affecting the number of trains, by making it possible to increase tonnage per train, then a very wide group of accounts would be included in the value of a train hour.

This is illustrated by the table prepared by the committee showing accounts to be considered under a representative group of possible improvements affecting train hours.

A question has been raised as to the inclusion of roller bearing cars as a means of saving train hours. The committee did not intend to convey the impression that the replacement of friction bearing cars by roller bearing cars would automatically produce net benefits. The report points out that all factors must be considered.

The committee did consider the effect upon ease of acceleration to running speeds in cold weather upon solid trains equipped with roller bearings compared with friction bearings; also, the effect this might have upon tonnage of time-freight trains. No positive conclusions were drawn.

Another consideration was the thought that any type of equipment which suggested the possibility of reducing hot boxes and burned-off journals, thereby resulting in improved performance, a reduction in the number of train accidents, and fewer loss and damage claims incident thereto, with consequent improvement in public relations, was worthy of note in this report.

The second part of the assignment dealt with the cost of stopping and starting trains. The Signal Section, collaborating in this study, concluded a very elaborate study involving many thousands of calculations covering various operating conditions. Your committee examined these and concurred in the results. This report is submitted as information.

President Geyer: Thank you, Mr. Milner. The report will be so received.

Vice Chairman Christianson: Mr. Aydelott suggested this morning that perhaps our most difficult assignment is to analyze methods of improving railroad service and earning power by reducing loaded car time. Today we offer a talk on improving transit time, by Dr. L. K. Sillcox, vice chairman of the board, New York Air Brake Company, but since the time is late, Dr. Sillcox has consented to postpone his address until the afternoon session.

Mr. President, I request that our committee be dismissed, and that Dr. Sillcox be permitted to present his talk this afternoon.

President Geyer: Mr. Christianson, we have run a little late on our program this morning. This has not been the fault of your committee or of those preceding you. We just had a lot of valuable messages which had to be presented.

Dr. Sillcox always brings a message that is worth hearing and we want a large number of our members to hear him. In justice to your committee and Dr. Sillcox, and for the benefit of members, we will adjourn at the present and hear Dr. Sillcox at 2 o'clock, immediately after luncheon. Your committee is now excused.

(The meeting adjourned at 12:35 o'clock.)

A

Afternoon Session—March 17, 1953

(The meeting reconvened at 2 o'clock, President C. J. Geyer presiding.)

President Geyer: Will the Committee on Economics of Railway Location and Operation please come to the platform?

We did not quite finish the presentation of this committee before lunch. I will ask Mr. A. L. Sams, who is pinch-hitting for Mr. Christianson, who had to leave, to introduce the next speaker.

A. L. Sams (Illinois Central): President Geyer, I believe that Committee 16 owes the Association an explanation. Chairman Barriger, of course, was not able to be present today, and Vice Chairman Christianson, who is studying for a year at M.I.T., had to leave before our report was completed; therefore, the very pleasant task of introducing our speaker falls to me.

The main feature of our report is a discussion of the subject, "Improved Transit Time for Freight Shipments." Dr. L. K. Sillcox, vice chairman of the board, New York Air Brake Company, is qualified to talk on this subject. For several years he has spent part of his prodigious energy gathering transportation data—not cold statistics, but warm, vital information. He travels over 100,000 miles annually, lecturing on transportation and mechanical engineering. He is a railroader, a supplier, a shipper, an educator, and an eminent citizen. Dr. Sillcox.

Improved Transit Time on Freight Shipments

By L. K. Sillcox
Vice Chairman of the Board, New York Air Brake Company

A cargo plane requires only a day to deliver a shipment from California to New York. For the same service railway express requires five days, a highway hauler seven days, and a freight car nine. Based upon any comparison one desires to make in an existing competitive world, the conclusion is reached that the railways are faced with an immediate need to administer *time* as capably as they have done with respect to *tonnage-rating* of trains if they hope to attract new or retain old traffic on the rails. From 1900, and indeed up to and including World War I when the railways possessed a virtual monopoly of intercity freight traffic, with the exception of the inland waterways, the railways' proportion of that traffic has declined to a present low of about 58.5 percent, with highway accountable for 12 percent, inland waterways 16 percent, and pipelines 13.5 percent. A survey of some 1850 shippers and receivers of freight developed the following reasons and their relative importance in influencing the designation of truck transportation:

	Percent of Total
Shorter transit time	75.4
Lower costs	11.9
Less handling	3.9
PU&D service	3.2
Lower minimum weight	1.4
Less loss and damage	1.1
More personal service	0.85
Less marking and packing	0.75
Other	1.5
Total	100.0

Considered by itself, there is, perhaps, no more uneconomical vehicle than a railway freight car. It has been estimated that 12 percent of its life is spent in normal road haul, 66 percent of which time it goes loaded and 34 percent empty. The balance of its life, or approximately 21 hr per day is spent in terminal movements or standing still on sidings, in yards, at shops or loading platforms, etc. The plane and the truck are individually-manned, self-sufficient units of transportation operating over a fairly fluid route, whereas trains represent an assembly of cars destined to move via a fixed trackage to various different destinations. The inherent advantage of railways is that the tracks permit operation of long trains with a single crew. Offsetting this is the capital cost, maintenance and taxes paid for right of ways and tracks. Trucks and planes are high cost vehicles, *each* with its own driver or crew. This cost can be supported only because the public provides highways, airports, etc., for which the users pay less than compensatory charges.

Because of this very difference, railways require the most rigid type of pre-scheduled administration in order that not only time be saved, but that expense be minimized with a view to meeting the competitive challenge and utilizing the enormous capital investment more intensively than present figures disclose. This requires initiative, alertness, and intelligent planning on the part of management, and vigilant supervision with a most careful interpretation of mass statistics employed as indexes of actual individual performance.

The life line of our railways' interdependence is the enormous movement of freight cars from one line to the other which serves every vital industry in our midst. Freight cars move with their freight, store it, carry it to destination, protect it against theft, the elements, and from physical destruction. The line upon which they move is fixed, costly and relatively inflexible compared to the highway, waterway (if connected with large lakes or oceans), and airway. In many cases door-to-door service is not possible and rail routes do not display the freedom of the sky or the sea. As mediums of potential and actual, limited and strategic, storage, they are ideal and serve a wide purpose in this direction, representing an appreciable percent of the car-time.

This leads to the prediction that we will handle future traffic in larger capacity cars, with many more being built for specialized services in order to reduce costs of handling in fields where the railways have not moved in to attract the traffic as they perhaps should do—such as handling highway trucks in volume on specially designed cars. In addition, more particular attention will be given "nonstop" and properly organized movement of consolidated freight in solid trains between important centers of commerce. Railways must determine for themselves what rate and service levels will attract the traffic of the nation and set up a program to handle it on this basis, *and at a profit*. Otherwise, they must relinquish the business to those who can profitably do so and write off their nonessential investment.

High utilization of investment represented by railway motive power, rolling stock, and fixed property is essential to effective competition because of the tremendous aggregate of funds involved. If high utilization of equipment is to be attained the number of terminals and yards should be held to the minimum. The railway industry appreciates that there are too many terminals in the country for the most economical operation, but these terminals were established at a time when the characteristics of motive power and the system of operation called for their being placed about 100 miles apart, which is not necessary with modern motive power.

It may be impossible to change the condition until some agreement is reached with railway labor, and until it is reached the condition represents an indirect form of feather-bedding. The movement of a car through a large terminal absorbs the revenue derived from many miles of line haul, the actual amount depending on the terminal involved. In all cases the expense is appreciable and needs to be challenged in every instance. It is for this reason that many railways, particularly in congested metropolitan centers, suffer tremendous losses on tonnage they must accept and move through one or more terminals, but on which they receive a line haul of insufficient length to compensate for costs incurred during the terminal operation. Why not by-pass such terminals in every possible instance, even though the length of haul of the delivering line is reduced, and thus its division of rates?

It is axiomatic that to obtain the traffic the railways must give, first, adequate service and, second, a competitive rate. Rates are placed second on the basis of the many instances wherein service was deemed more important by the shipper than were rates. To provide either service or attractive rates, both time and facilities must be used intensively, intelligently, and efficiently. This immediately spells out timetable performance; not necessarily daily service in cases where the traffic does not warrant, but an administration of time however frequent, or infrequent, that service may be.

At first thought this may appear to be a backward step and freight would be unduly delayed. On the other hand, if trains can be operated "nonstop" between principal terminals, except for crew changes made on the main line, a major portion or all of the time spent in awaiting full through train consists would be regained and the traffic moved at a reduced operating cost. This is a desirable and necessary action if a continuing more favorable rate is to be economically possible. If a train provides the service dependably, it will pay, even though it is not so fast. Witness the rail-competing Seatrain, which moves full boatloads of 100 cars between New York and Savannah, Ga., and between New York and Gulf ports.

Seatrain schedules are predicated on full boatloads and service is available only at weekly or semi-weekly intervals, which experience has demonstrated will develop capacity loading. However, the service is dependable and the rates favorable, with the result that the Seatrain is affording brisk competition to the all-rail routes with which it must cope for the available traffic. This is attested to by its traffic volume of approximately 20,000 cars per year, transported by the 7 vessels now assigned to the service.

A month-long check for one industry in a metropolitan area discloses the following record of railway and consignee delays to 31 loaded cars received for unloading:

	Days	*Percentage*	*Average Days per Car*
Carrier—Placing loads	269	68.5	8.7
Industry—Unloading	46	11.7	1.5
Carrier—Pulling empties	78	19.8	2.5
Total	393	100.0	12.7

Of the 31 cars involved, the minimum time required for placing loads was 2 days, the maximum 15; the consignee released nine cars on the same day they were received and held one car for a maximum of five days; the carrier pulled four empties on the days they were released, but this was not accomplished in one case until seven days had elapsed. Delays of nine days occurred in placing one car because it was bad ordered, and another was out of service six days because it was off track at the industry, but no explanation is given for the other delays suffered by these cars. While this example is not listed as typical, since if it were our car supply situation would be paralyzing, it does illustrate what can happen when the matter of car service is not properly policed.

A survey has been conducted of car detention in the movement of grain to 18 of the larger elevators in the Chicago switching district. This survey included 353 cars, 90 percent of the 393 total, delivered by 9 rail carriers to elevators during the period July 30 to August 8, 1951. The average carrier detention varied from a minimum of 20 hr and 28 min to a maximum of 107 hr and 16 min. Likewise, consignee detention varied from a minimum of 17 hr and 51 min to a maximum of 96 hr. During this same period 117 cars were dispatched from the Chicago district for outbound road movement and these cars were delayed by road-haul carriers 20 hr and 7 min on the average.

A second survey was conducted of carload handling of grain shipments in the Chicago district under six conditions of operation, again for the period July 30 to August 8, 1951. These six conditions of operation, with resulting average detentions, are as follows:

1. Terminated movement—one road-haul carrier involved—4.4 days' detention.
2. Through movement—one road-haul carrier involved—3.9 days' detention.
3. Through movement—two road-haul carriers involved—3.5 days' detention.
4. Terminated movement—road-haul carrier and one delivering carrier involved—6.2 days' detention.
5. Terminated movement—one road-haul carrier, one intermediate carrier, one delivering carrier involved—7.7 days' detention
6. Through movement—inbound road-haul carrier, intermediate carrier, and outbound road-haul carrier involved—5 days' detention.

While there is no definite pattern of time required to move through or terminate in the Chicago switching district disclosed from the above data, generally one can say that, as is to be expected, the greater the number of carriers involved the greater the time expended. An important time-consuming requirement is that for grain inspection—a detention over which the railways have no control. If this time is removed, we find the preceding average detentions under the six conditions of operation are reduced to 2.5, 1.3, 1.8, 4.5, 6.0, and 3.3 days, respectively. When one considers the extremely intricate operations of the Chicago terminal area and the number of railways involved, these times appear to indicate commendable handling.

Freight car utilization may be measured by two yardsticks; namely, percentage of capacity utilized when loaded, and loaded car-miles per car-day. There are many subsidiary considerations which affect these two prime criteria, but in the final analysis they are the factors which determine freight car earnings.

As an example of subsidiary considerations, attention is directed to the truism that, while "percentage of capacity utilized" is the actual measure of car capacity utilization, "tons per loaded car" is the unit that is statistically recognized, since, if one ton moves one mile, a ton-mile of transportation is produced whether the car be of 40 or 70 tons capacity. The second ruling factor which governs ton-miles per car-day is loaded car-miles per car-day, and here we cannot paint as pretty a picture. It is true that car-miles per serviceable car-day (loaded and empty) have increased in 20 years from 30.5 in 1930 to 46.5 in 1950 (having declined from 51.9 in 1944), but even yet it is patent that there is much room for improvement. Of significance is the effect of the relation between loaded and total car-miles on this statistical measure of freight car utilization.

As indicated, the foregoing values of car-miles per serviceable car-day apply to all cars, loaded and empty. Inasmuch as one of every three car-miles operated represents empty car movements, it is apparent that the reduction in empty car mileage is an objective toward which every operating officer aspires.

We must administer time on an exact basis so that in setting up the schedule the actual running time is set out, also the actual dead time, and some allowance made for contingencies. Schedules should be predicated on traffic volume to insure that fully loaded trains are dispatched. There need be no conflict between scheduled service and adequate tonnage. If such performance is maintained, nobody should be criticized, but, if it is not, the most vigorous and intelligent action should be forthcoming. It requires careful evaluation of the facts in the light of operating and traffic experience to achieve an economic balance between maximum utilization of equipment and train-mile production.

We know from experience that freight cars in transit, with very few exceptions, are moving at a speed of not less than 20 mph, and quite often at 50 and 60 mph. If a car moves at the lower speed of 20 mph it will cover 46.5 miles in 2 hr and 20 min. We then ask ourselves what the car is doing the other 21 hr and 40 min of the 24. It is evidently standing still or being switched.

A part of each of these items is unavoidable since included is time for loading and unloading—controlled by the shipper and consignee; or time awaiting loads, which depends on business level and production. We are sometimes told that no means of improvement are known, and that the only solution is an increase in car inventory, but, when all is said and done, we need to emphasize the fact that the best kind of systematic work and policing by on-line officers can improve the situation.

President Geyer: Members of this Association, I do hope that you listened to Dr. Sillcox' message earnestly, and that you will take it home to your people and study it, and see what can be done. In essence, he told us that our speed, while running, is all right, but that our standing-still speed is too slow, and that we must speed up that standing-still speed. Dr. Sillcox promised that the committee was going to give further study to this problem of train movement. I don't know of any more important subject that could be studied. I was glad to hear him say they would make a study of the individual car movements, instead of averages through yards; it makes a lot of difference. If you will follow up individual car numbers as they go from origin point to delivery point you will see the difference. You can take enough individual cars to get a good figure of what it is really costing in standing-still speed.

Mr. Sams, this committee, through the year, under Mr. Barriger and Mr. Christianson, has done a wonderful job, and the Association is very thankful for the contribution you have made. The committee is dismissed with the thanks of the Association.

Discussion on Waterways and Harbors

(For report, see pp. 523 530.)

(President C. J. Geyer presiding.)

President Geyer: This committee was discontinued in 1947 because of special conditions at that time, but because of the necessity for reviewing the Manual material on waterways and harbors, and other special work on matters pertaining to waterways, it was thought advisable to reactivate the committee.

Arthur Anderson, special assistant engineer of the New York Central System, is chairman of the committee. He was vice chairman, I believe, in 1947—and is very familiar with its work. He has just, this year, been getting the committee back into the harness, and this is the committee's first report since 1947.

It is a pleasure to present Mr. Anderson and his committee.

Chairman Arthur Anderson (New York Central): President Geyer, members and guests: Your committee this year is making a report on revision of the Manual. The report is published in Bulletin 504, November 1952, pages 523 to 530, incl. The report is divided into four parts.

Mr. Ben Elkind is chairman of Subcommittee 1–A, and I will ask him to present the report on behalf of that subcommittee.

Assignment 1–A—Revision of Manual, was presented by Subcommittee Chairman Benjamin Elkind (Erie).

Mr. Elkind: The revision of the Manual consists of reports of four subcommittees-1–A, 1–B, 1–C and 1–D.

The report of Subcommittee 1–A is published in Bulletin 504, starting on page 523. The recommended revisions of the Manual under Assignment 1–A start with Manual page 25–1 and extend through page 25–8 to include "Usual Slopes Taken in Deep Waterways." A few of the articles have been omitted, many have been rewritten, and new articles have been added.

Your committee recommends that the items in the Manual as contained on the above-named pages be reapproved with the revisions, deletions and additions shown in this report, and I so move.

(The motion was regularly seconded, was put to a vote, and carried.)

Assignment 1–B—Revision of Manual, was presented by Subcommittee Chairman A. F. Crowder (Missouri Pacific).

Mr. Crowder: The report of Subcommittee 1 B, "Sounding Methods in River and Tidal Waters," is published in Bulletin 504, pages 527 to 529, incl. Your committee recommends deletion of the existing material in the Manual, substituting therefore the report as published, and I so move.

(The motion was regularly seconded, was put to a vote and carried.)

Chairman Anderson: A. B. Stone (Norfolk & Western), chairman of Subcommittee 1–C, is absent, and I am asking G. K. Davis to present the third part of our report.

Assignment 1–C—Revision of Manual, was presented by G. K. Davis (Chesapeake & Ohio).

Mr. Davis: The report of Subcommittee 1–C is published in Bulletin 504, pages 529 and 530. The recommended revisions of the Manual under Assignment 1 C are printed on Manual pages 25–9, 25–10, 25–11, 25-12 and 25 13.

Your committee recommends that the items in the Manual as contained on the above pages be reapproved, with the revisions, deletions and additions as called for in the Bulletin, and I so move.

(The motion was regularly seconded, was put to a vote and carried.)

Chairman Anderson: C. J. Henry (Pennsylvania Railroad), chairman of Subcommittee 1–D, is absent, and I am asking Mr. Droege to present the report on the fourth and final part of our report.

Assignment 1–D—Revision of Manual, was presented by J. A. Droege, Jr. (New York Central).

Mr. Droege: The report of Subcommittee 1 D is published in Bulletin 504 on page 530. Your committee recommends reapproval of the existing material in the Manual, as noted, with the addition of the word, "Alteration," in the title on page 25–13, and I so move.

(The motion was regularly seconded, was put to a vote, and carried.)

Chairman Anderson: President Geyer, that concludes the report of Committee 25—Waterways and Harbors.

President Geyer: Mr. Anderson, your committee was able to present this report in very short order, and probably very few members of the Association, except those who have worked on this committee, know what long hours you have spent in its preparation, which required that the Manual material be examined carefully.

Your committee is excused with the thanks of the Association.

Discussion on Highways

(For report, see pp. 465–500.)

(President C. J. Geyer presiding.)

President Geyer: W. H. Huffman, assistant to chief engineer, Chicago & North Western Railway, is chairman of this committee. This committee has a pretty tough job in that it has to deal with municipal, state and federal authorities, and it is often quite a job to get those folks to do what we would like to have them do as far as the railroads are concerned. But they are making good headway.

Chairman W. H. Huffman (Chicago & North Western Railway): Mr. President, members and guests of the Association: Our committee, like most of the other standing committees, as Mr. Howard mentioned this morning, has spent a great deal of its time on revision of the Manual. Our workhorse on this particular assignment, Revision of Manual, is H. G. Morgan, who recently retired as signal engineer of the Illinois Central Railroad. I would like to give you a brief summary of his activities, if I may, because he really has been a workhorse, and I'm not kidding about that. He joined the Association in 1924, and was a member of Committee 10—Signals and Interlockers, from 1925 to 1944, when it was discontinued, being chairman of that committee from 1938 to 1941. He was a member of Committee 26, Standardization, from 1938 to 1941. He was a member of Committee 28, Clearances, from 1938 to 1941. He was a member of Committee 9—Highways, in 1927, again taking it up in 1946, to date. He was made a Life Member of the Association on January 3, 1953. I am very happy to present Mr. Morgan.

Assignment 1—Revision of Manual, was presented by Subcommittee Chairman H. G. Morgan (Illinois Central, retired).

Mr. Morgan: Thank you, Mr. chairman.

Mr. President, members and guests: Mr. Huffman's remarks remind me that a workhorse is different from a race horse. A workhorse doesn't get turned out to pasture.

You will find the subcommittee's assignment beginning on page 466 of Bulletin 504.

There is a series of forms on pages 9–36 to 9–41 of the Manual. After a review, the committee finds that the above forms are typical and provide up-to-date information, and it is recommended that these forms be reapproved without change, except to change the title of the Form for Recording Highway Grade Crossings, and I so move.

(The motion was regularly seconded, was put to a vote, and carried.)

Mr. Morgan: Pages 9–67 to 9–72 of the Manual comprise a series of drawings covering suspended overhead crossing signs. It is recommended that the six drawings—Figs. 11 through 16 on pages 9–67 through 9–72, be deleted from the Manual, since a canvass of various manufacturers shows that suspended overhead crossing signs are no longer manufactured and that only a few of them have been installed—and I so move.

(The motion was regularly seconded, was put to a vote, and carried.)

Mr. Morgan: On page 9–51 of the Manual, pertaining to recommended use of highway–railway grade crossing signs, the committee recommends that this material be reapproved, with necessary changes in page references, deleting the fifth and sixth sections, which refer to the suspended overhead crossing sign—and I so move.

(The motion was regularly seconded, was put to a vote and carried.

Mr. Morgan: Manual material on pages 9–111 and 9–112 is recommended for reapproval with the minor changes shown to take care of revision in drawings, and deletion in the matter of manually-operated crossing gates—and I so move.

(The motion was regularly seconded, was put to a vote, and carried.)

Mr. Morgan: The drawings of the Signal Section covering highway crossing signs and highway crossing signals, which are included in the AREA Manual, are subject to revision, usually in details not greatly affecting the general assembly.

AREA approval of these revised drawings takes a year, so the AREA Manual carries an earlier revision date than is shown in the Signal Section Manual.

The ten new drawings which are listed on page 468 of Bulletin 504 are all assembly drawings. It has been suggested that the second drawing, shown on page 470, is not a complete assembly, and should be drawn to accord with the drawing on page 469. However, the drawing shown on page 470 should be included with another group of drawings, and it appears unnecessary to redraw this one on 470 at the present time.

These new drawings show only important details and dimensions, and refer to the corresponding Signal Section drawings. This is to simplify the AREA drawings and avoid the necessity for constant revision to cover detailed changes on the Signal Section drawings. As recommended, I move the deletion of the ten existing drawings shown, and the adoption of the ten new drawings listed.

(The motion was regularly seconded, was put to a vote, and carried.)

[In connection with the immediately preceding recommendation, attention is called to the typographical error in listing the title of Fig. 8 on Manual page 9–103. This title should have read, "Fig. 8—Highway Crossing, Flashing-Light Signal Assembly, 6-Ft and 8-Ft Cantilever Span." Also, noting that in the first eight new drawings shown, all of the auxiliary reflectorized signs are shown in outline letters, whereas the similar signs in the last two drawings (Highway Crossing Signal, Flashing-Light Type with Extended Lights and Mast-Mounted Gate; and Highway Crossing Signal, Flashing-Light Type with Extended Lights and Pedestal-Mounted Gate) are shown in solid black letters, the committee agreed to change the latter two drawings to show the signs in question in outline letters. Furthermore correction was made of the length of mast on the drawing on page 477, to 13 ft (instead of 12 ft 10 in) to correspond with Signal Section drawing 1489.]

Mr. Morgan: The nine drawings listed on page 479, beginning with page 9–55 in the Manual, covering detailed drawings of the Signal Section, should be withdrawn, as they may be found in the Signal Section Manual when needed—and I so move.

(The motion was regularly seconded, was put to a vote, and carried.)

Mr. Morgan: The two crossbuck signs entitled "Painted Highway Crossing Sign," on pages 480 and 481 of the Bulletin, have been prepared to provide drawings of the two types of painted crossbuck signs. They are to replace the drawing on page 9–53 of the Manual, which is a painted highway crossing sign, and on 9–57 of the Manual, which is the 90-degree cast iron crossing sign—and I so move.

(The motion was regularly seconded, was put to a vote, and carried.)

Mr. Morgan: The Manual now contains five typical location plans as shown on the top of page 482. These cover highway crossing signals and automatic crossing gates. These location plans are to be replaced with the four new drawings which are shown on pages 483 to 486, incl.

These location plans have been prepared with the approval of Committee 8 of the Signal Section. They provide the same locations for flashing-light signals with and without automatic crossing gates.

These are submitted for approval for inclusion in the Manual—and I so move.

[In order that all reflectorized auxiliary signs on the various drawings submitted by the committee be shown in outline letters, it was agreed that the drawing on page 486—Typical Curb and Gutter Location Plan for Automatic Crossing Gates and Flashing-Light Signals—should be revised to show the lettering on its three signs in outline letters.]

(The motion was regularly seconded, was put to a vote, and carried.)

Mr. Morgan: On Manual page 9–26, "Requisites for Floodlighting of Highway–Railway Grade Crossings," it is recommended that they be reapproved with the substitution of new wording for Art. 12 as shown on page 482—and I so move.

(The motion was regularly seconded, was put to a vote, and carried.)

Mr. Morgan: The documents listed at the bottom of page 482 and the top two-thirds of page 487 of Bulletin 504 are recommended for reapproval, without change, as all of these documents except one were either adopted or revised since 1947—and I so move.

(The motion was regularly seconded, was put to a vote, and carried.)

Mr. Morgan: It is recommended that the material listed on the remainder of page 487 of Bulletin 504 be reapproved with the necessary changes in Manual page references—and I so move.

(The motion was regularly seconded, was put to a vote, and carried.)

Mr. Morgan: It is recommended that the drawing shown on Manual page 9–106, with the elimination of the Signal Section, AAR, reference, be reapproved—and I so move.

(The motion was regularly seconded, was put to a vote, and carried.)

Mr. Morgan: This concludes the report on Assignment 1.

President Geyer: Thank you, Mr. Morgan.

Chairman Huffman: As you can see, that is a lengthy report. I would like to state for the record that every page that Committee 9 will have in the new Manual will have a 1953 date—and that meant a lot of work.

Assignment 2—Design and Specifications of Open-Grating Type Crossings, was presented by Subcommittee Chairman R. E. Nottingham (Louisville & Nashville).

Mr. Nottingham: Mr. Chairman, members of the AREA, this assignment is now under active study to determine the service life of various types of open-grating installations now in use. The committee considers the present available data inadequate for a formal recommendation, and desires to continue the study until longer service life has been observed.

President Geyer: The report will be received as information.

Chairman Huffman: Assignment 4, Highway Profile at Highway-Railway Grade Crossings, and Assignment 8, Widths of Multiple-Lane Highways at Highway–Railway

Grade Crossings, are both submitted as final reports. As these two assignments more or less dovetail with one another, they will both be submitted by J. S. Findley, of the C. B. & Q. I might mention that C. I. Hartsell was subcommittee chairman on Assignment 8.

Assignment 4—Highway Profile at Highway–Railway Grade Crossings, was presented by Subcommittee Chairman J. S. Findley (Chicago, Burlington & Quincy).

Mr. Findley: The report of subcommittee 4 appears in Bulletin 504 on pages 488 and 489. It includes:

Article 1. General Specifications.

To be reapproved without change.

Article 2. Profile of Crossing and Approaches.

Delete sketch shown as Fig. 1, and revise Art. 2 as shown.

Article 3. Width and Surfaces of Approaches.

This is new article proposed for insertion. [In the third line, insert the words "and width" between the words "number" and "of".]

Article 4. Drainage.

This is a revision of former Art. 3, now proposed for adoption.

Renumber Arts. 4 to 8 in present Manual, making them 5 to 9.

Mr. President, I wish to move the adoption of Arts. 1 to 9, incl., as called for in Bulletin 504, for publication in the Manual.

(The motion was regularly seconded, was put to a vote and carried.)

Assignment 5—Factors to be Considered in Classifying Highway–Railway Crossings with Respect to Public Safety, was presented by Subcommittee Chairman B. M. Stephens (Texas & New Orleans).

Mr. Stephens: The report on Assignment 5 is published on pages 489 to 491, incl., of Bulletin 504. The report is offered as information, and is a final report on Assignment 5.

President Geyer: Thank you, Mr. Stephens. The report will be received as information.

Assignment 6—Economics of Highway–Railway Grade Separations, was presented by Subcommittee Chairman J. E. K. Krylow (Pennsylvania).

Mr. Krylow: This is a progress report, submitted as information. It will be found in Bulletin 504, pages 491 to 499, incl.

This assignment, at first, lead your committee towards exploring the subject on the basis of determining the benefits the railroads have or may receive from such grade separations. The result of the study indicates that the greater portion of the benefits are enjoyed by the highway user.

A railroad's economies resulting from a grade separation, particularly if the railroad's apportioned cost is small, may appear very attractive, however, we cannot lose sight of the fact that there are cases where the railroad's annual tax bill in a certain state may exceed the annual earnings of that railroad within that state.

Present records indicate that there are more than 226,000 highway–railway grade crossings in service, increasing at the rate of about 100 each year. The registered motor vehicles now exceed 50 million and are increasing at the rate of over 4 million each year. Under these conditions, it can be expected that highway railway grade crossings and their separation will continue to increase in importance.

President Geyer: The report will be received as information. Thank you, Mr. Krylow.

Assignment 7—Sight Distance at Highway–Railway Grade Crossings, was presented by Subcommittee Chairman J. M. Trissal (Illinois Central).

Mr. Trissal: Your committee has been studying the question of sight distance at highway–railway grade crossings. This subject is also being actively considered by several State Commissions as well as the American Association of State Highway Officials.

Several formulas have been advanced for determining the size of a triangle which would have to be left free of buildings, trees, etc., in order to provide unobstructed view of the crossings. These formulas have all been developed by highway people and take into consideration the speed of highway vehicles as well as trains. In no case is any allowance made for any automatic crossing protection which may be provided.

It is recognized that it is impossible to provide sight distance triangles in urban areas, and consequently any recommendations would of necessity apply only to rural areas, and in most cases to new highway construction.

Due to the complexity of the situation, your committee is not prepared to make any recommendation at the present time, but this does give you an idea of our thinking. This progress report is submitted as information.

President Geyer: Mr. Trissal, the report will be so received.

Assignment 8—Widths of Multiple-Lane Highways at Highway–Railway Grade Crossings.

(The recommendation of this subcommittee was incorporated in the report on Assignment 4, and acted upon with that report.)

Chairman Huffman: This completes our assignment reports. However, before closing, I would like to mention one other member of this committee who recently retired, a high engineering officer on one of our northwestern railroads, who joined this Association in 1917. He was a member of Committee 3 from 1924 to 1927; a member of Committee 9 since 1928; and, listen to this—he has been vice chairman of this committee since 1929. That is 24 years.

He was a director of this Association from 1935 to 1937, and was made a Life Member January 1, 1952. I believe a man of this caliber should stand and be recognized. I am referring, of course, to Bernard Blum, chief engineer of the Northern Pacific until his retirement on March 1, 1953.

This convention ends my term as chairman, and at this time I would like to express by deep appreciation for the wonderful cooperation I have received from my committee members. I would also like to express my appreciation to Secretary Howard and his staff, who have helped me tremendously in the last three years in getting this Manual material and other information out.

Now I would like to present the new officers of this committee. The chairman will be W. C. Pinschmidt, engineering assistant to the vice president—construction and maintenance, Chesapeake & Ohio. The new vice chairman will be C. I. Hartsell, division engineer of the C&O, Pere Marquette District.

This wasn't done, of course, because our president this year is a C&O officer. They are just two good men, that's all. We couldn't keep them out of the jobs.

Mr. President, this completes my report.

President Geyer: Mr. Huffman, on behalf of the Association, thank you very much for the fine work you have done as chairman of this committee for the last three years.

I am very glad to welcome as chairman my friend and co-worker, W. C. Pinschmidt, and C. I. Hartsell as vice chairman of the committee.

Your entire committee has done splendid work, and is excused with the thanks of the Association.

Discussion on Cooperative Relations With Universities

(For report, see pp. 877 902.)

(President C. J. Geyer presiding.)

Chairman C. G. Grove (Pennsylvania): Mr. President, members of the American Railway Engineering Association: Your Committee 24 will make a report on the three assignments which have been in effect for a number of years. These three assignments pretty well cover our objective: to sell to the railroads the idea that it is to their decided advantage to hire engineering graduates for service in many of their departments, and to encourage young graduate engineers to know about the opportunities for them on railroads, and to enter our service.

The report on Assignment 1 will be presented by J. B. Akers, chief engineer of the Southern Railway System.

Assignment 1—Stimulate Greater Appreciation on the Part of Railway Managements of:

(a) the importance of bringing into the service selected graduates of colleges and universities, and

(b) the necessity for providing adequate means for recruiting such graduates and of retaining them in the service by establishing suitable programs for training and advancement,

was presented by Subcommittee Chairman J. B. Akers (Southern).

Mr. Akers: The committee's report is published in Bulletin 506, Vol. 54, for January 1953, on pages 878 to 899, incl. It consists primarily of the tabulated returns to a questionnaire sent out to the chief operating officers of the railroads, as referred to in the report to the 1952 convention. The questionnaire was designed to ascertain the views of top management on the need for recruiting college graduates for railroad service, and finding means of attracting, training and holding them for service in the railroad industry.

The questionnaire was sent out through the secretary of the AREA to chief operating officers of 132 railroad companies in the United States, Canada and Mexico, and replies were received from 62.

The number of replies indicates that the importance of the subject is becoming more widely recognized. Seventeen roads now have training programs.

It is believed that the questionnaire has been of value in pointing up the importance of the subject, but it is still true that the problem can only be solved by the technical personnel of each railroad selling its importance to the management of the individual railroad company. The report and the supporting data contain information as to methods which are operating successfully.

We hope that this report will find your interest. There has been a great deal of work done on it, not only by the subcommittee, but by the committee as a whole, and by the secretary. We hope you will read the report, and that by next year there will be a number of other railroads establishing such programs of training.

This is a progress report.

President Geyer: Thank you, Mr. Akers. The report will be so accepted.

Chairman Grove: The report on Assignment 2 was to have been presented by Professor R. P. Davis, the subcommittee chairman, Dean of the College of Engineering of West Virginia University, but in his absence a member of that subcommittee, L. L. Adams, chief engineer of the L&N Railroad, will present the report.

Assignment 2—Stimulate Among College and University Students a Greater Interest in the Science of Transportation and Its Importance in the National Economic Structure, By Cooperating with and Contributing to the Activities of Student Organizations in Colleges and Universities, was presented by L. L. Adams (Louisville & Nashville), in the absence of Subcommittee Chairman R. P. Davis.

Mr. Adams: The report of this subcommittee appears in Bulletin 506, starting on page 899. This is necessarily a progress report, for, if the railroads are to meet their needs for engineering graduates, they must not only go out of their way to stimulate greater interest among college and university students in a railroad career, but they must also convince professors of engineering that the railroads offer an attractive career for their graduates.

This is not a job to be done in one year and then forgotten, but must be followed up each year. There is a new graduating class every year, and a complete change of students every four years, so our work is continuous.

Your committee, during the past year, has continued to aid the National Railway Appliances Association in circulating among engineering colleges lantern slide sets of the historical exhibit prepared jointly by the AREA and the NRAA. To date these slides have been shown before student groups of 20 colleges and universities, and 5 institutions have purchased sets of them.

Your committee appeals to all of you to avail yourselves of every opportunity to visit engineering colleges and universities in your respective territories and explain to the students the opportunities offered by the railroads to engineering graduates—for the opportunities are many.

You can also aid in securing more engineer graduates by interesting high school students in taking an engineering course when they enter college so there will be more graduates in the future to meet the needs of the engineering profession.

President Geyer: Thank you, Mr. Adams. The report will be received as information.

Chairman Grove: The report on Assignment 3 will be presented by O. W. Eshbach, Dean of the Technological Institute, Northwestern University. In addition to the report on his assignment, Dean Eshbach will bring us up to date on the engineering manpower shortage. He is well qualified to talk on this subject, because he is a member of the Engineering Manpower Commission of the Engineers Joint Council.

Assignment 3—The Cooperative System of Education, Including Summer Employment in Railway Service, was presented by Subcommittee Chairman O. W. Eshbach (Northwestern Technological Institute).

The Manpower Situation

By O. W. Eshbach

Dean, Northwestern Technological Institute

It is my intention to direct the discussion today to the present situation regarding technical manpower and point to vital factors which should be considered in effecting a better balance in future defense efforts.

Your Committee on Cooperative Relations with Universities has given continuous consideration to the effect of the defense program and has reported to you each year since the Defense Act went into effect. The justification of doing so arises from current and long-term need of the railroads for engineers. The fact that the situation is national in scope and that critical situations exist with varying relative urgency makes it important for the engineering profession, industry and the colleges to cooperate in making the facts and consequences generally known.

It is important that all of us be diligent in searching for the facts and in presenting the truth, as intelligence and understanding permit, in order to cooperate most effectively in the defense effort, guide our legislative representatives, and advise the executive branch of our government. While both selfish and altruistic motives indicate the desirability of changes in policy, we are tolerant of the fact that political expedience takes precedence over less obvious long-term consequences. But this should not license stupidity nor stultify constructive effort.

The present situation differs little from that which could have been and was predicted two years ago. The number of engineering seniors available for industry is less than one quarter of the number industry should have. Next year will be no better. Some impovement may be expected in succeeding years, resulting from the return of service men, unless more widespread military conflicts are experienced. In effect, the main supply of engineering graduates for the immediate future will come from the military forces, not directly from the colleges. Past recruiting procedures at the colleges will be superseded by uncertain methods of contacting dischargees.

For those who are interested in the employment of graduate students with advanced degrees the picture is less encouraging. There are still a few veterans available, but graduate education in engineering is approaching a collapse which will not recover for at least 3 to 5 years, and which will probably not reach its present level in the next 20 years. If research and development are to be critical factors in the next war, this is a situation which needs attention. When we consider that the inventive talent of engineers and scientists is most productive in the early years of their careers, we can only conclude that the sacrifice of creative ability is too high a price to pay for a program that ignores one of America's greatest assets.

TABLE 1

PRE-WAR AND POST-WAR COMPARISON OF ENGINEERING ENROLLMENTS AND DEGREES (ACCREDITED CURRICULA)

	Undergraduate Total	*Undergraduate Freshmen*	*First Degrees*	*Master's Degrees*	*Doctor's Degrees*
1940	108,911	33,175	11,358	1,318	108
1947	230,180	57,507	18,592	3,090	127
1948	226,117	47,672	27,460	4,303	252
1949	180,646	36,508	41,793	4,783	417
1950	140,954	29,394	48,160	4,865	492
1951	128,367	34,147	37,904	5,134	586
1952	138,170	45,854	27,155	4,132	586
1953			23,000*		
1954			21,000*		

* Estimated.

Long Term Supply

Since our report a year ago, there is reason to have less concern about the long-term supply of engineers. The reason for this is that the effectiveness of the publicity of the Manpower Commission has caused an increase in freshmen enrolment, amounting this year to about 30 percent. Most of this has occurred in the state institutions, and further increases may be expected by them because Public Law 550 favors colleges with low tuition. Another reason for less concern about long-term requirements is the fact that today's seniors will not be available for industry for two or three years, at which time graduates will be larger in number. The change in birth rate of the 1940's will also have an appreciable influence upon the supply ten years from now. A conservative estimate of yearly needs for peace-time conditions may be estimated as 25,000 to 30,000 graduates, which would supply a 3 percent growth and 2 percent attrition (due to death and retirement).

While there is justification for relatively less concern about long-term needs, there is need to give serious study to our human resources in relation to future professional needs and educational provisions. For example, there are about 2,200,000 young people in the 18-year age group. Of this group, less than 60 percent graduate from high school and only one-fifth of this number, or 12 percent, will graduate from college—or about 1 out of every 8 becomes a college graduate.

In the engineering profession, we are concerned mostly with the male talent interested in the physical sciences, and with ability to make a professional contribution to the understanding of them and their application to industrial and social needs.

Competing with the engineering profession (450,000) for talent are the scientists (225,000), the doctors (210,000), the dentists (110,000) and others, totaling over 1,000,000 people, mostly males, whose contributions to society depend upon some scientific knowledge and competence. This number is about one-third of all professional personnel.

Such as it is, the only good index of the distribution of intellectual ability is the I.Q. score or the Army General Classification Test Scores. From the latter distribution, it is not difficult to calculate potential supply. From past experience, a person with a score of 115 seems to have only 1 chance in 5 of graduating from college. Very few engineering graduates are found in this group. The good talent will be found among those whose scores are above 120. This represents the upper 16 percent of any age group or, approximately 170,000 males. Of this number about 80,000 will be college graduates. If all of them went into the professions requiring some scientific education, and they were proportionally allocated, engineering would receive no more than 35,000. Obviously, many are going to choose the ministry, law, journalism, commerce and other occupations. Furthermore, there are not now enough high school students studying mathematics and science to prepare for college courses leading to scientific occupations. Present experience points clearly to the fact that we will do well indeed to produce the minimum peace-time needs for good engineers in the future. On the other hand, there are as many people in this talented group who have not graduated from college and are capable of development for positions of leadership.

Immediate Supply

Present estimates of industrial needs are considerably reduced from a year ago and are reliably reported at about 40,000, in contrast to over twice this number in 1951–1952. One reason is that considerable thought has been given to the better utilization of engineering talent and also the impossibility of securing the desired number.

Since it is the policy of Selective Service to induct all able-bodied graduates into service for two years there will be few industrial deferments. Under the circumstances, it is doubtful if more than 5000 of the present graduating class will be available to industry. The remaining needs will have to come from returning veterans. While this group will be large in numbers, the number of engineers among them will not approach the current need. Next year it should be better.

Because of the rapid expansion of the military forces two years ago, the largest draft of new personnel will occur this year and next. It is evident that the normal expectancy from the pool now available will fall short of requirements. This was predicted two years ago. To meet draft quotas, one or more of the following will be considered:

1. Draft fathers under 26 years of age with no previous military experience.
2. Extend the period of service from 24 to 30 months.
3. Raise the college draft deferment score from 70 to 75.

Of these the last is most probable. It will obviously decrease engineering enrollments, but will not seriously effect the supply of good engineers.

The most serious problem affecting the defense effort or successful future war is the waste of professional engineering and scientific talent. This occurs in a number of ways.

No one will deny the need in the armed forces for technical talent. On the other hand, the quantities drafted and assigned to non-profesisonal work leaves much to be desired in a period of scarcity.

Interruption of development and research activities by the restriction of industrial deferment not only curtails production, but invariably interrupts the technical development of personnel which will be badly needed if the present emergency gets worse. Frequently, it means the permanent loss of good scientists. For the same reason there is need to control the recall of reservists. A revision, or amendment, to the Reserve Act should receive serious consideration, as likewise should the establishment of a technical review board to consider the merits of industrial deferments and act in an advisory capacity on a national and state level.

One of the most serious influences on the availability and development of high grade technical talent is the present R.O.T.C. program. If the proposed legislation extends the Halloway plan of the N.R.O.T.C. to other branches of the service, by virtue of deferment, subsidy and selective tests, they will enroll a very high percentage of the ablest potential engineers. These men will not be available for graduate work or industry until they have served from two to three years. Thereafter, they will be in the reserve, subject to call for six years.

Under the expanded R.O.T.C. programs of the several services, the number of engineering graduates commissioned as R.O.T.C. officers will rapidly increase, until by 1955 it may total as high as 60 percent of all engineering graduates of schools with accredited curricula. The engineering schools are therefore confronted with the immediate situation of being supplements of the military academies rather than the producers of professional talent for industrial support of the war effort.

In conclusion, we are sacrificing many of the broad objectives of the Defense Act for the expediency of filling military quotas. The multitude of activities involved in the defense effort are in effect sapping our economic and professional vitality. Little improvement can be expected until military quotas are drastically reduced and the national budget balanced.

Chairman Grove: We are very grateful to you, Dean Eshbach, for giving us this very interesting and comprehensive review of this very important situation.

For the ensuing year we have a new assignment for our Subcommittee 4, entitled, "Conduct a study looking to the publication of a booklet, or booklets, for distribution to educational groups, particularly high schools and undergraduates in colleges, designed to stimulate interest in the opportunities afforded in a railroad engineering career."

Lack of definite information concerning the opportunities for engineering graduates on railroads—such as is always available to students entering other industries—leads us to make this study with the thought of making available proper data for young men who may seek to enter our service. G. A. Kellow, special representative of vice president, Chicago, Milwaukee, St. Paul & Pacific Railroad, is chairman of this new subcommittee.

During the past year your Committee 24, with the approval of the Board of Direction, has prepared and sent out a leaflet entitled "Careers in Engineering" to some 7500 educational institutions throughout the United States and Canada. This leaflet was prepared from information worked up by the Engineering School of Iowa State College, and is an attempt to bring to the attention of young men the advantages in securing an engineering education. Its preparation and distribution was prompted by the shortage now existing in enrollments in engineering courses, and as a result of the shortage of engineers in industry.

From the schools to which these leaflets have been sent we have received requests for additional copies, showing that there is an interest. We firmly believe that if we are to have young men graduate from engineering schools, they must start to think about engineering when they are in high school, and this is an attempt—among many attempts on the part of a great many people—to stress the necessity of having more engineers.

Again, I wish to express my appreciation to the subcommittee chairmen and the members of the entire committee for their good work during the past year. To be a subcommittee chairman means that you must work, and these subcommittee chairmen have worked, and the results of their efforts have been made known to you today.

We have one new member on the committee—Prof. Frank Kerekes, assistant dean of engineering, and professor of civil engineering, Iowa State College.

We also have enrolled, as a "guest" member, a young man from the western part of our country, J. F. Pierce, who will sit in on our deliberations.

Mr. President, this completes the report of Committee 24.

President Geyer: Thank you very much, Mr. Grove.

This morning, in my address, I spoke to you of the lifeblood of our Association being our Junior Members. Your committee, Mr. Grove, is dealing with the lifeblood of our railroad organization, in which we are all so much interested. I hope that top managements of our railroads will read the reports that your committee is making, and will do something about them.

Your committee is excused with the thanks of the Association.

You will be interested to know that, as of 3:45, there were 1031 members and 408 guests registered, for a total attendance of 1439.

Discussion on Contract Forms

(For report, see pp. 531-557.)

(Vice President C. G. Grove assumed the chair.)

Chairman G. W. Patterson (Pennsylvania): Mr. Chairman, members of the Association, and guests: During 1952, due to retirement and resignation, Committee 20 suffered the loss of quite a few valuable members, several of whom had at various times served as committee chairmen. These men had done much to bring the committee along to fruitful endeavor; their services will be greatly missed. However, due to the efforts of the Association's secretary and the cooperation of the chief engineers of several railroads, new members have been brought in, and Committee 20 now represents 27 carriers.

In connection with the imminent reprinting of the Manual, and in line with similar efforts of other committees, Committee 20 elected to forego all other studies during the year just past and to concentrate upon a review of its entire chapter. Accordingly, seven subcommittees were formed, and each was assigned a few of the forms (related insofar as possible) for review.

The report is found in Bulletin 504, for November, 1952.

Assignment 1–A—Construction Agreements, was presented by H. F. Brockett (Santa Fe), in the absence of Subcommittee Chairman E. H. Barnhart, Baltimore & Ohio, retired.)

Mr. Brockett: Your subcommittee had assigned to it the five construction agreements listed at the top of page 532, Bulletin 504. It is our recommendation that these forms be reapproved without change. Mr. Chairman, I so move.

(The motion was regularly seconded, was put to a vote, and carried.)

Assignment 1–B—Agreements Covering Passenger and Freight Facilities, was presented by Subcommittee Chairman C. E. McCarty (Richmond, Fredericksburg & Potomac).

(Mr. McCarty then read the recommendations, of the committee as presented on page 532 of Bulletin 504, commenting as follows with respect to the Form of Agreement for Cab Stand and Baggage Transfer Privileges—Manual page 20–46.1):

The wording of this form was changed somewhat to harmonize with that of other chapter material, and this agreement was otherwise revised, particularly with the idea of strengthening the liability clauses. It is recommended that the existing Manual material be withdrawn and that the revised form shown in Bulletin 504, beginning on page 543 be substituted.

Mr. McCarty: Mr. Chairman, I move the adoption of the recommendations of the committee.

(The motion was regularly seconded, was put to a vote, and carried.)

Assignment 1–C—Electrical Agreements, was presented by Subcommittee Chairman E. M. Hastings, Jr. (Chesapeake & Ohio).

(Mr. Hastings read verbatim the report of the committee under this assignment on pages 532 and 533 of Bulletin 504, and then moved the adoption of the reapprovals and revisions recommended.)

(The motion was regularly seconded, was put to a vote, and carried.)

Assignment 1–D—Track Agreements, was presented by Subcommittee Chairman J. L. Perrier (Chicago & North Western).

(Mr. Perrier first read, by title, each of the forms of agreement referred to under Assignment 1–D, and then said:)

Mr. Perrier: Changes in these forms are largely for the purpose of more nearly conforming to the wording used in other portions of the chapter. In one instance, however, the matter of liability has been more clearly defined, and in two instances the payment of bills has been made more inclusive, in line with present-day taxes.

The proposed revisions are detailed in Bulletin 504, pages 533–537, incl., and are recommended by the committee. Mr. Chairman, I move their adoption.

(The motion was regularly seconded, was put to a vote, and carried.)

Assignment 1–E—Flood Control Agreement Forms, was presented by Subcommittee Chairman W. D. Kirkpatrick (Missouri Pacific).

Mr. Kirkpatrick: The committee has reviewed the three flood control agreement forms assigned and has made minor revisions thereto for the sake of uniformity with other Manual agreements. The revisions as approved by the committee are shown on pages 537 to 541, incl., of Bulletin 504.

Mr. Chairman, I move their adoption.

(The motion was regularly seconded, was put to a vote, and carried.)

Assignment 1–F—Revision of Miscellaneous Agreements Forms, was presented by I. V. Wiley (Milwaukee Road), a member of the subcommittee.

Mr. Wiley: Your committee has reviewed that portion of Chapter 20 containing three forms of agreement which have been classified under the heading of Miscellaneous and makes the following recommendations:

Page 20–105

Form of Agreement for the Use of Railway Property By High Pressure Pipe Lines With Special Reference to Pipe Lines Carrying Inflammable Oils and Gas.

It is recommended that this form be reapproved without change.

Page 20–117

Form of License for Pipes, Conduits, Drains, Hopper Pits and Other Structures on Railway Property.

Certain minor changes are recommended in the interest of conformity with other Manual material, and obligation for maintenance of facilities has been clarified.

Page 20–133

Form of Agreement for Unloading Liquefied Petroleum Gases and Other Liquefied Gases.

Here again minor changes are recommended in the interest of conformity, and the wording of the Whereas clause has been altered slightly. The revisions in the last two forms are shown on pages 541 and 542 of Bulletin 504.

Mr. Chairman, I move the adoption of the reapproval and the revisions as above outlined.

(The motion was regularly seconded, was put to a vote, and carried.)

Chairman Patterson: W. R. Swatosh, of the Erie Railroad, acted as subcommittee chairman on Assignment 1–G, which included a study of agreements covering land.

Mr. Swatosh will present the review, following which—and without further ado—he will proceed with the presentation of the special feature which has been prepared as part of the report of Committee 20. This special feature will consist of a brief talk on the subject, "Two Essentials of Engineering Science—Mathematics and Agreements."

Assignment 1–G—Agreements Covering Land, was presented by Subcommittee Chairman W. R. Swatosh, (Erie).

Mr. Swatosh: The committee, in conformance with the assignment, reviewed the Form of Lease for Industrial Site, page 20–77; the Form of Option for Purchase of Land, page 20–123; the Form of Conveyance of Title Granting the Right to Construct and Maintain Buildings Over Railway Property, page 20–125; and the Form of Agreement for Commercial Signs on Railway Property, page 20–129.

The agreement on page 20-125 is recommended for approval without change. In the main, the revisions in the other forms consist of editorial changes in the texts thereof, and in the Whereas and Now Therefore clauses. These revisions are listed in detail on pages 542 and 543 of Bulletin 504.

With the changes made, it is the considered opinion of the committee that the forms as revised will be comprehensive in scope and in harmony as to text and form with other Manual agreements. Mr. Chairman, I move their adoption.

(The motion was regularly seconded, was put to a vote, and carried.)

Two Essentials of Engineering Science—Mathematics and Agreements

By W. R. Swatosh

Assistant to Superintendent of Construction, Erie Railroad

Every young engineer no doubt knows that the mathematics of early man probably consisted of his counting by the aid of his ten fingers—in some parts of the world they still do; he no doubt also knows that the earliest written symbols were wedge shaped or in cuneiform, used by the Babylonians, and that the Egyptians used hieroglyphics, the Greeks letters of their alphabet for number symbols, and the Romans the letters of their alphabet for the same purpose.

He no doubt further knows that the mathematics used by almost all peoples of the civilized world originated in India with the Hindus, having been obtained from them by the Arabs, who introduced them into Europe soon after the Conquest of Spain in the Eighth Century A.D. For this reason the numerals or figures which all of us presently use are called Arabic. Their refinement through the ages has enabled us to carry on our present engineering and business activities.

The average young engineer, however, does not know or realize that the genesis of the agreement or contract was the Magna Charta of England—the Great Charter. The charter of English liberties, dated June 15, 1215, but actually sealed (not signed) was delivered June 19, 1215, by King John, at Runnymede, on the demand of the Barons of England. This instrument, solemnly declaratory of the rights of the people, has for more than seven centuries been regarded as the basis of English constitutional liberty. Among its more important provisions were exemption from arbitrary arrest, trial by a jury of one's peers, a provision that justice should be neither sold, denied or delayed, and the protection of life, liberty and property from unlawful deprivation.

Present-day engineering science in the main consists of two essentials, mathematics and agreements. The latter is generally approached by the young engineer with apprehension, yet his fears are unwarranted, because an agreement is merely a plan prepared with words and as easily understood as a conventional plan prepared for a structure.

As previously stated by Committee 20—Contract Forms, its uniform forms of agreement are not intended to make "Every young engineer member of this Association his own lawyer", but rather to acquaint him with one of the engineering essentials with which he will be required to work as he assumes greater responsibilities.

The Manual forms are voluntary agreements drawn between two or more parties, for a valid consideration, to do or abstain from doing some lawful act. An agreement may or may not be in writing. Many agreements are oral. There are four essentials to an agreement:

1. Mutual assent to the terms of the agreement.
2. Competent parties thereto.
3. A valid consideration, actual or presumed.
4. Definite and lawful subject matter to be acted upon.

If any of these four essentials is lacking there is no agreement.

In closing let me state that these forms of agreements, like the Magna Charta, have withstood the test of time and use. They are practical, written in plain terms so they are easily understood. Their revision during the past year has brought them to a uniform and current basis.

Your committee therefore recommends, that each young engineer study them so that when the time comes for him to write or administer an agreement, he will be fortified with the experience and knowledge that has been placed into these recommended forms.

Chairman Patterson: Thank you, Mr. Swatosh, for a very fine talk.

At this time I wish to express my thanks to the subcommittee chairmen and to all members of the committee for their efforts and cooperation during the past year.

Mr. Chairman, this concludes the report of Committee 20.

Vice President Grove: Mr. Patterson, under your direction, Committee 20 has done another fine piece of work for the Association. I particularly congratulate you upon the leadership that you have given the committee since you took over, and for the splendid work done in reviewing your entire Manual chapter during the past year.

Your committee is now excused, with the thanks of the Association.

Discussion on Records and Accounts

(For report, see pp. 845 875.)

(President C. J. Geyer presiding.)

Chairman Louis Wolf (Missouri Pacific): Mr. President, members of the Association, and guests: The report on the regular assignments of Committee 11—Records and Accounts, will be found in Bulletin 506, pages 845 to 875, incl., and a special report on The Federal Valuation of the Railroads in the United States is published in Bulletin 503, immediately following page 413.

In the absence of Subcommittee Chairman J. B. Mitchell (Great Northern, retired), the report on Assignment 1, Revision of Manual, will be presented by M. A. Bryant, assistant valuation engineer, Missouri Pacific Lines.

Assignment 1—Revision of Manual, was presented by M. A. Bryant (Missouri Pacific), in the absence of subcommittee Chairman G. B. Mitchell (Great Northern, retired).

Mr. Bryant: The report on Assignment 1 appears in January, 1953, Bulletin 506, pages 846 to 852, incl.

Your committee recommends the following changes in the new Manual of Recommended Practice, pages 11-1 to 11-70, incl.

First: Eliminate all form numbers in Chapter 11 and substitute full titles of forms.

Second: Adoption of revised Form 1125 "Side Track Record" and addition of instructions for its use. The proposed form and text are as shown in Statement "A", pages 846–849 of Bulletin 506.

Third: Reapprovals, revisions and deletions of the subject-matter appearing on pages 11–1 to 11–70, incl. These recommendations are as presented in Statement "B", pages 849 to 852, incl., of Bulletin 506.

Mr. President, I move the adoption of the foregoing recommendations for inclusion in the new Manual.

(The motion was regularly seconded, was put to a vote, and carried.)

Assignment 2—Bibliography on Subjects Pertaining to Records and Accounts, was presented by Subcommittee Chairman A. H. Meyers (Texas & Pacific).

Mr. Meyers: This report is a bibliography of subjects pertaining to records and accounts and is found in Bulletin 506, February 1953, pages 852–857.

It contains subjects pertaining to railroad records and accounts for the period August 1951 to September 1952, consisting of 41 articles considered worthy of note by your committee.

This report is submitted as information.

President Geyer: Thank you, Mr. Meyers. It will be so received.

Assignment 3—Office and Drafting Practices, was presented by Subcommittee Chairman W. M. Ludolph (Milwaukee Road).

Mr. Ludolph: The report of this subcommittee is published in Bulletin 506, on pages 858 to 862.

Supplementing the recommendations of Subcommittee 1 with respect to the Manual, your committee recommends the reapproval, or reapproval with revisions, of the text and figures appearing on pages 11–121 to 11–161, incl., as follows:

Since the publication of Bulletin 506, the attention of the committee has been called to one omission in connection with the preparation of this report—that is, the omission of "(Fig. 1110)" in parenthesis after "(Fig. 1109)" in the paragraph beginning "Pages 11–130 and 11–131" near the bottom of page 858. Also, in the Manual, the figures appearing on pages 11–132 and 11–133 are both called "Fig. 1112." The figure on page 11–132 should be shown as "Fig. 1111."

I move the approval of the last above correction.

(The motion was regularly seconded, was put to a vote, and carried.)

For reapproval without change:

Page 11–122—Mechanical Drawing.

Page 11–124—Fig. 1104—Sizes of Sheets for Engineering Drawings, Forms and Charts.

Page 11–125—Fig. 1105—Typical Titles.

Page 11–126—Fig. 1106—Lettering.

Page 11–127—Fig. 1107—Lettering.

Page 11–128—Fig. 1108—Lines and Line Work.

Page 11–130—Fig. 1109.

Page 11–131—Fig. 1110.

Page 11–134—Fig. 1113.

Page 11–135—Fig. 1114.

Page 11–137—Fig. 1116.

Page 11–138—Fig. 1117.

Page 11–139—Fig. 1118.

Page 11–140—Fig. 1119.

Page 11–141—Fig. 1120.

Page 11–113—Fig. 1121—Methods of designating Taper, Batter, Cant, Slope, Incline and Grade.

Pages 11–153 and 11–154—Methods of Folding Drawings.

Pages 11–155 to 11–159, incl.—Specifications for Preparation of Maps and Profiles.

Page 11–160—Fig. 1132—Progress Profile.

Page 11–161—Fig. 1133—Track Chart.

I move the reapproval of the above without change.

(The motion was regularly seconded, was put to a vote, and carried.)

Pages 11–121 and 11–122—Office and Drafting Practices. Reapprove with the changes shown.

I move the reapproval of the above with changes proposed.

(The motion was regularly seconded, was put to a vote, and carried.)

Page 11–123—Fig. 1103—Shapes of Drawings.

Reapprove with the change shown.

I move the reapproval of the above with the change proposed.

(The motion was regularly seconded, was put to a vote, and carried.)

Page 11–129—Alphabetical Index.

Correct as necessary, and I so move.

(The motion was regularly seconded, put to a vote and carried.)

Page 11–133—Fig. 1112—Track Fixtures.

Reapprove with changes shown on new drawing (Fig. 1112)

I move the reapproval of the above with the changes shown on the new drawing.

(The motion was regularly seconded, was put to a vote, and carried.

Page 11–136—Fig. 1115—Water Supply and Pipe Lines.

Reapprove with changes shown on new drawing (Fig. 1115). I move the reapproval of the above with changes shown on the new drawing.

(The motion was regularly seconded, was put to a vote, and carried.)

Page 11–142—Graphical Symbols for Plumbing, Piping, Pipe Fittings and Valves, Heating and Ventilating, Duct Work, Heat–Power Apparatus, Refrigeration and Welding.

Under this heading substitute the new material shown on page 861.

I move the approval of this substitution.

(The motion was regularly seconded, was put to a vote, and carried.)

The second portion of the report of this subcommittee covers a brief description of two office machines which have come to the attention of this subcommittee during the year, as follows:

1. An electrically-operated calculating machine which will extract the square root automatically of any number within the capacity of the machine, as well as perform division and multiplication automatically.

2. A typewriter with changeable type, of which there is an engineering model which will letter tracings and produce very legible work. This portion of the report is submitted for information.

President Geyer: It will be so received, Mr. Ludolph.

Assignment 4—Use of Statistics in Railway Engineering, was presented by Subcommittee Chairman W. M. Hager (Southern).

Mr. Hager: The report on Assignment 4 appears in Bulletin 506, January 1953, pages 862 to 870, incl. It is submitted as information.

This report presents the findings of the committee in its study of several noteworthy methods currently in use for analyzing and controlling engineering department expenditures.

This completes the second of four projects undertaken by the subcommittee. There remains to be completed:

(a) A final report on the development of standard costs by statistical methods.

(b) A report on budgetary procedures.

A timely and interesting articles by L. W. Howard, subcommittee chairman on Assignment (a) entitled, "Time Studies—A key to Organization and a Tool for Increased Output for Maintenance of Way Machines", appears in the March 1953 issue of the magazine Railway Track & Structures. The article is based on the studies and investigations already completed, and which are to be broadened for a more comprehensive report to this Association at some future annual meeting.

Much thought has already been given to a report on budgetary procedures. Much more thought and study will be required to solve the manifold complexities arising in the design of a budgetary system suitable to the precise requirements of our engineering departments.

President Geyer: Thank you Mr. Hager. Your report will be received as information.

Assignment 5—Construction Reports and Property Records, was presented by Subcommittee Chairman W. S. Gates, Jr. (Chicago & Illinois Midland).

Mr. Gates: The report on Assignment 5 appears on page 870, Bulletin 506. This is a progress report, submitted as information.

In the past few years tabulating machine equipment has undergone a very remarkable technical development, which development is still going on. It is too early to say just how the engineering department can benefit from this trend.

President Geyer: Thank you, Mr. Gates. Your report will be received as information.

Chairman Wolf: Relative to the report on Assignment 6, Valuation and Depreciation, we have no reports to offer at this time on subassignments (b) ICC Valuation orders and reports, and (c) Development of depreciation data. Subcommittee Chairman H. T. Bradley, Valuation Engineer, Missouri Pacific Railroad, will present the report on subassignment (a), Current Developments in Connection With Regulatory Bodies and Courts.

Assignment 6a—Current Developments in Connection With Regulatory Bodies and Courts, was presented by Subcommittee Chairman H. T. Bradley (Missouri Pacific).

Mr. Bradley: The report of this committee is quite lengthy and needs no additional comment except for the statement made therein that elements of value prepared by the Bureau of Valuation, Interstate Commerce Commission, as of January 1, 1952, were not available at the time the report was made. These elements of value have since been released. Briefly, they show by individual Class I line haul railways, and by districts, and regions, the cost of reproduction new, cost of reproduction less depreciation, original cost, except lands and rights, present value of lands and rights, and working capital, including material and supplies, as of the date indicated. The reproduction estimates and original cost are further divided between road and equipment. These elements of value are used by ad valorem taxing authorities of many states as one of the factors considered in arriving at the assessed value of railroad properties. It is sometimes advisable to have additional information respecting these estimates, and the following data can be obtained by writing John E. Hansbury, acting director, Bureau of Valuation, Interstate Commerce Commission, Washington, D. C.;

(a) A percentage distribution of road property by states, both for the cost of reproduction new and cost of reproduction less depreciation.

(b) A breakdown of equipment by primary accounts, both new and less depreciation.
(c) The present value of land and rights broken down by states.
(d) The original cost of road and equipment by primary accounts.

In making these reproduction estimates using the so-called short form method, road property is treated as a whole and no breakdown by primary accounts is available. Copies of the work sheets used for developing working capital and other underlying data can be obtained by paying the cost of photostating.

The Land Section of the Bureau also maintains a record of unit values per square foot, or per acre, for each land zone. The last appraisal made was in 1945, which is somewhat out of date, but the information is useful for checking lease values and other purposes, and can be copied in Washington or photostatic copies obtained.

The report of this subcommittee is submitted as information only.

President Geyer: Thank you, Mr. Bradley. The report will be so received.

Assignment 7—Revisions and Interpretations of ICC Accounting Classifications, was presented by Subcommittee Chairman H. N. Halper (Erie).

Mr. Halper: In last year's report we mentioned a proposed order of the ICC relating to units of property. It is the usual procedure for the ICC to send such proposed orders to the Association of American Railroads, its Accounting Division, for review and report. Cognizant of the important engineering aspects of this order, the division appointed a working committee of engineers and accountants to study and recommend a list of units which would be in conformity with good engineering practice as well as the existing depreciation rates of railroad property. All four engineers of this working committee are members of this Association and its Committee 11. The working committee held several meetings, rendered a tentative report, and was invited to participate in the discussion of this report with a group of engineers and accountants representing the Interstate Commerce Commission. The suggestions made in the report are now being considered by the representatives of the ICC. This subcommittee will keep the Association advised of further progress.

There were several orders and cases issued by the ICC since the last report of this subcommittee in 1951 which may be of interest to engineers. These are mentioned in Bulletin 506 on page 875, with the exception of the following which was received after the subcommittee report was rendered:

By order of August 15, 1952, the ICC reissued in codified form, as of October 1, 1952, the accounting rules and regulations previously in effect as amended from time to time, and which were hereafter to be known as "Uniform System of Accounts for Railroad Companies, issue of 1952." This order was made to conform to the Administrative Procedure Act. There is no change either in the text of the accounts or in the text of instructions preceding them as they now exist. The only change is in the system of numbering. The new Classification has a prefix 10 appearing in front of all accounts and instructions. For instance, the former maintenance Account 212—Ties, now reads 10.212. Also, the Roman numerals which were applied previously to the General Accounts have been cancelled and numbers substituted therefor; thus, the investment Account Equipment, which was formerly designated as Roman numeral II is now changed to 50, which, with the prefix 10 attached, reads 10.50.

Copies of this Classification are available and may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C.

This report is submitted as information.

President Geyer: Thank you, Mr. Halper. Your report will be so received.

Chairman Wolf: This completes the reporting by the subcommittee chairmen, and I now wish to call further attention to our special report, "The Federal Valuation of the Railroads in the United States." The foreword of this monograph reads as follows:

"Committee 11—Records and Accounts, American Railway Engineering Association, presents for the information and benefit of its membership this monograph entitled 'The Federal Valuation of the Railroads in the United States,' by B. H. Moore, Valuation Assistant and Accountant of the Finance, Accounting, Taxation and Valuation Department of the Association of American Railroads. Mr. Moore is a member and Secretary of Committee 11, and formerly was secretary of the Presidents' Conference Committee on Federal Valuation of the Railroads in the United States.

"The membership of Committee 11 includes valuation engineers of the principal railroads, and for a number of years it has been suggested within the committee that such a history of railroad valuation be prepared. To attain this objective a special committee was appointed, comprising Messrs. J. H. Roach, now consulting valuation engineer of the New York Central System; F. B. Baldwin, valuation engineer, system, of the Atchison, Topeka & Santa Fe Railway; H. T. Bradley, valuation engineer of the Missouri Pacific Railroad Company; and B. H. Moore. Mr. Moore agreed to prepare a manuscript, which has been reviewed by the committee, and their suggestions incorporated therein.

"In the opinion of Committee 11, the monograph is an outstanding contribution to valuation literature, and will be valuable not only to those engaged in valuation work, but also in rate cases, income and ad valorem taxes, and related activities, both as a reference book and as an authoritative statement of the procedures of the Interstate Commerce Commission and its Bureau of Valuation, and the carriers in the initial inventory of railroad property and of its perpetuation."

Since that was printed, Mr. Moore has been made assistant to vice president of the Association of American Railroads.

The monograph was published for distribution to AREA members in Bulletin 503, and has been reprinted in separate pamphlets. Copies of the reprint, which includes 87 pages, 6 by 9 in, are available from the AREA secretary's office at a cost of $1 per copy, but with a scale of prices ranging downward for copies in multiple.

The publication has been listed by the Library of Congress, and its card was sent to approximately 5000 libraries, which is notice that the publication is available.

There have been 1000 reprints of the monograph distributed by the Public Relations Department of the Association of American Railroads to a selected list of college and university professors. In addition to this, N. D. Howard's secretary's report for the past year indicates that, as of February 1, 1953, 525 copies of the monograph had been sold to a wide variety of interested persons from the secretary's office.

The monograph lists the principal uses of valuation data by the Interstate Commerce Commission, by the railroads, and by government agencies—federal, state and municipal—and the general public.

Stated briefly, some of the principal uses made by the railroads are for protecting the company's interest in connection with tax assessments; arriving at proper insurance schedules covering properties; protecting the company's interests in rate cases; arriving at proper rentals in connection with the leasing of property; arriving at a proper basis in covering the use of joint facilities; acquisition of properties from other railroads, individuals and corporations; making estimates as to the cost of trackage rights; supplying ledger values provided for under the ICC accounting classification in connection with abandonments, sales, retirements and other changes in property; development of data to comply with the requirements of depreciation orders and rules of the Interstate Commerce Commission and the Bureau of Internal Revenue; protecting the company's interest in meeting the demands of public authorities for elimination of grade crossings; preparing data to be used in connection with approval of new construction projects; formulating plans of reorganizations, mergers, consolidations, and so forth; making application for loans; settlements of damage claims; and in complying with requirements of state commissions.

I point out these items to show that valuation is far-reaching, and affects many departments of railroads in many ways, and, therefore, we believe that railroad men generally, and others who are concerned with the problems of railroads, will find the monograph interesting and informative.

This concludes the reporting of Committee 11 to the convention, and also concludes my term as chairman.

I now turn to the members of our committee to try to express to them my appreciation for their cooperation while I have served as chairman. A chairman is only as good as the support he is given by the members. Thus, probably, I should have been a better chairman than I have been, as all members of this committee have stood behind me wholeheartedly and were always willing to tackle any new problems as well as all the old ones.

I sincerely thank each one of you, and now wish you good luck, with plenty of lively discussions and interesting reports under the able leadership of H. N. Halper, your new chairman, with L. W. Howard, vice chairman, and B. H. Moore, secretary.

I now have the pleasure of introducing to the convention the new chairman, Mr. H. N. Halper, valuation engineer, Erie Railroad. Mr. Halper, will you please stand?

President Geyer: Mr. Wolf, as you complete your term of three years as chairman of this committee, on behalf of the Association I thank you for the good work you have done, and particularly in your review of the Manual. We welcome Mr. Halper as the new chairman of your committee. The committee is dismissed with the thanks of the Association.

Discussion on Water, Oil and Sanitation Service

(For report, see pp. 427-463.)

(President C. J. Geyer presiding.)

Chairman G. E. Martin (Illinois Central): Mr. President, members of the Association, and guests: Committee 13—Water, Oil and Sanitation Services, had 11 subjects assigned to it in the last year. We have reports on 9 of them.

Subcommittee 1—Revision of Manual, has a rather long report. If you will bear with us, we will have that one first.

I appreciate the efforts of the committee chairmen in preparing the reports, and particularly the work of Subcommittee 1 on Revision of Manual, which did an enormous amount of work.

I now present to you the chairman of Subcommittee 1, who will present his report.

Assignment 1—Revision of Manual, was presented by Subcommittee Chairman H. L. McMullin (Texas & Pacific).

Mr. McMullin: The report on assignment 1, Revision of Manual, is found on pages 428-438, of Bulletin 504.

The proposed revision of Chapter 13, AREA Manual, is rather extensive and there are many items to be presented to the Association for adoption. To act on each item of proposed change would consume more of the convention's time than has been allotted or is available; besides, it is thought to be unnecessary to present each item separately. We have, therefore, grouped the proposed revisions into several categories and will present the revisions by categories. This method of handling has been chosen in the interest of time and does not preclude discussion of any proposed item which may be brought up at the time of the presentation of the category in which such item occurs. It is assumed that the proposed changes, as reported in Bulletin 504, have been read and studied by all those who are interested.

(Mr. McMullin then presented all of the various recommendations of the committee, as appearing on pages 428 to 438, incl., Bulletin 504, grouped in related categories, along with a series of motions that the recommendations be adopted. In connection with the deletion of the material on Sewage Disposal Where Sanitary Facilities Are Not Available, and on Disinfectants, Deodorants, Fumigants and Cleaning Materials, referred to on page 436, Mr. McMullin stated that this material is obsolete, and that to bring it up to date will require full committee study. With respect to the proposed changes of text under General Principles of Water Supply Service, referred to on pages 428 to 430, incl., he said that all of these changes were of minor nature and were presented primarily for the purpose of bringing this material up to date in the light of new developments.

All of the motions by Mr. McMullin were duly seconded and carried, without discussion.)

President Geyer: Thank you, Mr. McMullin. You have presented a difficult report in a very able manner.

Assignment 3—Federal and State Regulations Pertaining to Railway Sanitation, was presented by T. A. Tennyson, Jr. (St. Louis Southwestern), in the absence of Subcommittee Chairman H. W. Van Hovenburg (St. Louis Southwestern).

(Mr. Tennyson read, in full, the report as presented on page 438 of Bulletin 504.)

President Geyer: Thank you Mr. Tennyson. The report will be received as information.

Assignment 5—New Developments in Water Conditioning for Diesel Locomotive Cooling Systems, was presented by I. C. Brown, (St. Louis–San Francisco), in the absence of Subcommittee Chairman M. A. Hanson (Gulf, Mobile & Ohio).

Mr. Brown: Research is being continued to find alternate corrosion inhibitors for diesel cooling systems to supplant the commonly used alkaline chromates. This work is being done for two reasons: 1. Some users object to the possibility of persons developing skin inflammation due to handling the chromate compounds or to handling engine parts which have been in contact with the treated water. 2. The probability of a chromate shortage during a national emergency.

The extensive use of chromate compounds as corrosion inhibitors on numerous railroads without experiencing unfavorable physiological effects indicates that the health hazard is rather mild if reasonably common-sense precautions are observed.

The alternate inhibitors tested have been of the sodium nitrite-borax-phosphate type. The field testing has been of rather limited scope, but from the data obtained it appears that a substantially heavier dosage of inhibitor is required and that the protection is somewhat inferior to that obtained with chromates.

Field tests have not been conducted in all types of locomotives in current usage. Some types are considerably more difficult to protect than others. Thus, a final evaluation cannot be made until further field tests are conducted.

A number of railroads are now testing the alternate inhibitors. It is to be expected that a reasonably complete field evaluation will be available within the next two years.

This is submitted as a progress report, and is offered as information.

President Geyer: Thank you, Mr. Brown. It will be so received.

Assignment 6—Railway Waste Disposal, was presented by Subcommittee Chairman T. A. Tennyson, Jr. (St. Louis Southwestern).

(Mr. Tennyson read, practically in full, the report on Assignment 6, as published on page 440 of Bulletin 504.)

President Geyer: Thank you, Mr. Tennyson. The report will be received as information.

Assignment 7—Water Facilities for Diesel Locomotives, was presented by Subcommittee Chairman G. F. Metzdorf (Nickel Plate).

Mr. Metzdorf: The report on Assignment 7 will be found in Bulletin 504, pages 441 and 442, and is submitted as information.

This report covers water station arrangements and requirements for servicing the diesel locomotive cooling system, steam generators, water closets and lavatories. It outlines in general the amounts and kind of water requirement; the number, spacing and types of service outlets needed; and the sizes of service hose and couplings generally used. The method of water treatment is not a part of this report.

Because of the variation in sizes of, and requirements for, diesel switcher, freight and passenger locomotives, and variation in the operation requirement of different railroads, this report has been prepared to serve as a guide or bases for designing diesel locomotive watering facilities.

President Geyer: Thank you, Mr. Metzdorf. The report will be received as information.

Assignment 8—Specifications for Design and Installation of Diesel Fuel Oil Facilities, was presented by Subcommittee Chairman H. M. Schudlich (Northern Pacific).

Mr. Schudlich: This is a final report and is being submitted as information.

The assignment was divided into two parts. The first portion was reported in Bulletin 497, Vol. 53, page 266. At the conclusion of the above reference it was mentioned that the final report would cover heating, fire protection and painting, and this is found in Bulletin 504, Vol. 54, pages 443 to 454, incl.

Diesel fuel oil has depreciated in quality, and in cold climates should be heated to avoid fueling station operational difficulties. The heating can be accomplished in various ways; with steam, electricity, or hot water, providing automatic controls for safety and efficiency. Tanks and pipe lines should be insulated to conserve heat, and water neutralizing additives should be proportioned to the fuel when low temperatures prevail.

It is generally recognized that fire-fighting facilities of proper design and well maintained are very necessary for safety and uninterrupted performance of fueling plant. Spillage should be discouraged, and the oil-saturated premises should be cribbed out and replaced with gravel. Maintenance should be encouraged to avoid pooled oil from leakage, and repairs should be made in an approved manner. Properly located hydrants, provided with water fog or foam nozzles connected to a reliable and adequate water supply, are necessary for major fires, although these major catastrophies can usually be avoided by strategically located and readily accessible portable extinguishers of suitable characteristics.

Corrosion can be a serious problem for storage tanks and pipe lines; therefore metal surfaces should be properly cleaned, primed and painted, using a paint adaptable to the conditions of service. Above ground tanks should have a three coat system. Underground tanks and pipe lines should be protected with a suitable bituminous coating, and in addition be cathodically protected to prevent corrosion should there be any breaks or holidays in the paint film.

President Geyer: Thank you, Mr. Schudlich.

I notice that this report is submitted as a final report, but is for information only. Is it the intent of the committee to follow this up next year, or thereafter, looking to the presentation of Manual material?

Mr. Schudlich: As far as I know, the report is for information only.

Chairman Martin: We have no plans for that.

President Geyer: Thank you. The report will be received as information.

Assignment 9—Rodent Control on Railway Property, was presented by Subcommittee Chairman T. L. Hendrix, Jr. (Chesapeake & Ohio).

Mr. Hendrix: This report appears in Bulletin 504, pages 454 to 460, incl., and is submitted as information.

Rats are the deadliest, most destructive of all animal enemies of humanity. It is estimated that there are as many rats as people in the United States—150,000,000. Each rat will eat, destroy or contaminate around $20 worth of material each year. This amounts to a $3 billion annual loss. Even worse, rats spread typhus, infectious jaundice, ratbite fever, and fatal food poisoning. They are the reservoir of bubonic plague.

The fundamental principles of rodent control are by no means specific or peculiar to the railroad industry. Prevention of rodent infestation through rat proofing, good sanitation, and orderly storage to eliminate hiding spaces and openings and access to food, is a basic approach wherever the problem is encountered, and constitutes the best and surest means of control. However, the environment and physical characteristics of some railway properties are not always favorable to sole dependence on good housekeeping, and supplementary measures, such as poisoning, trapping and fumigation may be necessary. In this case, the employment of reputable professional pest control operators is frequently the most satisfactory procedure.

For use by railway personnel not specifically trained in extermination work, warfarin is probably the best rodenticide available. Baited with dry cereal grains, it is applicable to use with permanent bait stations. Repeated small doses act on the rodents' blood to prevent coagulation, and death due to internal hemorrages is so gentle that survivors experience no bait shyness.

So far as practicable, control work should be regarded as a continuous program, with a sustained effort to eliminate the causes of infestation rather than one of recurrent intensive rat killing campaigns. The stakes of economic loss, potential disease, and more subtle esthetic considerations, justify the effort required.

President Geyer: Thank you, Mr. Hendrix. The report will be received as information.

Assignment 10—Prevention of Corrosion of Automatic Car Washing Equipment and Facilities, was presented by Subcommittee Chairman L. R. Morgan (New York Central).

Mr. Morgan: The report as prepared by this subcommittee appears on pages 460, 461 and 462 of Bulletin 504, and is presented as information.

President Geyer: Thank you, Mr. Morgan.

Assignment 11—Means of Conserving Labor and Materials, Including the Adaptation of Substitute Noncritical Materials, and Specifications for the Reclamation of Released Materials, Tools and Equipment, was presented by Subcommittee Chairman H. E. Graham (Illinois Central).

Mr. Graham: Your committee submits as information the report on Assignment 11 which appears in full on pages 462 and 463 of the AREA Bulletin 504.

When the National Production Authority directed the railroads to reduce their requirements for critical materials to a minimum, it was necessary to substitute non-critical materials and to develop conservation methods wherever possible. A number of practices are recommended in the report where labor and material can be saved in the water, oil and sanitation services.

At the present time the supply of materials for these services is not critical, and some of the recommendations in the report may not be economical. However, for the most part, the practices are sound and can be used to advantage any time.

President Geyer: Thank you, Mr. Graham. Your report will be received as information.

Chairman Martin: Mr. President, that completes the report of Committee 13, and I again wish to thank the committee members for their fine work during the past year.

President Geyer: Thank you very much. Your committee has presented a very difficult and very helpful report in a very efficient manner. You are now excused with the thanks of the Association.

President Geyer: I want to announce that R. A. Bardwell, engineer of tests, Chicago & Eastern Illinois Railway, has been appointed chairman of the Tellers Committee to canvass the ballots cast for the officers of the Association for the ensuing year.

The secretary has been instructed to turn over the ballots to the tellers, so the names of the successful candidates can be announced at the annual luncheon tomorrow noon.

President Geyer: Gentlemen, that concludes our sessions for today. I thank you very much for your attendance at our overtime meeting. We would like to see you on the job at 9 o'clock in the morning.

(The meeting adjourned at 5:30 o'clock.)

Morning Session—March 18, 1953

The meeting reconvened at 9 o'clock, President Geyer presiding.

President Geyer: The meeting will come to order.

Discussion on Wood Bridges and Trestles

(For report, see pp. 941-967.)

(President C. J. Geyer presiding.)

Chairman C. H. Newlin (Southern): Mr. President, fellow members and guests: The report of this committee will be found in Bulletin 506, beginning on page 941. Your committee is reporting on 5 of its 7 assignments.

Under Assignment 1, Revision of Manual; Assignment 2, Grading Rules and Classification of Lumber for Railway Uses, Specifications for Structural Lumber, Collaborating with Other Organizations Interested; and Assignment 4, Methods of Fireproofing Wood Bridges and Trestles, Including Fire Retardant Paints, Collaborating with Committee 17; we are presenting progress reports with recommended Manual revisions.

Under Assignment 6, Design of Timber Pile Dolphins, we present a final report.

Under Assignment 7, Conservation, we submit a progress report as information.

The report on Assignment 1, Revision of Manual, will be presented by Subcommittee Chairman C. V. Lund.

Assignment 1—Revision of Manual, was presented by Subcommittee Chairman C. V. Lund (Milwaukee Road).

Mr. Lund: The report of your committee on Revision of Manual appears in Bulletin 506 beginning on page 942.

Specifications for Wood Piles

Your committee devoted a good deal of time to revision of this specification, and has rewritten it completely. The revised specification appears as Appendix A, beginning on page 945, and your committee recommends its adoption, with the single editorial correction that the word "Pipes" in the heading at the top of page 946, be changed to "Piles."

Mr. President, I move that the text now appearing on pages 7-1 to 7-4, incl., of the Manual, under the title Specifications for Wood Piles, be deleted, and that the specification presented as Appendix A of the committees' report be adopted for publication.

(The motion was regularly seconded, was put to a vote, and carried.)

Specifications and Design of Fastenings for Timber Trestles

Your committee has reviewed this material and recommends it be reapproved with the minor revisions printed in Bulletin 506, page 942.

Mr. President, I so move.

(The motion was regularly seconded, was put to a vote, and carried.)

Specifications for Workmanship for Pile and Framed Trestles of Untreated Material to be Built under Contract

This specification has been completely rewritten, and the scope of the subject enlarged upon to include treated timber construction, and further revised so that the specification is applicable both to work done under contract and to work performed by railway company forces. The revised specification, as recommended by your committee, is printed as Appendix B, beginning on page 949.

Mr. President, I move that the text now printed in the Manual on pages 7-7 to 7-9, incl., under the title Specifications for Workmanship for Pile and Framed Trestles of Untreated Material to be Built under Contract, be deleted, and that the specification presented as Appendix B of the committee's report be adopted for publication.

(The motion was regularly seconded, was put to a vote, and carried.)

Specifications for Driving Wood Piles

Your committee has reviewed this specification and recommends that it be reapproved with the revisions printed on pages 943 and 944, Bulletin 506.

Mr. President, I so move.

(The motion was regularly seconded, was put to a vote, and carried.)

A

Economics

In connection with its review of the material on Economics in Chapter 7, your committee was instructed by the Board of Direction to review also the material on Economics of Filling Bridge Openings appearing in Chapter 1, and the material in the Chapter on Economics of Bridges and Trestles, collaborating with Committees 1, 8 and 15, with the view to consolidating these closely related treatments of similar subject-matter. This has been done, and the revised text on the subject, presented as Appendix C of this report, is recommended by your committee for adoption. Committee 1 is concurrently recommending the deletion of material in Chapter 1 on Economics of Filling Bridge Openings.

Mr. President, I move that the material now appearing on pages 7–55 to 7–59, incl., in Chapter 7, under the title Economics, including Figs. 712 and 713, be deleted, also that the entire material printed in the Manual in the Chapter on Economics of Bridges and Trestles be withdrawn, and that the material presented as Appendix C on pages 952 to 959, incl., of Bulletin 506, under the title "Economic Comparisons: Methods of Analysis", be adopted for publication.

[In connection with this recommendation, the following typographical error in the 4 percent Interest Rate Table on page 959 should be corrected: In Col. C, fifth line from bottom, change the figure "0.00174" to "0.00181."]

(The motion was regularly seconded, was put to a vote, and carried.)

Economy Curves

The text printed on page 7–62 under this title, also Fig. 714, are superseded by the new text on the subject of economics, hence your committee recommends that the material appearing on page 7–61 and 7–62 be deleted.

Mr. President, I so move.

(The motion was regularly seconded, was put to a vote, and carried.)

Comparative Merits of Creosoted Wood Ballasted Deck and Reinforced Concrete Ballasted Deck Trestles

Your committee has reviewed this text and finds that the essential material is for the most part now being adequately covered elsewhere in Chapter 7, and therefore recommends that the material appearing under this title on page 7–64 be deleted.

Mr. President, I so move.

(The motion was regularly seconded, was put to a vote, and carried.)

Mr. President, this completes the report of the subcommittee on Revision of Manual. Certain other recommendations pertaining to Manual material will be offered under other assignments.

Chairman Newlin: Thank you, Mr. Lund.

Assignment 2—Grading Rules and Classification of Lumber for Railway Uses; Specifications for Structural Lumber, Collaborating with Other Organizations Interested, was presented by Subcommittee Chairman W. C. Howe (Bessemer & Lake Erie).

Mr. Howe: The report of your subcommittee appears in Bulletin 506, beginning on page 960.

Manual material covered in this report embraces several subjects, under which it is recommended that present Manual material be deleted, and that a brief statement be substituted with proper reference to other organizations whose published material is accepted as AREA recommended practice.

Mr. President, I move that the material now appearing on pages 7–71 to 7–75, incl., under the title, "Nomenclature of Commercial Domestic Softwoods and Hardwoods," be deleted, and the material shown in the report under this heading be substituted therefor, including the change in title.

(The motion was regularly seconded, was put to a vote, and carried.)

Mr. President, I move that the material now appearing on pages 7–75 to 7–84, incl., under the title, "Definitions of Terms Used in Describing Standard Grades for Lumber," be reapproved with the changes as printed in the report.

(The motion was regularly seconded, was put to a vote, and carried.)

Mr. President, I move that the material now appearing on Manual pages 7–84 to 7–87, incl., entitled, "Standard Lumber Abbreviations," be deleted, and the material shown in the report be substituted therefor.

(The motion was regularly seconded, was put to a vote, and carried.)

Mr. President, I move that the material now appearing on Manual pages 7–89 to 7–99, incl., entitled "American Lumber Standards for Softwood Lumber," be deleted, and that we substitute therefor the statement shown in the report.

(The motion was regularly seconded, was put to a vote, and carried.)

Mr. President, this completes the report on this assignment.

President Geyer: Thank you, Mr. Howe.

Assignment 4—Methods of Fireproofing Wood Bridges and Trestles, Including Fire-Retardant Paint, was presented by Subcommittee Chairman J. V. Johnston (Gulf, Mobile & Ohio).

Mr. Johnston: Your committee has reviewed this subject as it is contained in the Manual on pages 7–66 to 7–68, incl., and adopted in 1941.

The subject-matter has been rewritten and includes pertinent data now in the Manual and the latest information that has been developed by the committee.

It is recommended that the entire material in the Manual under this title be deleted, except Figs. 715, 716, 717, and 718, and that the subject-matter found on pages 962 and 963 of Bulletin 506 be substituted therefor.

Mr. President, I so move.

(The motion was regularly seconded, was put to a vote, and carried.)

Assignment 6—Design of Timber Pile Dolphins, was presented by C. H. Newlin, chairman, Committee 7, in the absence of Subcommittee Chairman Milton Jarrell (Baltimore & Ohio).

Mr. Newlin: Last year your committee submitted a progress report (see Proceedings, Vol. 53, 1952, pages 635 to 645, incl.) as information, following a study of the design, plans and specifications for timber pile dolphins as prepared by a number of roads, consulting engineers and public authorities. The committee has no further information to submit at this time, and requests that the 1952 report be considered as a final report on this assignment.

President Geyer: Mr. Newlin, did your committee have in mind that it might later submit this as Manual material, or has that been considered at all?

Chairman Newlin: That has been considered. We do not expect to submit this as Manual material.

President Geyer: Thank you, Mr. Newlin. This report will be received as information.

Assignment 7—Means of Conserving Labor and Materials, Including the Adaptation of Substitute Noncritical Materials, and Specifications for the Reclamation of Released Materials, Tools and Equipment, Collaborating with Committee 3–A, General Reclamation, Purchases and Stores Division, AAR, was presented by Subcommittee Chairman S. L. Goldberg (Northern Pacific).

Mr. Goldberg: The report on Assignment 7 appears on pages 963 to 967, of Bulletin 506.

This report is submitted as information, and consists of a list of suggestions which, when put into practice, will lead to some extent to the conservation of both labor and material.

The suggestions are applicable to timber bridges only, except Suggestion 1, "Good Personnel Relations," which applies in any field where there is an employer-employee relationship.

President Geyer: Thank you, Mr. Goldberg. The report will be received as information.

Chairman Newlin: Mr. President, this concludes the report of Committee 7.

President Geyer: Mr. Newlin, I thank you and your committee very much for the prompt manner in which you have submitted this report, which I am sure represented a lot of work. The committee is excused with the thanks of the Association.

Discussion on Clearances

(For report, see pp. 833 844.)

(President C. J. Geyer presiding.)

Chairman A. R. Harris (Chicago & North Western): Mr. President, members of the AREA and guests: Committee 28 is reporting on three of its assigned subjects. Our report may be found in Bulletin 505, beginning on page 833.

Mr. Fanning will report on Assignment 1, Revision of Manual.

Assignment 1—Revision of Manual, was presented by Subcommittee Chairman J. E. Fanning (Illinois Central).

(Mr. Fanning read the committee's report, as published on pages 833 and 834 of Bulletin 505, and moved that the recommendations presented be adopted.)

(The motion was regularly seconded, was put to a vote, and carried.)

Assignment 5—Clearance Allowances to Provide for Vertical and Horizontal Movements of Equipment Due to Lateral Play, Wear and Spring Deflection, Collaborating with the Mechanical Division, AAR, was presented by Subcommittee Chairman S. M. Dahl (Milwaukee Road).

Mr. Dahl: The report on this assignment is found on pages 834 to 838, incl. of Bulletin 505.

Considerable progress on this assignment was made in the last year in securing field data on the lateral displacement of equipment on both curved and tangent track. Running and static tests on selected passenger equipment were made by the AAR under the direction of G. M. Magee. Such tests were made on the Kansas City Southern, Lackawanna, New Haven, Burlington, Milwaukee, and Pennsylvania Railroads.

The field data is quite voluminous and is presently being analyzed by the research staff, AAR. Until this analysis has been completed, no report on the results can be made.

The report on this assignment this year is designed to acquaint the membership with the problem to be solved and the type of information secured in the field tests.

President Geyer: Thank you, Mr. Dahl. The report will be received as information.

Assignment 6—Methods for Measuring Railway Clearances, was presented by Subcommittee Chairman A. M. Weston (Baltimore & Ohio).

Mr. Weston: At the annual meeting in 1951 your committee presented as information a report pertaining to present practices of the railroads in measuring clearances. Included in the report was a detailed description of cars used by the New York Central System and the Baltimore & Ohio Railroad.

Since that report, the Pennsylvania Railroad has constructed a new car, and the Erie Railroad has submitted a description of a modern device which it uses for measuring clearances.

The Pennsylvania car and the Erie machine are fully described in the report on pages 838 to 844, incl., of Bulletin 505.

This is a final report, presented as information.

President Geyer: Thank you, Mr. Weston. Your report will be so received.

Chairman Harris: Mr. President, this concludes the report of Committee 28, and ends my period of service as chairman of Committee 28. I take this opportunity to thank all members of the committee for their cooperation and assistance in the work of this committee.

I should now like to introduce to you the new chairman of Committee 28—Mr. A. M. Weston, senior assistant engineer, Baltimore & Ohio Railroad.

I should also like to present to you the new vice chairman of Committee 28—Mr. E. R. Word, assistant engineer, Illinois Central Railroad.

President Geyer: Mr. Harris, on behalf of the Association I thank you for your term in office as chairman of the Committee on Clearances. You have done your job in a fine and able manner, and the Association particularly thanks you for carrying over beyond the regular three-year term to a fourth year.

The Association also welcomes Mr. Weston as the new chairman and Mr. Word as the vice chairman.

Your committee is excused with the thanks of the Association.

Discussion on Waterproofing

(For report, see pp. 823-832.)

(President C. J. Geyer presiding.)

Chairman T. M. von Sprecken (Southern): Mr. President, fellow members and guests: The report of Committee 29 is published in Bulletin 505, pages 823 to 832, incl. We were assigned four subjects, and are reporting on Assignments 1 and 3. Assignment 2, on which considerable collaboration was done by Committee 29, is covered by a report to be made by Committee 15. On Assignment 4 we have no report.

Following the report on Assignment No. 3, J. B. Blackburn of Purdue University, will give a short discussion of the final report on "Tests on Waterproofing Coatings for Concrete Surfaces," published in Bulletin 503, and on the tests being made on bituminous materials—all conducted at Purdue University.

Assignment 1—Revision of Manual, was presented by Henry Seitz (Baltimore & Ohio).

Mr. Seitz: Your committee has for sometime recognized the necessity for modernizing our Manual material covering waterproofing, and especially waterproofing materials. The current specification was developed based on the use of asphalts derived from Mexican crudes, which are no longer economically available in the markets of this country. For this reason manufacturers of asphalt products have generally looked with disfavor upon our specification, and in some instances quotations on certain types of material have been difficult to obtain.

Also, several paragraphs of the current specifications are not entirely clear, and this has resulted in varied interpretations, especially in those paragraphs pertaining to application of materials. Other features, such as methods of mixing materials, designation of sizes, etc., are considered obsolete as now written.

From the above and other considerations, your committee has revised its chapter on Waterproofing as it now appears in the Manual. We believe the changes as recommended will provide a modern specification to cover the best materials obtainable in commercial markets today without sacrificing the quality required for railroad work.

Time does not permit the reading of the rather extensive revisions, but these are as set forth on pages 823 to 828, incl., of Bulletin 505, dated December 1952.

I move the reapproval of the Manual material cited in the report, with the revisions called for, for publication in the Manual.

(The motion was regularly seconded, was put to a vote, and carried.)

President Geyer: Thank you, Mr. Seitz.

Assignment 3—Waterproofing Protection to Prevent Concrete Deterioration, was presented by L. J. Deno (Chicago & Northwestern) in the absence of Subcommittee Chairman E. A. Johnson (Illinois Central).

Mr. Deno: Your committee is reporting on tests made to determine the merits of waterproofing coatings in sealing the surface of concrete against the entrance of moisture. It is recognized that the life of a concrete structure will be extended by the elimination of moisture from the concrete mass.

This work has been in progress at Purdue University Engineering Experiment Station for the past 2½ years. Tests were made on 103 coatings, of which 85 were obtained from manufacturers of commercial waterproofing materials. The remaining 18 coatings were of an experimental nature.

At the conclusion of the tests, only 2 of the commercial coatings had retained a sufficient degree of impermeability to be considered as satisfactory waterproofing coatings. These were both basically pigmented linseed oil coatings. In addition, excellent results were obtained from 9 brands of white house paints, and in the application of raw linseed oil.

Three reports containing the detailed data on each individual coating tested were prepared and distributed to the chief engineers of member roads during the progress of the work. The final report on tests on waterproofing coatings for concrete surfaces is printed on pages 191 to 242, incl., in Bulletin 503.

Based on the results of these tests, your committee formulated an acceptance type of specification for waterproofing coatings for exposed concrete surfaces. These specifications are printed in Bulletin 505, pages 829 to 832, incl.

With the recommendation of the Waterproofing Committee, I move that these specifications be adopted as printed for publication in the Manual, with the following minor exceptions:

In Sec. F, Art. 1, in the first line, following "Sec. E," delete the word and number, "Art. 2"; and in Sec. G, Art. 1, in the first line, following "Secs. E" "and F," delete the word and number "Art. 2" after both E and F. The reference to Art. 2 in these instances is superfluous.

Mr. President, I move the adoption of these recommendations.

(The motion was regularly seconded, was put to a vote, and carried.)

Chairman von Sprecken: Mr. J. B. Blackburn, research engineer, Purdue University, has been in direct charge of the research work of waterproofing coatings for this committee. He is now engaged in making further tests on bituminous coatings.

There is quite a bit of difference of opinion as to what these coatings will do; we are trying to find out.

Mr. Blackburn will give a short talk on this subject—on the final report on waterproofing coatings—and also on the work now being done.

Tests of Coatings for Waterproofing Concrete Surfaces

By J. B. Blackburn

Research Engineer, Purdue University

At the annual meeting a year ago it was my privilege to present to you a brief report of the results of tests on approximately 100 surface coatings. The purpose of our investigation was to develop information from which a specification for waterproofing coatings could be written. This task has been completed. I would like to emphasize that there are very strict limitations on the use of the information and data contained in the three progress reports, the report of a year ago, and the final report which appears in the Bulletin 503. Anyone reading these reports should keep in mind that the problem with which we were working was the deterioration of existing concrete surfaces exposed to freezing and thawing weather conditions in which these surfaces were becoming saturated *by rain penetration or snow melt,* and spalling as the result of subsequent expansion when freezing occurred.

To combat this type of deterioration we have found that, of the coatings tested, an impermeable coating with properties similar to those of a good house paint which does not appreciably change the surface appearance, best serves our purpose. However—and this is what we would like to emphasize—if moisture is entering a structure from some unprotected surface which cannot be waterproofed, such as the fill side of a retaining wall or abutment, the application of such a coating on the exposed surfaces through which this moisture will try to escape will result in blistering and loosening of the coating from the surface, and will actually speed up the rate of deterioration of the underlying concrete.

Our data and recommendations are applicable to slowing or preventing deterioration on hand rails, bannisters, curtain walls and other thin-wall sections, and piers and columns above grade. The exposed surfaces of retaining walls and abutments may be coated if it is certain that the surfaces against which fill was placed were adequately waterproofed at the time of construction or the permeability of the concrete mass is so low that moisture is unable to penetrate it to the exposed surfaces.

Since the completion of the program on coatings for exposed concrete surfaces we have undertaken a series of tests on asphalts and tars in which we hope to develop data which will enable your committee to revise the present specifications for waterproofing and dampproofing above and below ground. With the assistance of P. D. Meisenhelder we have obtained samples of asphalts from manufacturers throughout the United States and in Mexico and Venezuela, and samples of tars from six plants in the United States. There is very little data available at present, although within the next two or three years we hope to present a rather complete report for your conderation.

President Geyer: Thank you, Mr. Blackburn.

Chairman von Sprecken: In concluding this report, I wish to say that Committee 29, Waterproofing, needs additional members. We have lost several valued members due to retirement and other causes. I wish to extend to any member of the Association who is interested in the subject an invitation to join us. Membership on other committees does not bar anyone from membership on this committee. The Waterproofing committee is one of those in which you can have dual membership.

This concludes the report of Committee 29.

President Geyer: Mr. von Sprecken, on behalf of the Association, thank you very much for the able manner in which your committee has carried on its work on waterproofing during the past year, and for the extensive work done on reviewing and revising the Manual material coming under your jurisdiction.

I am sure that the specifications which have here been adopted on waterproofing coatings for exposed concrete surfaces will be of great help in carrying on our work on our railroads.

The Association also thanks Mr. Blackburn for the research and tests he has made on this subject at Purdue University. The committee is excused with the thanks of the Association.

Will Committee 30—Impact and Bridge Stresses, please come to the platform? Committee 30 has been under the direction of J. P. Walton, engineer of bridges and buildings of the Pennsylvania, who has been ill for some time, and therefore was unable to be with us on this occasion. The report will be presented by E. S. Birkenwald, vice chairman and acting chairman, who is engineer bridges, Southern Railway System.

Discussion on Impact and Bridge Stresses

(For report, see pp. 621–623.)

(President C. J. Geyer presiding)

Acting Chairman E. S. Birkenwald (Southern): The report of Committee 30—Impact and Bridges Stresses, may be found in Bulletin 505, Vol. 54, pages 621 to 623, incl., in which four assignments are covered. The year 1952 was productive of one published report in Bulletin 503, Vol. 54, which concerns (1) stresses in four reinforced concrete bridges and (2) magnitude of the braking forces and the distribution of the forces between the running rails and concrete piles of two reinforced concrete bridges. The year 1953 promises to be more productive in that four reports on research connected with reinforced concrete and steel structures will be published.

After 15 years of structural research by the Association of American Railroads, in which Committee 30 participates, it might be well to review what has been accomplished and what lies ahead in the foreseeable future. As you all probably know, Committee 30 serves to guide the AAR research staff in planning and carrying out various structural projects having to do with steel, reinforced concrete and timber; makes recommendations for appropriations necessary for conducting this research work; and reviews the results and conclusions reached for each project under the direction of the committee, which are then presented to the Association in the form of a report.

Initially, based on the desires of the committees on timber, masonry and steel for research work, a Special Committee on Impact, predecessor of Committee 30, was established in 1938, which was composed of an equal number of members of Committees 7, 8 and 15, and had 5 assignments on steel and concrete. Of interest is the fact that one of these assignments, covering tests of short steel spans, has been completed. Another assignment "Tests of impact in columns and hangers of steel spans" showed the foresightedness of the committee in anticipating the possibility of fatigue failures in connection with floorbeam hangers.

In 1946, the Special Committee on Impact was made a standing committee, which bears the present name "Impact and Bridge Stresses". Meanwhile, several additional assignments had been given to the committee, including the assignment, entitled "Determination of stresses and impacts in timber stringer bridges, collaborating with Committee 7".

It should be pointed out that in addition to its normal functions, Committee 30 serves as a clearing house for research work desired by other committees, and approves special tests for individual railroads, a large number of which have been made. The committee, using appropriations assigned to its work, has obtained or is obtaining research data for other committees for their use in specification writing. Some examples of this kind of research work requested by other committees, are:

1. Determining the strength of reinforced concrete pipe
2. Secondary stresses in truss spans
3. Stresses in counterweight trusses of heel trunnion bascule bridges. In this work Committee 30 exercises all of its functions before turning over the completed report to the committee making the request for research data.

When one looks at an annual report of Committee 30, it dos not appear that much has been accomplished, and it is a fact that making strain measurements, compiling the test data, and drawing conclusions, take considerable time. Yet the accomplishments of the research staff over the past 15 years are impressive, as the following record shows:

1. Impact stresses in short spans up to 40 ft in length have been investigated, from which a new impact formula was derived. This resulted in substantial savings to the railroad industry in cost and use of materials.

2. From data accumulated, it was found that shorter girder spans were in line with longer beam spans, which permitted the use of the new impact formula and made further savings possible.

3. From limited data accumulated, it was found for truss spans that the 1935 AREA impact formula provided less impact than determined by measurement. It was therefore felt justified to revise the impact formula for trusses to provide somewhat greater impact until more data could be accumulated.

4. It was determined that locomotives without counterbalancing, like diesel and turbine, produce less impact than steam locomotives with counterbalancing.

5. Developed that the shortening of eyebars in truss spans could be done by heating within certain temperature ranges and upsetting, without possibility of fatigue failure. The use of this method by railroads has resulted in the deferment of many renewals and has been productive of savings.

6. Developed that the method of artificially inducing vibrations in a truss span with an oscillator did not afford a means of determining the impacts produced on a bridge by the motive power in use.

7. By laboratory testing, the proportions of the slab under a rocker shoe were determined so as to provide less varied distribution of load on the supporting masonry.

8. The fatigue strength in flexure of beams with welded or riveted partial cover plates was determined by laboratory testing, as well as a means to increase the fatigue strength of such beams by extending the cover plates further than present specifications provide.

9. It was determined by laboratory testing that cold-driven rivets did not provide as much fatigue strength as hot-driven rivets or high-tensile-strength bolts—thus making the use of cold-driven rivets undesirable in bridge structures.

10. It was determined by laboratory testing that high-tensile-strength bolts were superior to hot-driven rivets as fasteners, and by field installations that these bolts, when properly applied, did not loosen when subjected to vibration. The use of high-tensile bolts in making repairs or in field erection will undoubtedly make considerable savings to the railroad industry.

11. It was determined by field measurements that coped flanges of hangers, which produce high stress raisers, should have large fillet radii to reduce these stress raisers. This determination is most useful in modifying hangers in existing trusses to avoid hanger failures where flanges have been coped with small or practically no fillet radii.

12. As a result of failures in counterweight trusses of Strauss bascule bridges of the heel trunnion type, it was determined by field measurements where were the locations and intensity of high stress, thus permitting strengthening, and thereby reducing high stress concentrations.

13. Exploratory field tests of concrete bridges were made, which developed that theory needs to be correlated closer to the actual effect of loads on reinforced concrete slabs and frames.

14. It was determined by field measurements for the few concrete bridges tested that the greater portion of longitudinal forces, caused by braking or traction of a locomotive, is carried through the rails to the embankment. Further tests are needed to confirm this action and to determine the magnitude of the forces for which a bridge should be designed.

15. Exploratory field tests, made on a concrete pier at the ground line, indicated no longitudinal force apparent, but an increased vertical load with an increase in locomotive speed.

16. Exploratory field tests, made on several reinforced concrete piles at the ground line in existing concrete trestles, showed that lateral effects were present under moving loads and that there is an apparent increased vertical load with an increase in locomotive speed.

17. The manner in which pile loads are transferred to the supporting soil, and the distribution of loads in group piles, were determined by field testing.

18. The distribution of load and magnitude in stress in timber bridge ties were determined by field testing. While exploratory, there was sufficient evidence to revoke from the specifications of Committee 15 a complicated formula for computing these values.

19. Exploratory field testing of timber stringers in open and ballasted-deck construction has indicated the magnitude and duration of the loads carried.

Within the next year, reports will be forthcoming on dead and live load secondary stresses and live load impact stresses in double-track 350-ft long truss spans of the Santa Fe's Colorado River bridge; impacts in the structure, vertical pile loads, bending in the piles, and the effect of longitudinal braking and tractive forces on pile bents of the Nickel Plate's bridge at Fillmore, Ill., composed of beam spans on bents made of concrete filled steel pipe pile shells capped with reinforced concrete; distribution of axle loads to transverse and longitudinal steel beams on a number of bridges for use of Committee 15 in rewriting its specifications on this subject; and the capacity of reinforced concrete pipe, built to a new specification proposed by Committee 8. Should the strength capacity of this reinforced concrete pipe satisfy the requirements, the proposed specifications will be published as Manual material.

You may be interested to know that laboratory tests of five full-size reinforced concrete slabs, two of which are being removed from existing structures because of deterioration, will be soon undertaken to determine a correlation between field measurements made and reported, and the ultimate capacity of the slabs. A report of this testing will indicate if there is a need for revising the specifications to effect savings in reinforcing steel. It is hoped that sufficient information may be obtained to make possible the use of prestressed reinforced concrete slabs, which will provide details for fabrication and maintenance acceptable to the railroads.

Over the past several years, impact tests have been made on approximately 30 more girder spans. The enormous amount of field data to be analysed is now being actively worked on, and it may be expected that several reports, based on spans grouped by railroad ownership, will be forthcoming.

In spite of all of the research done and under way, it appears that many questions in regard to the behavior of timber, reinforced concrete, and steel structures still remain unanswered. Research by field testing and laboratory study affords the only way to this knowledge which may directly or indirectly provide savings in first cost and/or in maintenance. Much remains to be done in research to determine the behavior of truss spans, gusset plates, viaduct columns, and lateral bracing. Much is needed to be known about earth pressures as they may affect the design of retaining walls and abutments, as well as about long time pile loads as they may affect the design of foundations for piers and abutments. Fatigue tests are needed on timber stringers and timber bolted joints. Your committee looks forward to the prosecution of this research work with the view of obtaining the maximum savings possible to the railroad industry.

Mr. President, this concludes the report of Committee 30.

(Vice President G. W. Miller assumed the chair.)

Vice President Miller: Mr. Birkenwald, some of the most important and most extensive research work of our Association continues to be carried out under the direction of your committee. The results of this committee's work have been far-reaching as regards capacity of bridges, and our bridge engineers are now able to check the formula which they have used for many years in determining the capacity of a particular structure, and it has meant many thousands of dollars to railways in being able to operate power over old bridges and to study the effect of a diesel-electric locomotive as compared with the old steam engine.

We appreciate the leadership which you have given this work, and welcome you as the new chairman of Committee 30 for the next three years.

Your committee is now excused with the thanks of the Association.

Discussion on Masonry

(For report, see pp. 791-821.)

(President C. J. Geyer presiding.)

Chairman W. R. Wilson (Santa Fe): Mr. President, members of the American Railway Engineering Association and guests: Before giving the report of Committee 8—Masonry, it is my sad duty to express to the Association our loss and regret in the death of Lawrence Spalding, principal assistant engineer, Bessemer & Lake Erie Railroad, and a member of this committee for five years. Mr. Spalding died on August 8, 1952. His memoir is included in the report of your committee, on page 792.

A large amount of research is being done all over the world on reinforced concrete. To coordinate the work and prevent duplication of effort, the Reinforced Concrete Research Council was organized in 1948. The American Railway Engineering Association, through the AAR, supports this council financially, and our representative is E. A. McLeod, a member of Committee 8. Mr. Ruble, Research Engineer Structures, AAR, is also a member.

However, in spite of how much research is done or how much care and thought are put into the design of a concrete structure, the kind of structure you get is in the hands of the foreman who does the actual mixing, placing and curing of the concrete, and in the quality of inspection, which is often done by a rodman or transitman.

With this in mind, the members of your committee have been active in organizing schools on quality concrete. These schools, usually of two days' duration, are conducted by the Portland Cement Association, under the direction of G. H. Paris, a member of Committee 8. To date, 30 schools have been held on 17 railroads. Those attending are bridge gang foremen, assistant foremen, rodmen, transitmen, concrete inspectors, and signal gang foremen, as well as members of the engineering staff. They are instructed in the best ways of proportioning, mixing, placing and curing concrete.

P. D. Meisenhelder, AAR research engineer for concrete, has attended the majority of these schools, where he has done an excellent job of summing up at the end of the course, and answering the many questions which arise.

This brief description of the schools is given the Association to acquaint you with one of the practical ways by which the members of your committee are working for better concrete. It is our belief that these schools should be continued in the interest of improving concrete structures.

Your committee's report will be found on pages 701 to 821, incl., of Bulletin 505.

Because of the large amount of work needed in preparing for the new Manual, the work of revising our chapter was divided among the subcommittees. This work was closely coordinated by the Subcommittee on Revision of Manual, Assignment 1, whose chairman, A. C. Johnson, will now report.

Assignment 1—Revision of Manual, was presented by Subcommittee Chairman A. C. Johnson (Elgin, Joliet & Eastern).

Mr. Johnson: As chairman of Subcommittee 1, I was privileged some six years ago to present to the Association, in the form of a recommendation from Committee 8, a statement calling for certain revisions in the mechanical structure of our Manual.

During this year of 1953, this recommendation will become a reality in the complete reprinting of the Manual, and I, therefore, wish to take this opportunity, in behalf of Committee 8, to express our appreciation to the Board of Direction and the secretary's office for their willingness to expend the time, money and effort required to make this major revision possible, and for their evident unlimited desire to produce, if possible, a better working Manual.

Assignment 2—Principles of Design of Masonry Structures, Including Design of Masonry Culverts, was presented by Subcommittee Chairman R. L. Mays (Nickel Plate).

Mr. Mays: The report on Assignment 2 is to be found in Bulletin 505 for December, 1952, beginning on page 703.

Your committee recommends the adoption of the revisions, additions to and withdrawals of material now in the Manual, as indicated on pages 703-706, incl., Bulletin 505, with regard to the following subjects.

Revision on page 793 and 794 of the Bulletin: "Specifications for Concrete and Reinforced Concrete Railroad Bridges and Other Structures" (Manual pages 8–1 to 8–26, incl.), revised with provisions for the use of rail and axle steel, the addition of ASTM Specification A 305 for Minimum Requirements for Deformation of Steel Bars, and revision to table of "Sizes and Areas of Reinforcing Bars."

Mr. President, I move that these revisions, as indicated in the Bulletin, be adopted.

(The motion was regularly seconded, was put to a vote, and carried.)

Mr. Mays: Revision on pages 794 and 795 of the Bulletin: "Specifications for Design of Plain and Reinforced Concrete Members." (Manual pages 8–35 to 8–67, incl.) Reapprove with revisions for deletion of the special loading of two 90,000-lb axle loads from Cooper E 72 Axle Load Diagram, and the increase in the allowable shear, bond and flexure stresses in concrete (as the result of your committees recommendation that deformed reinforcing bars be used and manufactured in accordance with the minimum requirements for deformations as provided for under ASTM Specification A 305), and, in addition, other editorial revisions.

Mr. President, I move that these revisions and reapproval of the material as indicated in the Bulletin be adopted.

(The motion was regularly seconded, was put to a vote, and carried.)

Mr. Mays: Your committee recommends revisions to three additional items now in the Manual, and in order to expedite the handling, I would like to present these three items in one group. All of these items are to be found on page 796 of the Bulletin.

First, "Specifications for Rigid Frame Concrete Bridges." (Manual pages 8–73.1 to 8–74, incl.) Make minor revisions.

On the same page, Appendix A, "Plain and Reinforced Concrete." (Manual pages 8–76 to 8–80, incl.) Reapprove with revisions.

On the same page in the Bulletin, "Specifications for the Placement of Concrete Culvert Pipe." (Manual pages 8–123 to 8–127, incl.) Reapprove without change, pending the preparation of a new specification.

Mr. President, I move that these revisions and Manual reapprovals be adopted.

(The motion was regularly seconded, was put to a vote, and carried.)

Mr. Mays: Your committee further recommends the withdrawal of three items now in the Manual, and I would like to present these as one group.

On page 795 of the Bulletin, Sec. 309, (Manual pages 8–53 to 8–56, incl.) "Design of Girderless Flat Slab Structures for Railroad Locomotive Loadings." Withdraw, along with the two diagrams on page 8–81, as this material is obsolete.

On page 796 of the Bulletin, Sec. 312, "Design of Reinforced Concrete Arches for Railroad Loading" (Manual pages 8–59 to 8–67, incl.). Withdraw portions of this material which are out of date, and reapprove the remaining material.

On page 796 of the Bulletin: "Specifications for Reinforced Concrete Culvert Pipe" (Manual pages 8–90.7 and 8–90.8). Withdraw all material, as it is inadequate, pending the offering of a new specification now being prepared.

Mr. President, I move that this material, as indicated in the Bulletin, be withdrawn from the Manual.

(The motion was regularly seconded, was put to a vote, and carried.)

(Mr. Mays then read the short progress report on the proposed Specifications for Reinforced Concrete Culvert Pipe," beginning at the bottom of page 796, revising the last paragraph, as follows, to bring the information up to date since publication of the Bulletin:)

Tests have been made on 12 additional pieces of pipe, in diameters ranging from 36 to 84 in, and these have just been completed. This pipe was manufactured with 4500-lb maximum strength. When all test results have been compiled and the information made available, it will be used in the preparation of a final draft of the proposed specifications, which should be completed this year.

Mr. President, this is presented for information, and concludes the report on Assignment 2.

President Geyer: It will be received as information. Thank you, Mr. Mays.

Assignment 3—Foundations for Masonry Structures, was presented by Committee Chairman W. R. Wilson in the absence of Subcommittee Chairman Max Nearing (New York Central).

Mr. Wilson: The report on this assignment is on page 797 of Bulletin 505.

Since the General Specifications for Substructures of Railroad Structures is a repetition of the more comprehensive material on pages 8–14 to 8–20 of the Manual, your committee recommends that these specifications be withdrawn.

Mr. President, I so move.

(The motion was regularly seconded, was put to a vote, and carried.)

Assignment 4—Earth Pressure as Related to Masonry Structures, was presented by Subcommittee Chairman Dr. R. B. Peck (University of Illinois).

Dr. Peck: In 1951 the committee presented as information a tentative draft of specifications for design pertaining to retaining walls and abutments. These are in the Proceedings, Vol. 52, pages 384 to 393, incl. The committee requested comments and criticisms thereon. These specifications, with additions and revisions, are now submitted, in full, in Bulletin 505, pages 798 to 813, incl. They are presented with the recommendation that they be adopted and published in the Manual, and that the material which they will replace be withdrawn. That material is Sec. 310—Design of Retaining Walls, and 311—Design of Reinforced Concrete Retaining Walls, pages 8–56 to 8–59, incl., and Appendix B—Retaining Walls, pages 8–82 to 8–86, incl.

Mr. President, I move that these recommendations be adopted.

[In connection with these recommendations, the following editorial corrections are pointed out:

Pages 806, 807, and 808

To correct errors in original tracings, change word "Surcharge" in title line of Diagrams 1, 4, and 7, to the word "Fill."

Page 809

Fourth line, to correct typographical error, change designation "BC1" to "ABC1."

Page 810

To correct error in original tracing, top portion of Fig. 3, Chart 1, left-hand broken vertical line, change figure 6′, appearing vertically between A and C′, to B′.]

(The motion was regularly seconded, was put to a vote, and carried.)

Dr. Peck: This concludes the report of this subcommittee.

Assignment 5—Tunnel Linings; Design, Construction and Maintenance, was presented by Subcommittee Chairman D. H. Shoemaker (Northern Pacific).

Mr. Shoemaker: During the past three years your subcommittee has been engaged in reviewing and rewriting specifications in the Manual so that these specifications will be up to date for reprinting in the Manual in 1953. The report on Assignment 5 is contained in Bulletin 505, pages 814–818, incl.

We have three items which we wish to present to this convention:

We recommend the reapproval without change of the specifications in the Manual for lining railway tunnels with brick, pages 8–135 to 8–140, incl. We have had correspondence with the majority of the chief engineers of member railroads about this specification and it is the consensus and the recommendation of your committee that these specifications be reapproved without change, even though they are not being used for new construction. These specifications are of value in connection with repairs to present tunnels which are lined with brick.

I move for reapproval, without change, these specifications.

(The motion was regularly seconded, was put to a vote, and carried.)

Your committee recommends the deletion of the current specifications in the Manual for lining railway tunnels with metal liner plates and shotcrete, pages 8–129 to 8–133, incl.

This type of construction is not considered a structural lining. It necessarily could be used only in tunnels where there is little or no pressure on either the sides or the roof.

This type of lining prevents corrosion on one face of the metal liner plates, but the backside of the plates are unprotected. The cost of this type of lining is such that unless there are limited clearances involved it would not be generally used.

Specifications as contained in the Manual for tunnel lining are all prepared assuming that the lining is through ordinary rock formation involving no special features.

I therefore move that this present specification for lining railway tunnels with metal liner plates and shotcrete be deleted from the Manual.

(The motion was regularly seconded, was put to a vote, and carried.)

In Bulletin 505, referred to previously, your committee reports on a new specification for lining railway tunnels with concrete to replace the present specifications in the Manual on pages 8–103 to 8–108, incl. In the opinion of your committee the specification on which we are now reporting better represents current practice than the previous specification.

I move the adoption of this material for publication in the Manual.

[In connection with this recommended action, the following editorial corrections in Fig. 1 of the specifications are pointed out:

In Fig. 1, folded insert between pages 818 and 819, on first drawing appearing in lower left-hand corner, "Double Track, Solid Floor," top line of dimensions, change 7′–0″ to 6′–6″; in middle line of dimensions, change 3′–3″ to 2′–9″; in bottom line of dimensions, change 5⅜″ to 5⅛″. In third drawing from left-hand side of Fig. 1, "Plain Concrete Lining, Single Track—Tangent," correct third dimension up from bottom on left-hand side of drawing, from 2″–2″, to 2′–2″.]

(The motion was regularly seconded, was put to a vote, and carried.)

President Geyer: Thank you, Mr. Shoemaker.

Assignment 6—Methods of Repairing Masonry, Including Internal Pressure Grouting, was presented by Subcommittee Chairman R. W. Gilmore (Baltimore & Ohio).

Mr. Gilmore: Last year your committee presented a tentative draft of Specifications for Shotcrete which was published in the Proceedings, Vol. 53, 1952, pages 617 to 622, incl., requesting comments and criticisms thereon.

We have received the following criticisms and would like to amend two paragraphs as follows:

Page 620, Art. 4, fifth paragraph, second sentence; change to be more specific as follows: "These bars shall be securely wired to the anchors and spaced the same as the anchors in both directions. The last layer of mesh shall be secured by wiring to the bars."

Page 621, Art. 6, first paragraph should be changed to read: "The shotcrete shall be kept wet until at least four days after application of the final coat."

No other criticisms having been received, the specifications are now submitted with the recommendation that they be adopted with the above changes and published in the Manual, and that the material which they will replace, pages 8–95 to 8–99, incl., be withdrawn.

Mr. President, I move that these specifications be adopted.

(The motion was regularly seconded, was put to a vote, and carried.)

Your committee further recommends that the material under Specifications for Repairing Deteriorated Concrete, pages 8–99 to 8–101, incl., be withdrawn from the Manual. This has been superseded by material under Repairing and Solidifying Masonry Structures, pages 8–141 to 8–142.6, incl.

Mr. President, I move that these changes be made accordingly.

(The motion was regularly seconded, was put to a vote, and carried.)

Assignment 7—Methods for Improving the Quality of Concrete and Mortars, Collaborating with Committee 6, was presented by Subcommittee Chairman M. S. Norris (Baltimore & Ohio).

Mr. Norris: The report on Assignment 7 is in Bulletin 505, December 1952, beginning on page 819.

Last year your committee presented as information proposed revisions to include the use of air-entrained concrete in the Specifications for Concrete and Reinforced Concrete Railroad Bridges and Other Structures, pages 8–1 to 8–26, incl., in the Manual. These revisions, which were published in the Proceedings, Vol. 53, 1952, pages 623 to 625 incl., provided for: the use of types IA, IIA, IIIA portland cement and air entraining admixtures; the measurement of the air content of freshly mixed concrete with the limits of volume of entrained air specified; and, the inclusion in the Appendix of applicable ASTM references on air entrainment.

This year, in view of the proposed revision of the Manual, your committee has proposed additional revisions to these specifications. It is recommended that Sec. 103, pages 8–1 and 8–2 in the Manual, include four additional ASTM methods of testing aggregates as given on page 819 in the Bulletin. The subsections should be listed as l, m, n, and o, to follow the references in the Manual.

It is recommended that Appendix A, pages 8–25 and 8–26 in the Manual, be completely revised to include additional aggregate, steel reinforcement, and air-entrainment references; to delete references to cement tests which are included by reference in ASTM Designation C 150; and, to insert the latest dates of revision by ASTM of all of the documents involved.

After the report was printed, it was brought to the attention of the committee that the ASTM Specification for General Requirements for Delivery of Rolled Steel Plates, Shapes, Sheet Piling, and Bars for Structural Use, Designation A 6–52T, should be included in the list of references in Appendix A to complete the ASTM Specification for Steel for Bridges and Buildings, Designation A 7–50T, now included in the revised list of references. It is recommended that this reference be added.

It is also recommended that the Specifications for Portland Cement, pages 8–27 to 8–30, incl., in the Manual, be deleted. It is now proposed to refer to this specification only by serial designation in Appendix A.

I move that the Specifications for Portland Cement, pages 8–27 to 8–30, incl., in the Manual, be deleted, and that the revisions of the Specifications for Concrete and Reinforced Concrete Railroad Bridges and Other Structures, pages 8–1 to 8–26, incl., as recommended by the committee, be adopted for publication in the Manual and the specifications reapproved as revised.

That completes the report on Assignment 7.

(The motion was regularly seconded, was put to a vote, and carried.)

Assignment 8—Specifications for the Construction and Maintenance of Masonry Structures, was presented by Committee Chairman W. R. Wilson (Santa Fe), in the absence of Subcommittee Chairman R. E. Paulson (Milwaukee Road).

Mr. Wilson: The report is on page 821 of Bulletin 505, and has to do with specifications for stone masonry, pages 8–109 to 8–114, incl., of the Manual. It is recommended that these specifications be approved with the revisions as listed in the Bulletin.

Mr. President, I so move.

(The motion was regularly seconded, was put to a vote, and carried.)

Chairman Wilson: During the last few years a new technique for reinforced concrete has been developed and has attracted the attention of the engineering profession. This method appears to be well suited for use at many places on the railroad. In view of the possibilities of prestressed concrete, your committee requested an assignment for study on Use of Prestressed Concrete for Railway Structures, which was approved by the Board of Direction.

Committee 8 is fortunate in having a member who is engaged in research on this subject, and it is with much pleasure that I present to you Prof. W. J. Eney, head of the Department of Civil Engineering and Mechanics, Lehigh University, who will address you on the subject, "Repeated Loading Tests on Prestressed Concrete Beams."

Prof. W. J. Eney: Mr. President, members of the AREA: I have taken some liberties with the title of the paper as presented, and while I shall include the subject matter as outlined, I have gone a slight bit further, and the title of the paper will be "Prestressed Concrete Bridge Members for Highway and Railroad Traffic."

(Due to the status of his tests, and prior commitments, Prof. Eney's remarks were off the record and, therefore, are not included in this volume of the Proceedings.)

Chairman Wilson: Mr. President, that concludes the report of Committee 8—Masonry.

President Geyer: I can't help but thank Dr. Eney for the report that he gave us. It was a splendid message—a fine report—in my opinion.

I could say quite a little bit about the sponsors of the report, but I believe I'd better not. I can say, however, that all the money that is appropriated from this Association, or from the Association of American Railroads, comes directly out of the earnings of the railroads, and not from the taxpayer.

Mr. Wilson, your committee has done splendid work in the handling of your assignments, particularly in the Manual revision. You are now dismissed with the thanks of the Association.

Discussion on Iron and Steel Structures

(For report, see pp. 903 940.)

(President C. J. Geyer presiding.)

Chairman J. L. Beckel (New York Central): Mr. President, members of the Association and guests: The report of Committee 15 is printed in Bulletin 506, pages 903 to 940, incl. Your committee is reporting on 8 of its 11 assignments.

It is with deep regret that I report the death of one of our members. Mr. O. E. Hager, bridge engineer for the Pere Marquette District of the Chesapeake & Ohio Railway, passed away July 15, 1952. Committee 15 and the Association, his associates and a host of friends have suffered a great loss. Mr. Hager's memoir appears on page 904 of Bulletin 506.

I will call on Mr. Birkenwald to report on Assignment 1—Revision of Manual.

Assignment 1—Revision of Manual, was presented by Subcommittee Chairman E. S. Birkenwald (Southern).

Mr. Birkenwald: The report on Assignment 1—Revision of Manual, may be found in Bulletin 506, pages 905 to 914, incl.

You will note that the Specifications for Steel Railway Bridges are to be reapproved with certain revisions, and that rewritten Specifications for Movable Railway Bridges and Specifications for Steel Railway Turntables are submitted for adoption and publication in the Manual.

The committee deems certain changes essential in the Specifications for Steel Railway Bridges before being reapproved, as follows:

1. Art. 102, page 15–4, has been editorially revised to deemphasize the use of pin-connected trusses, which, as a matter of fact, are presently not being purchased by consumers. It is felt that the provisions for pin-connected trusses should be retained, since there may be occasions where the use of these trusses may be warranted.

2. Art. 443, page 15–21, has been revised by letter ballot to insure against uplift, inasmuch as there is no provision in the specifications for anchorage.

3. Arts. 444 and 445, pages 15–21 and 15–22, have been revised by letter ballot to embody the results of the AAR test data contained in Vol. 49, pp. 213 to 230, incl., and Vol. 53, pp. 91 to 146, incl. You will note that their revision embodies specifications for shoes and pedestals, base and masonry plates, and rockers and rollers.

4. Art. 535, page 15–26, has been revised editorially, inasmuch as the tolerance in the length of members from outside to outside of pin holes has to do with tension and not compression members; furthermore, this article deals with tolerance in the length of built-up members in line 5.

Mr. President, I move that these revisions to the Specifications for Steel Railway Bridges be adopted, and that the specifications, with the adopted revisions, be reapproved for publication in the Manual.

(The motion was regularly seconded, was put to a vote, and carried.)

Mr. Birkenwald: The balance of the report on Assignment 1 will be discussed by Chairman Beckel and Mr. Guerin. Mr. Beckel will treat with the Specifications for Movable Railway Bridges, and Mr. Guerin with the Specifications for Steel Railway Turntables.

Chairman Beckel: Dr. Shortridge Hardesty was unable to be here, and I will read his report on the Specifications for Movable Railway Bridges.

The Specifications for Movable Railway Bridges have been completely rewritten during the last few years. A complete revised draft appeared in Bulletin 499, January 1952, pages 522 to 591, incl., submitted as information for the purpose of soliciting comments and criticisms. The rewritten specifications are now recommended for adoption, a few changes in the 1952 draft being indicated in Bulletin 506, January 1953, pages 906 and 907.

The revision of the specifications was begun in 1935. Preliminary drafts of four sections were prepared in 1936 and 1937, and reviewed by the committee during the following years. The work was interrupted during the war. It was again taken up in

1946, studies of basic unit stresses and other fundamental considerations made, and revised drafts prepared and reviewed by the committee. Drafts of Secs. I, II, III, and V were printed as information in Bulletin 485, January 1950, pages 445 to 469, incl. A draft of Secs. IV, VII, VIII, and IX was prepared in 1950, and printed in Bulletin 492, January 1951, pages 447 to 477, incl., together with revisions in the draft printed in Bulletin 485. During 1951 the draft of Sec. VI was prepared, the other sections reviewed and put into final shape, and the draft accepted by Committee 15 at its October meeting and ordered printed as information. Credit is due H. C. Tammen for the preparation of the drafts of the sections written in 1950 and 1951.

The revisions have consisted of bringing all features of the specifications into line with current movable bridge practice, a general rearrangement of certain portions, and a basic change in design procedure. Allowable unit stresses have been increased in general, computed stresses increased by K-factors to provide for the effect of repetitions and reversals of stress, and provision made for stresses produced by the prime movers. Sec. VI, Power Equipment, now Sec. F, has been completely rewritten.

I move the withdrawal of the Specifications for Movable Railway Bridges now appearing in the Manual, pages 15–49 to 15–92, incl., and the substitution therefor of the Specifications for Movable Railway Bridges published in AREA Proceedings, Vol. 53, 1952, pages 522 to 591, incl., modified by the revisions shown in AREA Bulletin 506, January 1953, pages 906 and 907.

(The motion was regularly seconded, was put to a vote, and carried.)

Chairman Beckel: Mr. President, I would like to state at this time that Dr. Hardesty is very modest. It was through Dr. Hardesty's work, and also the work of Mr. Guerin, that this movable bridge work has been accomplished.

President Geyer: Thank you, Mr. Beckel. Your remarks will appear in the record.

Chairman Beckel: I am going to call on G. V. Guerin, Jr., to report on the Specifications for Steel Railway Turntables.

Mr. G. V. Guerin (Great Northern): Complete new Specifications for Steel Railway Turntables are printed in Bulletin 506, pages 907 to 914, incl. The present specifications in the Manual are dated 1943 and the committee prepared the new specifications to bring them up to date. The new specifications are in substantially the same form and outline as the present ones.

The committee recommends that present Specifications for Steel Railway Turntables appearing on pages 15–109 to 15–114.1, incl., be withdrawn from the Manual and that the new Specifications, as printed in Bulletin 506, pages 907 to 914. incl., be substituted in the Manual therefor. I so move.

(The motion was regularly seconded, was put to a vote, and carried.)

President Geyer: Thank you, Mr. Guerin.

Assignment 3—Design of Expansion Joints Involving Iron and Steel Structures, Collaborating with Committee 29, was presented by Subcommittee Chairman A. R. Harris (Chicago & North Western).

Mr. Harris: The report of the subcommittee will be found on page 915 of Bulletin 506.

The subcommittee has received no new material for the past year that would indicate that changes should be made in the material submitted last year as a progress report.

It is recognized that each expansion joint is a problem of design to meet some particular condition, and the details are an intimate part of the specifications. However, it is believed that the committee has presented a satisfactory classification and general details of the basic types of expansion joints.

In view of the importance of the proper design of expansion joints, and the attention they should receive, I move that the subcommittee report in full, as printed on page 915 of Bulletin 506, be accepted, and the recommendations for adoption and publication in the Manual be carried out.

(The motion was regularly seconded, was put to a vote, and carried.)

Assignment 4—Stress Distribution in Bridge Frames. (a) Floorbeam Hangers, (b) Counterweight Trusses of Bascule Bridges, was presented by Subcommittee Chairman C. H. Sandberg (Santa Fe).

Mr. Sandberg: The Subcommittee on Stress Distribution in Bridge Frames submits a report of progress in the study and investigation of the causes and remedies of floorbeam hanger failures in railway bridges.

The research work on this project is being conducted at Purdue University, under the able direction of Prof. L. T. Wyly. This project is sponsored financially by the AAR, and the research staff of the AAR assists and advises regarding the work.

A general method of analysis of rigid frames composed of members having a variable section—such as that found in floorbeam hangers and the counterweight trusses of bascule bridges—is given in Bulletin 502, pages 3 to 64, incl. The report in this Bulletin also includes the results of laboratory studies on bridge frame models of floorbeam hangers, pages 65 to 147, incl., and the results of field tests on bascule bridges, pages 148 to 173, incl. This year we plan to finish the work on this project.

President Geyer: The report will be received as information.

Chairman Beckel: Mr. D. V. Messman, who was to report on Assignment 5, is unable to be here, and, therefore, I am going to call on Subcommittee Chairman Staley to present this report.

Assignment 5—Design of Steel Bridge Details, was presented by Subcommittee Chairman G. L. Staley (Missouri-Kansas-Texas).

Mr. Staley: Your committee's report is published in Bulletin 506, January 1953, pages 916 and 917.

You will recall that a questionnaire sent out some years ago revealed a more widespread occurrence of floorbeam hanger failures than was previously realized, because the information had never before been assembled.

In order to discover at an early date any widespread occurrence of fatigue failures of other main material of bridges your committee sent out another questionnaire to all Class I railroads in 1951. The replies to this questionnaire indicate no widespread occurrence of fatigue failures which are unexplainable or which need special study beyond test programs already under way or consideration.

This report is presented for information.

President Geyer: Thank you, Mr. Staley. Your report will be so received.

Assignment 6—Preparation and Painting of Steel Surfaces, was presented by R. C. Baker (Chicago and Eastern Illinois).

Mr. Baker: The progress report of your committee, submitted as information, is given in Bulletin 506, page 917.

Your committee is also interested in other tests on the preparation and painting of steel surfaces, which the Steel Structures Painting Council is now conducting.

One of these tests is now being made jointly by the council, the AAR, and the New York Central Railroad, on the railroad's through girder bridge at 32nd St., Chicago.

This test was started July 1951 and covers 31 different combinations of cleaning, surface treatment, prime coat, and finish coat of paint.

Your committee hopes to receive valuable information from these tests for the improvement in our present-day practices of cleaning and painting steel surfaces.

President Geyer: Thank you, Mr. Baker. Your report will be received as information.

Assignment 7—Specifications for Cold Riveted Construction, was presented by Subcommittee Chairman K. L. Miner (New York Central), who read in full the report as presented on pages 917 and 918 of Bulletin 506, and then continued:

This report is submitted for information. If anyone would care to go into more details on this investigation, Northwestern University Technological Institute Research Report C–110 is a reprint of AREA Bulletin 503 of September–October, 1952, and Research Report C–109 is a reprint of the paper presented by Prof. Frank Baron at the annual meeting of the American Society of Civil Engineers.

President Geyer: Thank you, Mr. Miner. The report will be received as information.

Assignment 8—Design of Metal Culverts of 60-In Diameter and Larger, Including Corrugated Metal Arches, was presented by Subcommittee Chairman J. F. Marsh (Rock Island).

Mr. Marsh: This is a progress report presented as information. It deals with the verification or modification of the design data (gage tables for pipe) in the Specifications for Corrugated Structural Plate Pipe as prepared by Committee 1, and adopted by the Association in 1944, and includes the submittal of new tentative specifications.

This report does not cover corrugated metal arches because it was decided that further study should be made before specifications are proposed for these structures.

The committee's 1949 report, Vol. 50, pages 449–451, presented data on two theoretical approaches and gave consideration to a rational approach developed by M. G. Spangler on the Structural Design of Flexible Pipe Culverts.

Having carefully examined the theoretical possibilities the committee turned its attention toward the structural performance of existing field installations, with the hope that their performance would show either that the present design practice is sound or that it should be revised. On August 22, 1949, G. M. Magee, director of engineering research, AAR, at the request of this committee, wrote the chief engineers of all Member Roads of the AAR, asking each to report the vertical and horizontal deflections of a representative member of structures 5 ft or more in diameter, along with all other pertinent information. Data from this questionnaire have been assembled in the detailed report in Bulletin 506. The vertical and horizontal diameters of approximately 300 corrugated metal pipes of riveted and bolted construction, installed either with or without strutting in compacted and non-compacted embankment, were tabulated and charted. Approximately one-fourth of the structures were installed by jacking or tunneling the structure through the existing embankment, while the remaining structures were installed prior to building the embankment. In general, the average vertical deflection supports the design criteria for flexible structure that has been in common use. Excessive deflection in a few cases has been checked and satisfactorily explained by unusual installation conditions.

A separate study was made on 60-in diameter culverts as this is the lowest size limit in the committee's assignment, and also is in a range where the transition from riveted to bolted construction occurs.

As to the modification of the specifications, a new factor has to be considered. In 1944, when the subject specification was adopted by the Association, there were three manufacturers making the same 6-in by 1½-in corrugation. Since then, the original corrugation has been abandoned and the manufacturers are all now making 6-in by 2-in corrugations. Comparative section modulii between the two corrugations are given in the detailed report.

It is the recommendation of your committee that the following Specifications for Structural Plate Pipe (1952) be held over for one year before adoption as Manual material. Sec. E covering construction, and Sec. F covering payment have not been revised as they are now contained in Chapter 1 of the Manual, and are under the jurisdiction of Committee 1.

This specification is intended eventually to replace those sections of the specifications for Corrugated Structural Plate Culverts and Arches dealing with General, Material, Fabrication and Design now contained in Chapter 1.

References on design data are given in the detailed report.

President Geyer: Thank you, Mr. Marsh. Your report will be received as information.

Assignment 9—Use of High-Strength Structural Bolts in Steel Railway Bridges, was presented by Subcommittee Chairman A. G. Rankin (Texas & Pacific).

Mr. Rankin: This subcommittee's report is divided into two parts.

(a) The first part covers additional field test installations of high-strength structural bolts in a climate where extremely low temperatures occur, together with comments on recent inspections of all field test installations. This portion of the report is submitted as information.

(b) The second part is a result of the superior behavior of these high-strength bolts over a period of four years. It is recommended that the Specifications for Assembly of Structural Joints Using High-Tensile Steel Bolts in Steel Railway Bridges, which were presented as information in AREA Proceedings, Vol. 53, 1952, page 607, be adopted and published in the Manual with the revisions noted on page 940 of AREA Bulletin 506.

Mr. President, I move the adoption of this revised specification.

(The motion was regularly seconded, was put to a vote, and carried.)

Chairman Beckel: Mr. President, this concludes the report of Committee 15, and also my term as chairman of the committee. It has been a privilege and a pleasure during the last four years to serve both the Association and the committee in the capacity of chairman. I wish to take this opportunity to thank each member of the committee for his cooperation and assistance during these years.

It gives me great pleasure to introduce to you at this time the new chairman of Committee 15, Mr. J. F. Marsh, engineer of bridges, Chicago, Rock Island & Pacific Railroad; and the new vice chairman, Mr. A. R. Harris, engineer of bridges, Chicago & North Western Railway. I wish to extend to them my best wishes for a successful term of office.

Mr. President, this concludes the report of the Committee on Iron and Steel Structures.

President Geyer: Mr. Beckel, we thank you and your committee for the very complete report which you have just submitted. I also wish to thank you on behalf of the Board of Direction and our Association for extending your usual three-year term as committee chairman an additional year. You have done splendid work throughout your four years as chairman of this committee.

We welcome Mr. Marsh as the new chairman of this committee, and Mr. Harris as the new vice chairman.

Your committee is excused with the thanks of the Association.

We are adjourned until 2:30 pm.

(The meeting recessed at 12 o'clock noon.)

Annual Luncheon

Grand Ballroom—12:30 p.m.

Wednesday, March 18, 1953

Following the luncheon, President C. J. Geyer arose and said:

I understand there have been several requests that we open the meeting by singing "The Star Spangled Banner." Will everybody rise and sing one verse of our National anthem?

(Singing of "The Star Spangled Banner" by the audience.)

President Geyer: Fellow members of the American Railway Engineering Association, ladies and honored guests, it is a great pleasure to have all of you with us here today on this occasion of our annual convention luncheon.

At this time I want to introduce the honored guests here at our speaker's table, some of them members of our Association and some not. But they are all interested in and believe in the economics of railway transportation.

(President Geyer then introduced the 19 guests at the speaker's table, following which he introduced the committee chairmen of the Association, who were seated at a second speaker's table immediately in front of and parallel with the main speaker's table.)

President Geyer: Some few years ago in the affairs of this Association—and not very many years ago, either, the ladies were admitted to the August gatherings of this Association. Prior to that time it was against the rules to have them at our meetings. But we are honored today in having them with us. At the President's wife's table, immediately in front of us, are the wives of the officers of our Association, the wives of the members of the Board of Direction, and the wives of some of our past presidents. We also see other ladies through the audience—wives of our members and our guests. We appreciate having you with us; it has made this a far better convention than it would have been otherwise.

I know you will all be interested to know how many are registered at our convention. As of noon today we had 1208 members and 498 guests registered, for a total attendance of 1706. We have 1184 people at this luncheon.

Everyone is also interested in the results of our election of officers. Our incoming officers are the ones to whom we look to keep the wheels rolling in this Association, and it is a great pleasure to announce the results of our annual election.

(President Geyer then announced the results of the annual election—as are noted in the Teller's report appearing on page 1270.)

President Geyer: Ladies and gentlemen, it has been our general custom in the past in selecting a speaker for this occasion to invite a man from our own circles—our own railway circles. We have been unusually fortunate in having fine messages from those railroad people. However, it seemed to me that occasionally we should have a speaker from outside of our own circles, who would talk in a different language from that we know on the railroads.

You will see from your programs that on this occasion we have such a speaker—Dr. Francis Pendleton Gaines, president of Washington and Lee University. Dr. Gaines does not know many of you people, and, in all probability, only a few of you in the audience know him. I will, therefore, introduce you to each other.

Dr. Gaines, this is the audience—officers from every railroad on the North American Continent, and from many railroads in foreign lands, officers and technicians of our allied railway supply industry, professors from colleges interested in railway transportation, consulting engineers from private practice, and their ladies. No finer group of people exists anywhere.

Audience, this is Dr. Gaines. I will not relate his background, his honors, his achievements. You can read them in "Who's Who." I will tell you, however, that he is the successful president of one of our great universities, the university that was made possible through the generosity of the Father of our Country, George Washington, and which was later headed by that peerless man, General Robert E. Lee, until his death a leader and an example of a good citizen.

Ladies and gentlemen, it is indeed a great pleasure to present to you Dr. Francis Pendleton Gaines, the president of Washington and Lee University.

Annual Luncheon Address

Hand and Spirit

By Dr. Francis Pendleton Gaines
President, Washington and Lee University

Mr. President, ladies and gentlemen: I wish first of all to acknowledge my pleasure at that fine introduction, by which I have now enlarged my circle of friends by at least 1184.

It was different from the introduction my good Kentucky friend, Senator John Sherman Cooper, received last fall. That fine and able man, who was on our campus recently, told me that in the campaign, which ended that recent memorable November date, he was running for United States Senator, and that one of his best friends was running for Congress in the same party, and they campaigned together in the Congressional district.

On one occasion there was a large audience gathered. The chairman was a wheelhorse of that party, and he rose to the occasion magnificently. He said, "Ladies and gentlemen, I have the honor of presenting a man of uncommon distinction. His distinction is no greater than his character. His character is no greater than his friendship. He is the friend of labor and the friend of business. He is the friend of the young fellow just starting on life's long journey, and he is the friend of the older person seeking serenity as that journey draws to an end. He is the friend of the farmer who tills the soil, and he is the friend of the veteran who offered his blood to water that soil. He is an acknowledged authority on every domestic question, and he has made brilliant contributions to the national questions." Then he turned to the two men and asked, "By the way, which one of you guys wants to speak first?"

I am honored by this participation for a few brief minutes in the deliberations of one of America's competent and important groups. I regret my complete inability to say anything technical. As a man who took his own degree in Contemporary Literature, and who has been for 27 years a college administrator, my knowledge of right-of-ways and hot boxes would not be consistent with your own.

I am reminded of a minister in my own state, a lovely soul who has an excellent church. One of the members of his church was a gifted person who came to church regularly and sat very close to the front, turning a responsive face to the minister, positively inspiring him by his sympathy and cooperation.

However, after the minister on one occasion had announced a series of what he called "Six Sermons on Sin," this member didn't show up for one of the series. The minister was a little bewildered, and perhaps a little disturbed.

He met this fine member of his church on the street, and made a gentle sort of inquiry as to why he hasn't been attending church. The man threw his head back and said, "Look here, Doctor, let's get this straight. When you're talking about Job or the Epistles, or the Gospel according to Matthew, I'm going to sit at your feet and learn gladly, but when you begin to talk about sin, well, I just naturally know so much more about that than you do that there is no use of my wasting my time."

Anything that I might say about engineering would certainly be a waste of your time, with the possible exception—of which Mr. Geyer's introduction reminded me—that I might bring a small but significant testimonial of our Southland.

When Robert E. Lee surrendered an army on the field at Appomattox, he lost his job, he lost his profession, he yielded his country, he yielded his cause. He had already lost his fortune. Life spread out before him as though it were a continuing pathway for a defeated man.

He was not defeated. He turned aside from many remunerative positions and took the presidency of a small college, and on the campus of that small college he dreamed of rebuilding his Southland, which was not only prostrate from a war that had been lost, but which had been fought on its own soil. As the first step of rebuilding his Southland, he created a school of engineering. He knew that the blueprint of that civilization which must be constructed, and which must be constructed well, was the task of engineering.

And so history becomes prophecy, and if you ask me what kind of a civilization we will have 75 years from now, I will say that the answer, to a large extent, is in the hands of the engineers. But perhaps the answer is larger than we may think.

Because I know nothing of engineering, I venture to bring to the consideration of this gathering some of the larger fields in which our common thought might well be engaged—fields that, from one point of view, might seem remote from yours, but which are still the problem of the engineer.

I venture to present a thesis which I have in no sense completed, and toward which I struggle imperfectly, but a thesis that lures me on with some real promise of glorious results if we can ever work it out. I want to talk about "The Central American Idea", as engineers might look at it.

What is the Central American Idea? I wish I knew. The editor of a magazine once proposed that question. He invited his readers to send in, in a few well chosen words, their thoughts as to the Central American Idea.

That reminds me of a story I heard that Governor Stevenson told—and he does tell them delightfully. It is about a little boy who appeared as an amateur on a radio program, and in the course of the program the master of ceremonies offered the little boy a handsome prize if he would finish this sentence—"I like this radio program because."

Well, the little boy wanted the prize. He worried about the sentence. He took it into deep cogitation in his youthful head, and finally he said he was ready. The master of ceremonies, with a great radio audience listening, said, "All right, Johnnie, what is it?"

The boy said, "I like this program because when its over, the Lone Ranger comes on."

Well, going back to the editor, he had this idea of inviting people to fill out this sentence, "The Central American Idea is—." And he got a perfectly bewildering variety of replies. There seemed no unity, and yet, when he analyzed them, he found that every one of them had one word, or the equivalent of the word, and that word was "freedom." In that abstract term somehow resides what that audience decided as its Central American Idea.

I have not attempted to try to define freedom. If you will look at Noah Webster's great book, you will find 17 definitions of the word, "freedom," and you will find it in quotations that run into many hundreds. Some rainy day at home, when you want to forget the problems of engineering for a while, get your dictionary and read what it says about freedom. And yet, for all that magnificent involvement of our philosophy of life, everybody in this room knows what we mean when we say that freedom is the Central Idea of America.

We mean the ancient freedoms which were our forefathers' dreams, for which they dared and for which some of them died. We mean the freedom of opportunity—or you would call it freedom of economic enterprise. We mean the freedom of speech. We mean the freedom of thought, which we educators would call the freedom of inquiry. And we mean the freedom of conscience, by which a man approaches God through the processes that best satisfy his own soul.

The thesis that I have been trying to develop is that those freedoms are essentially one, and yet they are independent of each other, and if one of them dies, all of them die.

I ventured to project myself this far along the thesis, that freedom of enterprise—which we might call the most material of them all—is their immediate servant. Freedom of the soul we might call the most spiritual of them all. Therefore, I have tried to say that under the American system, the creative hand becomes ministrant unto the spirit, and it is that thesis which I would like to explore with you for a little while.

I submit that as we think about the fact that the material freedom, as we know it, serves the spiritual freedoms which we covet, we may remember one thing—that it is the ownership of property made possible for every American, but in no sense guaranteed to every American, which, more than any other earthly thing, emphasizes and enlarges the inherent dignity of man.

As I explore my thesis, I find that in many ways the first instinct of a little baby—and those of you who are fortunate enough to have children, and those of you who are much more fortunate to have grandchildren, will recognize that fact immediately—is what we call "possession." When you give him something, he clings to it. Perhaps you give him a little piece of candy; you have difficulty in taking it away from him, and one of your administrative problems will be to keep him from taking away Little Sister's piece of candy. "This is mine," he says, and there is a little stiffening of pride, and a little development of the soul when the little boy realizes that something upon which he can put his hand is incontestably his own.

The same instinct is reflected in the story of American history. The glory with which we stood and saluted with the singing of "The Star Spangled Banner" was confined not only to those moments when "The rockets' red glare, the bombs bursting in air, gave proof through the night that our flag was still there." It was also reflected in the spirit of our pioneers—perhaps a young boy and a young girl who joined hands under the eyes of God and crossed the wildernesses, crossed streams that had no bridge. The engineers hadn't gotten there yet. In some wilderness they felled the trees and tilled the soil and built a little cabin; a little cabin, if you please, ten by sixteen, and stood and looked at it, with more pride than Arthur ever looked upon Camelot, and with a greater feeling of security than George Washington ever had as he looked upon Mount Vernon, because it was the product of their hands. The title of it was to be contested by no man, and the estate was incorruptible, and ineffably rich, because it was theirs.

They became great, and the country we have is the kind of country that they built. The dimension of their personalities came from the fact that this was a country in which endeavor made it possible for them to feel that they were a part, and to feel that they had achieved.

I could support my thesis from a religious viewpoint. The loveliest dreams that God ever gave any man, I suppose, were given to the prophet Isaiah, and when the prophet, almost at the end of his great vision, looked across the troubled centuries unto a glory that is still ahead of us, and saw that this sinful world would come to tranquility and brotherhood and—God grant it—to peace, almost the climax of that vision of splendor was the fact that in that day men would own things.

He said it with such emphasis that he had to say it positively and then say it negatively. He said, "And they shall build houses, and inhabit them; and they shall plant vineyards, and eat the fruit thereof. They shall not build, and another inhabit; they shall not plant, and another eat." This is a basic American doctrine.

Although we fear to mention the word "Communism," because it has become synonymous with cruelty and brutality, there is still a sort of feeling that if we could forget the bloodshed and brutalities that discolor that word, it is still the ultimate idea that everybody shall own everything, and nobody shall own anything, if you can work that paradox out.

We have become great and responsible people. The frontiers are all gone, they say. The rivers are bridged; the mountains have been crossed; the engineers have been at work.

One life insurance company, about two weeks ago, put out an annual statement and reported that it serves 33 million American people with protection that amounts to more than $51 billion. The bank stocks and the corporate stocks that our people own are all eloquent testimony that vision still lives, and that we still have frontiers.

One time a farmer took a load of produce to an insane asylum, and an inmate who was trustworthy most of the time went to help the farmer unload at the dining room. The farmer wanted to be friendly, and he said to the inmate, "Did you ever work on a farm?"

"Sure," replied the inmate.

"Did you like it?" asked the farmer.

The inmate said, "Not a bit. Did you ever live in an insane asylum?"

The farmer said, "No."

The inmate said, "Well, I'll tell you something. It's a damned sight better than farming."

If security and material comfort were all that life had to offer us, the fellow might have been right. It is the farmer—or the engineer—who takes the hazards and sweats and creates. The man might be right. If security and three meals a day and heat against cold and a roof against the rain were all that life had to offer us, he would be correct, but it offers something immeasurably greater—the privilege of our own achievement, of our own tradition, of our own development as the children of God.

I submit just one other thesis, and that is that the material freedom serves the spiritual freedom, or the hand becomes the servant of the soul. It is the struggle for these material things that produces—perhaps as much as anything else—that priceless by-product we call character.

As an educator I am supposed to be concerned about character. It is a part of my commitment to my country and to my God that we try to develop character. I have given some thought to it, and I have decided that most people define the word in less than half its full context, and with what is possibly the least important.

Whenever we say that a man is a man of character, we immediately hang around his neck a necklace of "nots." He does not get drunk—publicly. He does not steal—or he hasn't the courage. He does not run away with his neighbor's wife; maybe he's afraid of his neighbor. But it is a long series of what he does not do.

Of course, please don't let me be misunderstood. There is a character that is strong to resist, and I do hope that we will never minimize the power of a man to rise and say, "No, I'm not that kind of person." But there is another character that is strong to avert and strong to progress and strong to triumph.

When I was a college boy, a long time ago, a professor said something about character. One of the students asked him for a definition of character. He said, "I'll give you one. You keep it until you get a better one." That was more than four decades ago, and I am still carrying it around with me. The professor said, "Character is an inner force that enables a man to carry out a worthy resolution when the mood in which the resolution was born has passed away."

I have been given to think that is the best definition of character—the inner force that enables us to carry out that good resolution when the mood in which the resolution was born no longer inspires us.

I presume there is not a person in this room who doesn't know moods in which powerful and noble intentions are created. A great voice in poetry or song inspires us. We suddenly live on a lofty plane. Or a bottomless remorse rebukes us—we never will do that again. Or the sweet face of a little child that is ours looks up at us with trusting eyes, and we are suddenly aware of a terrible responsibility—walking the rest of our days in the gaze of those little eyes. Or we stand for a tragic moment beside an open grave, soon to be filled with the form of one we loved with all our hearts. Then we say, "There is nothing I can do now except to be worthy."

The mood of heavenly purposes claims us, but the great voice dies in our ears. The Monday morning contrition is forgotten because we are so busy. We are in the march of the world, and we have left the peace of the cemetery for the clamor and confusion of the city. And what becomes of the purpose of the resolution, of the nobility of our dedication? It depends on how much character we have. That's all.

Now, character comes by struggle. In the struggle for the material things of life, we are involved in planning and frugality, and self-denial. Suddenly, as by-products of that, we have developed the man or woman, or group of men or women, who are capable of denying the impulse of the moment, the desire of the present, for that remote excellence to which they have pledged themselves. Through these things we build a greater people.

If I have belabored the point in developing this thesis—which I have certainly not completed, even for myself—I can only remind you that I am talking about the Central American Idea, and the Central American Idea is that our material triumphs ultimately define their fruitage and their eternal conservation in these spiritual matters. I have no doubt that this is the Central American Idea, and I think I can prove it to you. I will go through ignorance to wisdom, if you will permit me.

When the great democratic idea swept the western world in the latter part of the 18th Century, the slogan on the lips of those great dreamers was "the rights of men."

We stand up on our hind legs and calmly survey great stretches of the universe, and we call ourselves "Lords of Creation," and insist upon our rights. And so the slogan went over the hopeful democratic world.

You remember when the final charter was written. A young Virginian (just 33 years old, let me remind you) sat down in the city of Philadelphia and began to write with a quill pen, and he wrote the adequate words of our democratic hope for all time. He said, "We hold these truths to be self-evident, that all men enjoy certain rights of men, and that among these rights of men are life, liberty and the pursuit of happiness." That was a great statement that Jefferson made, wasn't it?

And you know, as well as I do, that he didn't say anything in the world like that, and that I credited him with a wholly fictitious authorship. What Mr. Jefferson said that night was, "We hold these truths to be self-evident, that all men are created equal, and are endowed by the Creator with certain inalienable rights. Among these rights are life, liberty and the pursuit of happiness."

Incontestable rights? Not if you are in accord with the Central American Idea. It is a trust you hold from the Creator, given to you. "I gave the talents for you to manage, for you to increase, for you to enrich, for your creative hand to turn back to the spirit that received them from God, and must give final accountability unto Him."

And the question is raised with us, "What have you done with the endowments I gave you—your liberties, your efforts, your life?"

President Geyer: Dr. Gaines, it was certainly a great tribute to our organization to have you come here and deliver that message to us today. I'm sure that this group of railroad people understands and agrees with the basic thought of your message, and that is that there is no division between personal rights and property rights—they are one and the same thing. Engineers must protect them, if we would hold our liberty.

(The luncheon adjourned at 2:40 o'clock.)

Afternoon Session—March 18, 1953

The meeting reconvened at 2:50 pm, Vice President C. G. Grove presiding.

Vice President Grove: Gentlemen, the meeting will come to order.

The first report this afternoon will be that of Committee 17—Wood Preservation, of which W. F. Dunn, Sr., tie and timber agent, Southern Railway System, Washington, D. C., is chairman. Will Mr. Dunn and members of his committee please come to the platform and present their report?

Discussion on Wood Preservation

(For report, see pp. 701-752.)

(Vice President C. G. Grove presiding.)

Chairman W. F. Dunn, Sr. (Southern): Mr. Chairman and gentlemen, it is with regret that we advise the Association that Committee 17 has lost from its membership, by death, Dr. W. F. Clapp, Mr. J. W. Reed, and Dr. Hermann von Schrenk. (Memoirs on Dr. Clapp and Mr. Reed follow; a memoir on Dr. von Schrenk appears in the Memoir section of this volume.)

MEMOIR

William Frederick Clapp

William Frederick Clapp, who died on December 28, 1951, was born in Cambridge, Mass., October 31, 1880. He attended Harvard College and is listed as a member of the Class of 1908 in Science.

While still in college he acted as an assistant curator of Mulluscs. In 1912 he became curator, a position he held until 1923.

During this period he wrote a number of monographs on Mulluscs and became particularly interested in many aspects of marine borer activity. This led to his appointment as biologist, Marine Piling Investigation, Natural Research Council.

From 1924 to 1930 he was assistant in Marine Biological Research at Massachusetts Institute of Technology, and from 1930 to 1937, lecturer in the Department of Biology.

In the early Thirties he established a laboratory devoted to a new development in applied biology–biological engineering. At first located in an old schooner moored in Duxbury Bay, the laboratory was later transferred to its present location at the Clapp summer home at Duxbury, Mass.

Although the work of the laboratory was never carried out on a commercial basis, its reputation rapidly expanded. In 1947 it was incorporated as a non-profit corporation for scientific research, with Dr. Clapp as director and a staff of 13 assistants.

Dr. Clapp had served many important companies in the field of marine protection throughout the United States and Central and South America. Since 1934 he had been biologist, New England Piling Investigation, and more recently had been working on conditions in New York Harbor.

In the course of his work Dr. Clapp travelled extensively .and acquired an international reputation as an authority on the protection of marine structures. One of his most important accomplishments was the organization of a continuing survey of the activities of marine organisms that covers over 300 harbors, extending from Alaska to New Zealand and from Newfoundland to Brazil. The examination of monthly samples from these testing stations gives a continuous record of marine borer activity, and warns of any dangerous conditions.

Dr. Clapp joined the AREA in 1935 and has been a member of Committee 17—Wood Preservation, since 1937. He acted as chairman of the subcommittee on Destruction by Marine Borers. His wide experience and authoritative knowledge has been of great assistance to this committee.

Dr. Clapp's personal life was as colorful as his professional one. He was interested in music and sang professionally for many years. He was also keenly interested in all athletic events, having been active in that field when in school.

In 1918 he married the former Nellie A. Mowry. They had no children.

MEMOIR

John Watson Reed

John Watson Reed, who died of a heart attack on December 3, 1952, was born May 22, 1899, at DuBois, Pa. He was graduated from Indiana State Normal School (Indiana, Pa.) in 1920, and from the University of Pittsburgh in 1927 with a Bachelor of Science in Mining degree.

Mr. Reed entered the service of the Pennsylvania Railroad on June 15, 1926, on the Panhandle Division, as an assistant on the engineering corps. He was promoted to assistant supervisor of track on May 1, 1929, on the Allegheny Division, and then served in that capacity on various divisions on the Central Region of that railroad.

On July 1, 1936, Mr. Reed was promoted to master carpenter of the Buffalo Division, and later served as master carpenter of the Pittsburgh Division. It was from the latter assignment that he was made an assistant engineer in the office of the chief engineer maintenance of way at Chicago on February 15, 1945.

Mr. Reed's extensive knowledge of bridges and buildings enabled him to render outstanding service to his company, and he had much to do with training young supervisors of structures on the Western Region of the Pennsylvania.

Mr. Reed became a member of the American Railway Engineering Association in 1946, and a member of Committee 17—Wood Preservation, in 1948. A man of high ideals and unquestioned integrity, he was a member of the Riverside Presbyterian Church, Riverside, Ill.

Mr. Reed is survived by his wife, Mrs. Dorothy Klingensmith Reed, and two daughters, Sara Jean Reed and Mrs. Margaret Reed Guy.

Chairman Dunn: The report of Committee 17 is published in Bulletin 505, beginning on page 701. For this fiscal year we have 11 assignments, and are offering 7 recommendation and progress reports.

Because they contain new material for the Manual, we will first offer reports on Assignments 6 and 8.

I will ask M. S. Hudson to present the report on Assignment 6, New Impregnants and Procedures for Increasing the Life and Serviceability of Forest Products.

Assignment 6—New Impregnants and Procedures for Increasing the Life and Serviceability of Forest Products, was presented by Subcommittee Chairman M. S. Hudson (Taylor-Colquitt Co.).

Mr. Hudson: Subcommittee 6 has studied during the past year seven new preservatives, and has come in with recommendations that five of these be accepted as standards of the Association.

Information on these preservatives will be found on pages 739 through 747 of Bulletin 505.

Two of the preservatives have previously been presented to this Association as information, in 1949; they are pentachlorophenol and copper naphthenate. In addition, three other water-soluble salt preservatives are being recommended as standards of the Association. They are chromated zinc arsenate (which is known commercially as Boliden Salts); acid copper chromate (which is known commercially as Celcure); and copperized chromated zinc chloride.

Mr. Chairman, I move that the five preservatives named, specifications for which appear on the pages indicated in Bulletin 505, be accepted as standards of the Association.

(The motion was regularly seconded.)

W. H. Fulweiler (Consulting Chemist): Mr. Chairman, since the preparation of this report, it has been brought to the committee's attention that one of the preservatives included in the previous motion—chromated zinc arsenate—is a proprietary product covered by patents that have not yet expired. Therefore, I am moving an amendment to the motion to delete from the motion reference to chromated zinc arsenate as given on pages 740, 741 and 742 in Bulletin 505. It is necessary under the rules for the Manual to delete this.

Mr. Hudson: The amendment is accepted. There is now a motion to accept as standards, pentachlorphenol, copper naphthenate, acid copper chromate, and copperized chromated zinc chloride.

Vice President Grove: Gentlemen, you have heard the motion, and the amendment to the effect that the portion of the report headed Chromated Zinc Arsenate will not be included in the Manual. Are there any questions?

(The motion was put to a vote, and carried.)

Mr. Hudson: The committee also offers—as information—the data given for chromated copper arsenate, which is Green Salt, and for ammoniacal copper arsenite, which is known as Chemonite.

In addition, the committee presents as information, data on lignite tar creosote on page 746, and on the wood preserving oil manufactured by a Pacific Coast company, on page 747. Then there is also given some information on the use of a new process for cleaning wood that has been impregnated.

This completes the report of Subcommittee 6.

Chairman Dunn: I will ask W. W. Barger to present the report on Assignment 8, on Creosote Specifications.

Assignment 8—Review the Specifications for Creosote, Particularly with Respect to Limitation of Residue Above 355 Deg C, and Other Revisions Resulting from Changes in Process of Manufacture, was presented by Subcommittee Chairman W. W. Barger (Santa Fe).

Mr. Barger: The Subcommittee on Assignment 8 is offering for your approval at this time a revised Specification for Creosote, and revised Specification for Creosote-Coal Tar Solutions. These revised specifications are published on pages 748–751 of Bulletin 505.

Mr. Chairman, I move that these two specifications be approved as standards and published in the Manual, replacing the present specifications on Manual pages 17–21, 17–22, and 17–23.

(The motion was regularly seconded, was put to a vote, and carried.)

Mr. Barger: That completes our report on this subject.

Chairman Dunn: Mr. Chairman, our next report, including recommendations, is submitted for adoption under Assignment 1—Revision of Manual, and I will ask C. S. Burt, chairman of the subcommittee handling this assignment, to present the report. Editorial changes and deletions will be pointed out as this report progresses.

Assignment 1—Revision of Manual, was presented by Subcommittee Chairman C. S. Burt (Illinois Central).

Mr. Burt: The report on Assignment 1 begins on page 702 of Bulletin 505. As indicated therein, your committee has made a comprehensive study of its entire chapter in the Manual, and recommends a number of deletions from it, and additions, as well as a number of revisions and reapprovals of Manual material.

As presented on page 702 of the Bulletin, I first call your attention to the three following documents in the Manual: Wood Preserving Fundamentals, Wood Preserving Plant Practice, and Forms for Reporting Inspection of Wood Preserving Operations and Results. In order to bring these three documents entirely up to date, and to include reference to the three additional preservatives, it is a recommendation of the committee that all three of these documents be deleted from the Manual, and that there be substituted therefor, under the main heading, "Wood Preserving," the material presented in Exhibit A on pages 704–707 of the Bulletin, and, Mr. President, I so move.

(The motion was regularly seconded, was put to a vote, and carried.)

Mr. Burt: May I say it is appreciated that those members who are especially interested in this particular chapter have reviewed the new material that is now being offered for adoption, but by way of explanation, it might be stated that to rearrange this material as now proposed will simply bring it together, put it all into one place, and will then include the new preservatives. The three additional preservatives are copper naphthenate, chromated zinc chloride and pentachlorophenol.

Mr. Burt: There is need for an editorial change in this connection. On page 702, under Revision of Manual, second paragraph, the beginning of the fourth line now reads, "to five new preservatives." This should be changed to read "to three additional preservatives."

On page 702, under the heading of "Requisitioning Preservatively-Treated Wood, the committee recommends new requisities for "Preservative" and "Retention of Preservative," in substitution for existing requisites now in the Manual, and I move the adoption of this recommendation.

(The motion was regularly seconded, was put to a vote, and carried.)

Mr. Burt: I now direct your attention to the following Manual documents referred to at the top of page 703, namely, Specifications for Treating Processes, and Specifications for the Preservative Treatment of Pacific Coast Douglas Fir.

In order to bring these two documents up to date with respect to treatment processes, new preservatives and suggested retention of preservatives, it is the recommendation of the committee that these documents be deleted from the Manual, and that there be substituted therefor the new material shown in Exhibit B—Specifications for Treatment, as presented on pages 708 through 724 of the Bulletin.

Note that these new specifications include recast Table 1—Minimum Net Retention of Preservative, now appearing on Manual pages 17–4 and 17–5, under a new table heading, "Specific Requirements for Preservative Treatment by Pressure Processes," this new table to replace former Table 1 on Manual pages 17–4 and 17–5.

Mr. Chairman, I move the adoption of this recommendation.

(The motion was regularly seconded, was put to a vote, and carried.)

Mr. Burt: I now direct your attention to the present Specifications for Preservatives, appearing on Manual pages 17–23 to 17–25, incl., as referred to in the middle of page 703. In order to bring these specifications up to date, the committee recommends the deletion of the present Specifications for Creosote-Petroleum Solutions; for Petroleum for Blending with Creosote; for Zinc Chloride; for Chromated Zinc Chloride; for Tanalith; and for Methods of Tests, in their entirety, and the substitution therefor of the revised specifications presented as Exhibit C, appearing on pages 725 and 726 of the Bulletin. Revised Specifications for Creosote and for Creosote-Coal Tar Solutions were presented in the report on Assignment 8.

Mr. Chairman, I move the adoption of this recommendation.

(The motion was regularly seconded, was put to a vote, and carried.)

Mr. Burt: An editorial change is necessary on page 726, under "Chromated Zinc Chloride." The second paragraph, second line, now reads, in part, "This may include chromium hydroxide." The word, "hydroxide," should be changed to "trioxide."

In the middle of page 703, as shown, the committee recommends reapproval without change of the Standard Volume Correction Table for Creosote-Petroleum Solutions, appearing on pages 17–29 and 17–30 of the Manual.

Mr. Chairman, I move the adoption of this recommendation.

(The motion was regularly seconded, was put to a vote, and carried.)

Mr. Burt: The committee further recommends reapproval of Measuring and Sampling Creosote, as appears on pages 17–31 to 17–38, incl., in the Manual, with the deletion therefrom of the entire Section II—Water in Creosote, appearing on page 17–23.

Mr. Chairman, I so move.

(The motion was regularly seconded, was put to a vote, and carried.)

Mr. Burt: The committee also recommends the deletion from the Manual of Tests Relating to Zinc Chloride Treatment, appearing on pages 17–43 to 17–46, incl., pertinent parts of this material having been included in the revised specifications for salt preservatives included in Exhibit C, and already approved.

Mr. Chairman, I move the adoption of this recommendation.

(The motion was regularly seconded, was put to a vote, and carried.)

Mr. Burt: As the last recommendation in the report of Subcommittee 1, your committee presents as Exhibit D, Standard Abridged Volume Correction Tables for Petroleum Oils, for adoption and publication in the Manual. These tables are shown in pages 727 and 728.

The information included in these tables is comparable to that now in the Manual for creosote, creosote–coal-tar solutions, and creosote–petroleum solutions, and is useful for petroleum oil used with pentachlorophenol and copper naphthenate.

Mr. Chairman, I move the adoption of the tables presented as Exhibit D.

(The motion was regularly seconded, was put to a vote, and carried.)

Mr. Burt: Mr. Chairman, that completes the recommendations of Subcommittee 1.

Assignment 2—Service Test Records of Treated Wood, was presented by Subcommittee Chairman A. J. Loom (Northern Pacific).

Mr. Loom: The report of this subcommittee is presented in Bulletin 505, commencing on page 728. It speaks for itself, and is submitted for information only.

Assignment 5—Destruction by Wood-Destroying Insects; Methods of Prevention, Collaborating with Committees 6 and 7, was presented by Subcommittee Chairman B. D. Howe (Louisville & Nashville).

Mr. Howe: It is felt that a final report on the soil poisoning tests at Florissant, Mo., will be of value, and it is the purpose of the subcommittee to make such a report as soon as conditions permit an inspection of the site.

This is a progress report, which is presented as information.

Assignment 7—Incising Forest Products, was presented by Subcommittee Chairman W. P. Arnold (Koppers Company).

Mr. Arnold: The report on Assignment 7 is printed in Bulletin 505 as information. Attention is directed to a paper which will be presented to the American Wood Preservers' Association at its meeting next month in Cleveland, Ohio, on the experiences of the Boston & Maine Railroad with the incising of cross ties.

This report is submitted as information.

Assignment 10—Artificial Seasoning of Forest Products Prior to Treatment, was presented by Subcommittee Chairman W. P. Arnold (Koppers Company).

Mr. Arnold: This report is also printed in Bulletin 505, and is presented as information. I move its acceptance as such.

Chairman Dunn: Mr. Chairman, that completes the working reports of Committee 17, but we have another feature, which Past President Blair requested last year. Due to the pressure of time, we have told Dr. Walter Buehler there were only 5 min available to him to comply with Past President Blair's request for a first-class speaker to discuss the Controversial Issues in Tie Preservation. Therefore, I do not have time to do justice to Dr. Buehler's background in introducing him, but I will say that he has been a Life Member of this Association since 1946, and that his service on Committee 17 started in 1917. In 1949 he became technologist, Wood and Wood Preservation, School of Forestry, University of Florida. Gentlemen, Dr. Buehler.

Controversial Issues on Cross Tie Preservation

By Dr. Walter Buehler

Consulting Technologist, School of Forestry, University of Florida

At the meeting last March President T. A. Blair suggested as the subject of an address "Controversial Issues on Cross Tie Preservation". I was requested to prepare a paper on this subject. Many of you received a questionnaire from me covering some of the fundamentals in cross tie preservation. In selecting the list of railroads to which I mailed this questionnaire, I endeavored to get a few representative roads in each of the regions used in the preparation of the annual Table "A", Cross Tie Statistics. In this way I hoped to get a comparison of treating practices and preservatives used between roads in about the same climatic environment, where similar species of wood were available for treatment.

One of the questions asked was, "What in your opinion are some controversial issues on cross tie preservation?" The answers to this question covered a very wide field, but could be divided into two general classes, namely, those dealing with methods of treatment, preservatives, seasoning, adzing, boring, incising etc., and those dealing with what can be called mechanical protection such as the use of tie pads, tie coatings, tie plates, anti-splitting devices, etc. Under the title of this paper I should confine myself to the first of these classifications. I do, however, wish to comment briefly on the broader aspect of tie life, which would include preservative treatment, mechanical protection, and a combination of the two.

I believe that we can accept as non-controversial the effect on tie life of poorly drained track and unstable embankment. We, however, get into the controversial field when we consider the use of all the various mechanical devices advocated to increase tie life. To illustrate, Mr. A. L. Kuehn in a recent address before the Railway Tie Association made the following statement: "There are indications that the railroads may actually have an advantage by using ties of shorter life, that is, a larger number. To obtain a longer life it is necessary to have costly protection. There is yet some doubt that the proposed additional protection will result in the hoped-for increase in life, but even if it is attained the cost may be too great, and it will be better to use more ties". He gave as an illustration the tie cost per year of 4 ties lasting 30 years compared with 3 ties lasting 40 years, where the increased life was obtained by the use of special spikes and hold-down dowels, tie pads, tie coatings, and anti-splitting devices. The cost per tie year of the 4 thirty-year ties was $0.292, compared with a cost of $0.30 per tie year for the 3 forty-year ties.

While Mr. Kuehn's thesis might be open to argument, I believe we can agree that there is some question as to how far we can go in increasing tie cost to get increased life unless we know definitely what increased life can be obtained. In other words, it resolves itself into simple mathematics when we have all of the elements of the problem we wish to solve. The controversial point is, of course, what increased life will we get from the use of these costly mechanical devices?

The answers to the questions on controversial issues in connection with methods of treatment, etc., can be divided into three general classifications, namely, seasoning, treatment, and preservatives. Under seasoning there are such issues as proper time of seasoning, effect of artificial seasoning on hardwood ties, moisture content of ties at time of treatment, and whether ties can be air-seasoned in certain Gulf Coast areas where humidity and temperature are abnormally high.

Under treatment the issues mentioned were: To what extent should hardwood ties, other than oak, be separated; treating under fixed retention; duration of pressure period under temperature of preservative to insure sterilization and distribution of the preservative; increased retention to off-set decreased content of creosote in creosote-petroleum solutions; required retention in different parts of the country.

Under preservatives the issues mentioned were: Petroleum versus coal tar as a vehicle for creosote; straight creosote versus mixtures; high or low residue creosote; value of heavy petroleum residue to decrease mechanical wear; and non-toxic oil doped with toxic chemicals.

In addition to the above classifications there were general issues mentioned, such as: Cross tie life of different woods, differentiating between mechanical damage and decay as factors causing tie failure, and accepting partially decayed ties for treatment.

An examination of the issues listed indicates that there are really no serious controversial issues. Many that appear controversial are really only differences of opinion resulting from experience under different climatic environment. Our committee representing all sections of the country experienced this difference of opinion when we endeavored to revise our Manual. It is the writer's opinion that standard specifications for preservatives and manual of good practice cannot be specific within narrow limits, but rather should be broad enough within safe limits so that the individual operator can write his specification to fit his particular condition, and yet be within the frame work of safe practice.

Take, for example, the standard specification for creosote oil. It is now quite generally conceded that there is a proper place for both high and low residue creosote. Therefore, the standard specification should contain limits of residue wide enough so that the individual operator can specify the limit he considers correct for his particular use, and yet write his specification within the framework of the standard specification.

It is estimated that the average life of treated ties in track throughout the country is about 33 years. Individual roads, depending on their location, estimate the life of treated ties on their lines from 20 to 40 years. The present treating practices are the result, therefore, of at least 30 years' experience. Over this period there have been changes resulting from better knowledge, and also departures from standard practice due to conditions beyond the control of the operator, such as coal strikes, war, etc. It is reasonable to assume, therefore, that present practice should give better than the present average life.

An examination of the answers to the questionnaire reveals that, generally speaking, all railroads are following the fundamentals of good practice. What appears to be the greatest difference of opinion lies in the use of different preservatives, namely, coal tar solution versus creosote-petroleum solution. However, it is interesting to note that the use of creosote-petroleum, with few exceptions, predominates in those regions where climatic conditions are less favorable to decay, namely, the New England, North-

(Text continued on page 1368)

CROSS TIE STATISTICS-CLASS 1 RAILROADS*

Region	Creosote-Petroleum 1**	2	3	4	5	Creosote-Coal Tar 1	2	3	4	5	6
New England											
B&M	143	8,140	52	180	1.8						50/50
CNR (New Eng.)	12	739	53	123	1.7						50/50
CPR (Me.)	19	627	86	208	3.0						50/50
CPR (Vt.)	15	376	119	289	4.0						50/50
Me. Cent.	61	3,510	64	230	2.1						50/50
NYNH&H						99	11,073	28	88	0.9	50/50
Great Lakes											
DL&W						148	6,625	69	247	2.2	60/40
Erie						368	13,612	80	283	2.7	60/40
L&NE						26	721	110	432	3.6	50/50
LV						189	7,484	76	244	2.5	60/40
NYC&StL						299	10,644	87	265	2.8	60/40
NYC						1,314	20,726	63	236	2.1	60/40
Central Eastern											
B&LE						30	1,515	61	253	2.0	80/20
B&O						909	10,381	88	252	3.1	80/20
C&EI						68	3,953	50	179	1.7	60/40
PRR						1,721	61,266	80	269	2.8	60/40
WM						87	3,394	75	261	2.6	50/50
EJ&E						56	2,642	65	189	2.1	Dist.
CofNJ	44	2,499	50	167	1.8						40/60
Reading	246	7,721	88	274	3.2						40/60
Pocahontas											
C&O						645	24,352	80	250	2.6	60/40
N&W						564	13,460	130	303	4.2	Dist.
RF&P						33	1,215	81	270	2.8	80/20
Virginian						134	2,907	142	397	4.6	80/20
Southern											
ACL						777	22,333	107	354	3.5	Dist.
CofG						353	6,667	153	343	5.3	80/20
FEC						128	3,354	117	403	4.0	50/50
GM&O						371	11,088	106	293	3.4	80/20
IC						1,429	29,983	145	374	4.8	60/40
L&N						795	19,306	118	319	4.1	80/20
NC&StL						226	3,904	159	421	5.3	80/20
N&S						71	2,260	166	387	5.7	Dist.
SAL						690	16,406	127	387	4.2	80/20
Southern						865	26,222	102	328	3.3	60/40
Northwestern											
C&NW	940	12,505	88	228	3.0						50/50
CMSt.P&P	372	41,660	35	77	1.1						50/50
DM&I	54	3,220	46	133	1.7						50/50
GN	1,105	31,801	108	328	3.5						50/50
MStP&SSM	455	14,041	97	245	3.3						50/50
NP	475	26,789	52	140	1.8						50/50
CGW						120	5,330	68	238	2.3	80/20
Central Western											
CB&Q	690	36,510	58	161	1.9						50/50
AT&SF	1,191	62,007	61	177	1.9						30/70
D&RGW	198	10,340	60	211	1.9						50/50
SP	865	35,876	72	231	2.4						25/75 & 50/50
UP	526	37,796	40	120	1.4						50/50
CRI&P						811	29,478	82	206	2.8	70/30
Southwestern											
StL&SW	256	5,725	140	374	4.5						70/30
KCS						199	4,112	154	434	4.9	Note "A"
L&A						115	2,879	130	367	4.0	70/30
M-K-T						298	2,369	76	217	2.4	80/20
MP						1,252	27,234	142	396	4.6	70/30
StL-SF						525	18,188	91	243	2.9	70/30
T&P						326	6,585	145	401	5.0	Note "B"

Note "A"-Gum ties 12½ lb per cu ft 50/50 creo.-pet. All other ties except fir, 8 lb per cu ft 70/30 creo.-coal tar.

Note "B"-All grades pine ties and grades 1, 2 & 3 gum ties, 50/50 creo.-pet. All grades oak ties and grades 4 & 5 gum ties, 70/30 creo.-coal tar.

*Source of information:
Table "A" Cross Tie Statistics, Dec. 31, 1951
Committee 17 Preservative Survey, March 1948
Answers to Questionnaire, March 1953.

**Column Headings:
1. Number new wooden ties treated (in thousands).
2. Estimated total cross ties in all maintained track (in thousands).
3. Number laid per mile of maintained track.
4. Renewal cost per mile of maintained track.
5. Percent new wood cross tie renewals to all ties in track.
6. Percent distillate creosote and coal tar or petroleum in solution.

ANSWERS TO QUESTIONNAIRE ON CROSS TIE PRESERVATION.

REGION	1	2	3	4	5	6
New England						
B&M	Oaks, Birch Maple & Cherry	Yes	No	Yes	All except Oak	Yes
Great Lakes						
DL&W	Oaks, Pine & Gum	Yes	No	Yes	No	Yes
Erie	Oaks, Mixed Hardwood	Yes	No	Yes	No	Yes
NYC	Oaks, Mixed Hardwoods, Gum & Pine	Yes	Yes	Yes	No	Yes
NYC&StL	Oaks, Beech, Birch, Gum & Maple	Yes	Yes	Yes	No	Yes
Central Eastern						
B&O	Ash, Beeches, Locusts, Birches, Oaks, Cherry, Black Walnut, Hard Maple, Hickorys, Gums, Soft Maple, Red Mulberry, Sycamore, Sassafras, White Walnut, Hackberry, Elms, Sap Pine, Firs, Sap Cypress	Yes	No	No	No	Yes
CRR of NJ	Oaks & Mixed Hardwoods	Yes	Yes	No	No	Yes
Reading	Oaks & Pine	Yes	Yes	No	No	Yes
EJ&E	Oaks (AREA) Group TA	No	No	Yes	No	Yes
PRR	(AREA) Groups TA-TC-TD	Yes	No	No	No	Yes
Pocahontas						
C&O	(AREA) Groups TA-TC	Yes	Yes	Yes	No	Yes
N&W	(AREA) Groups TA-TC-TD	Yes	No	Yes	No	Now Vapor
Southern						
GM&O	Pine, Gum & Red Oak	Yes	Yes	Yes	No	Yes
IC	Pine, Gum & Oak	Yes	Yes	Yes	No	Yes
L&N	Pine, Oak & Mixed Hardwoods	Yes	No	Yes	No	Yes
NC&StL	Red Oak & Gum	Yes	No	Yes	No	Yes
SAL	Oak & Gum	Yes	Yes	Yes	No	Yes
Southern	Red Oak, Gum & Pine	Yes	No	Yes	No	Yes Some Vapor
Northwestern						
C&NW	(AREA) Groups TA-TB-TC-TD	Yes	No	Yes	No	Yes
GN	Birch, Maple & Oaks Larch, Fir & Pine	Yes	Yes	Yes	Yes	Yes
NP	(Brainerd) Oak, Maple, Elm (Paradise) Fir, Larch, Pine (Western Yellow & Lodgepole) Hemlock (Seattle) Coast Fir & Hemlock	Yes	Yes	Yes	Yes	Yes
CMStP&P	Beech, Birch, Pine, Fir, Cedar, Hemlock, Maple, Larch, Red Oak, White Oak	Yes	Yes	Yes	Yes	Depending on wood
Central Western						
CB&Q	White & Red Oak	Yes	Yes	Yes	No	Yes
CRI&P	Oak, Pine & Gum	Yes	Yes	Yes	Some White Oak	Yes
SP	(Oakland & Eugene) D. Fir, White Fir, Lodgepole Pine	Yes	No	Bore	Yes	Yes
	(Alamogordo) Gum, Oak & Mixed Hardwoods	Yes	Yes	Yes	No	Yes
AT&SF	Oak, Gum, Southern & Western Pine Pacific Coast Fir	Yes	Yes	Yes	Fir	Yes
Southwestern						
KCS	Oak, Gum & Pine	Yes	Yes	Yes	No	Yes
M-K-T	Gum & Pine & Oak	Yes	No	Yes	No	Yes
MP	Oak, Gum & Pine	Yes	No	Yes	No	Yes
StL-SF	Oaks, Gum, Pine & Mixed Hardwoods	Yes	Yes	Yes	No	Yes
T&P	Oak, Gum & Pine	Yes	Yes	Yes	No	Yes
StLSW	Oak, Gum & Pine	Yes	No	Yes	No	Yes

Column Headings: 1. What species of wood do you accept for treatment? 2. Do you segregate species? 3. Do you specify different treatments for different species? 4. Do you adz & bore? 5. Do you incise? 6. Do you air season?

7	8	9	10
Rueping	50/50 Creo.-Pet.	No	Min 8 lb per cu ft.
Lowry	60/40 C. T. S.	No	3½ gal 7"-2½ 6".
Rueping	60/40 C. T. S.	No	Min 7½ lb per cu ft.
Lowry	60/40 C. T. S.	No	8 lb, except White Oak to refusal.
Lowry & Rueping	60/40 C. T. S.	No	Refusal. 65% rings Red Oak, others all sap.
Rueping & Bolton	80/20 C. T. S.	No	Min 7 lb per cu ft. Tolerance 90 to 110%
Rueping	40/60 Creo.-Pet.	No	8 lb. Refusal for Oak.
Rueping	40/60 Creo.-Pet.	No	AWPA Standard.
Rueping	Distillate	No	Min 5 lb. All sap.
Rueping	60/40 C. T. S.	No	Min 6 lb.
Rueping	60/40 C. T. S.	No	AWPA C6-51
Rueping	Distillate	No	Min 6 lb. All sap.
Rueping	80/20 C. T. S.	No	Min 6 lb. All sap.
Rueping	60/40 C. T. S.	No	Oak & Pine 8 lb. Gum 9.2 lb.
Rueping	80/20 C. T. S.	Dist. at 235	Min 7 lb.
Rueping	80/20 C. T. S.	No	Practical refusal.
Rueping	80/20 C. T. S.	No	100% sap wood.
Rueping	60/40 C. T. S.	No	Min 8 lb.
Lowry	50/50 Creo.-Pet.	No	Min 8 lb.
Rueping & Bolton	50/50 Creo.-Pet.	No	Min 7 lb.
Lowry & Bolton	50/50 Creo.-Pet.	No	AWPA Standard
Rueping (Preliminary Oil Bath) Bolton	50/50 Creo.-Pet.	Slightly	Min 8 lb. Fir refusal.
W. Oak Full cell, others Rueping	50/50 Creo.-Pet.	No	AWPA Standard.
Rueping & Lowry	70/30 C. T. S.	15% less Residue	White Oak 4 to 6 lb. Red Oak, Pine, Gum 8 lb.
Rueping	25/75 Creo.-Pet.	No	9.5 lb. 3/4 " 75% all pieces.
Oak Full cell, Gum Rueping	50/50 Creo.-Pet.	No	Gum 8½ lb. Oak refusal.
Oak Full cell, others Rueping	30/70 Creo.-Pet.	Residue limited to 20%	Oak refusal. Others min 9 lb. All sap.
Rueping	70/30 C. T. S. & 50/50 Creo.-Pet.	No	Gum 12½ lb. Others 8 lb.
Rueping	80/20 C. T. S.	No	Min 6 lb. All sap.
Rueping	70/30 C. T. S.	No	Min 3/4 gal per cu ft. Penetration AWPA.
Oak Lowry, others Rueping	70/30 C. T. S.	No	Min 6 to 8 lb.
Oak Lowry, others Rueping	70/30 C. T. S. 50/50 C.P.	No	9.5 lb Creo.-Pet. 8 lb C.T.S.
Oak Full cell	70/30 Creo.-Pet.	No	2½ gal. #3 Tie.

7. What treating method do you specify? 8. What preservative do you specify?
9. Does preservative specification vary from AWPA or AREA?
10. What minimum absorption and penetration do you specify?

western, and Central Western regions. The use of creosote-coal tar solutions predominates in the Great Lakes, Central Eastern, Pocohontas, Southern and Southwestern regions. For this reason one cannot draw conclusions as to the comparative efficiency of these preservatives from an examination of the tie renewal records, since the comparison between regions is of little value.

An examination of the record reveals further that in regions where climatic conditions are more favorable to decay, tie renewals, both in number and percent of all ties in track, increase, although the number of equated gross ton-miles per mile of maintained track are less, thus showing that decay is still the real factor causing renewals.

It is the writer's opinion that if there is a real controversial issue it is in the variation of absorptions specified. To the writer the practice of treating cross ties to a hit and miss fixed retention of preservative per cubic foot is archaic and should be discontinued. It should be replaced by a requirement of minimum penetration, which might vary to some degree between species of wood, but which should at least specify a minimum of 100 percent sap wood penetration.

In 1913 Dr. Herman von Schrenk, in a paper before the American Wood Preservers' Association, laid down five fundamentals in the preservation of wood:

1. Only perfectly sound timbers should be treated.
2. In order to obtain the best results properly seasoned materials should be used.
3. A good preservative is essential to long life.
4. Proper injection as to quantity and penetration is essential.
5. Proper subsequent handling of the timber is essential.

We cannot improve on these today. If you use a good preservative, treat only sound and seasoned ties, and specify a minimum of all sap wood penetration, irrespective of the amount of absorption obtained, the present average life of ties will be increased.

Vice President Grove: Mr. Dunn, this Association appreciates the fine work done by Committee 17 during the past year, and especially its detailed consideration of its Manual material.

We are particularly pleased to have had Dr. Buehler give us his able address as a part of your committee presentation.

Your committee is now excused with the thanks of the Association.

Discussion on Buildings

(For report, see pp. 559–612.)

(Vice President C. G. Grove presiding)

Chairman J. B. Schaub (Illinois Central): Mr. Chairman, members of the Association, and guests: Part of our committee is not on the platform, and we are really proud of that fact. There isn't room for them all.

Word has just reached me that Mr. F. H. Alcott, who was the New York manager of the National Lumber Manufacturers Association, passed away last Monday morning. This committee sincerely regrets this news, as Mr. Alcott was a highly valued member of our committee for many years. A proper memorial will be recorded later.

The report of Committee 6—Buildings, is found in Bulletin 504. Committee 6 has been assigned 10 subjects for study and consideration. It will report on 5 of them at this time.

The first subject, Revision of Manual, has been handled by Mr. O. W. Stephens, our vice chairman, who is assistant to chief engineer—Maintenance of the Delaware & Hudson, and I will turn the platform over to Mr. Stephens.

Assignment 1—Revision of Manual, was presented by Subcommittee Chairman O. W. Stephens (Delaware & Hudson).

Mr. Stephens: The report of this subcommittee appears in Bulletin 504, starting on page 560, and is quite lengthy for the reason that, in preparation of the new Manual, your committee thought it necessary to review the entire chapter, and offers the following recommendations:

In order to reduce the time required to vote on each recommendation individually, I would recommend that those sections which the committee has reapproved without change be voted on in one ballot, and I have grouped those sections to be reapproved without change.

(Mr. Stephens then read the titles and Manual page numbers of all of the documents listed on Bulletin pages 560 to 572, incl., which were offered for reapproval without change, and then continued):

Mr. Stephens: The committee recognizes that some of these specifications are not as up to date as they should be; however, we think the document dates should be changed, and with the understanding that your committee will review these specifications and bring them up to date as soon as time will permit, I move that they be reapproved without change.

(The motion was regularly seconded, was put to a vote, and carried.)

Mr. Stephens: The committee recommends the reapproval of Sec. II. Excavation, Filling and Backfilling, appearing on pages 6–5 to 6–7, incl., with the deletion of Art. 14. Pile Foundations, on pages 6–6 and 6–7, which is being rewritten under the jurisdiction of Subcommittee 5 for inclusion as a new separate document in the Manual.

Mr. President, I move the adoption of this recommendation.

(The motion was regularly seconded, was put to a vote, and carried.)

Mr. Stephens: The recommended changes under the heading of Brickwork, pages 6–10.2 to 6–14, incl., call for reapproval of the present material and the insertion of material shown on pages 560 to 563, incl., of the Bulletin, which is to be deleted from another section. I move that this recommendation be approved.

(The motion was regularly seconded, and put to a vote, and carried.)

Mr. Stephens: After considerable work and discussion with the entire committee, it is recommended that the sections on Structural Steel and Iron, pages 6–47 to 6–60.2, incl., and on Welded Structural Steel, pages 6–74 to 6–74.10, incl., be deleted and that there be substituted therefor the material appearing in Exhibit "A", beginning on page 572 of the Bulletin, which will allow all work performed under this section to conform to present-day standards, and I so move.

(The motion was regularly seconded, was put to a vote, and carried.)

Mr. Stephens: It is recommended that the sections on Carpentry and Millwork, pages 6–74.12 to 6–79, incl., and on Wood Screens, pages 6–198 to 6–200, incl., be deleted, and that there be substituted therefor the specification appearing in Exhibit "B" of the Bulletin, beginning on page 576, which conforms to present-day practice, and I so move.

(The motion was regularly seconded, was put to a vote, and carried.)

Mr. Stephens: The sections on Hot Air Heating and Hot Blast Heating Systems, dated 1926, on pages 6–104.1 to 6–112, incl., have been reviewed, and your committee recommends that this material be deleted and that there be substituted therefor the specifications for Warm Air and Blast Heating appearing in Exhibit "C", beginning on page 581 of the Bulletin, and I so move.

(The motion was regularly seconded, was put to a vote, and carried.)

Mr. Stephens: The section of Electric Light Wiring, pages 6–113 to 6–115, incl., has been revised to conform to present-day standard practices and safety codes, and it is recommended that it be reapproved with the revisions shown on page 565 of the Bulletin, and I so move.

(The motion was regularly seconded, was put to a vote, and carried.)

Mr. Stephens: The section comprising Concrete Pavements and Foundations, pages 6–127 to 6–133, incl., has been entirely revised to include the use of present-day materials and practices. It is recommended that the present Specifications for Concrete Pavements and Foundations be deleted and that there be substituted therefor the Specifications for Concrete Pavements appearing in Exhibit "D" of the Bulletin, beginning on page 584 and I so move.

(The motion was regularly seconded, was put to a vote, and carried.)

Mr. Stephens: Likewise, the section on Cement Grouted Macadam Platforms, Floors, Pavements and Pavement Bases, pages 6–153 to 6–153.6, incl., has been revised to include the use of present-day materials and practices. It is recommended that this section be reapproved with the revisions shown on pages 566 to 568, incl., of the Bulletin, and I so move.

(The motion was regularly seconded, was put to a vote, and carried.)

Mr. Stephens: Our present Manual, pages 6–171 to 6–198, incl., contains separate specifications for various types of chimneys; namely, Steel Chimney-Riveted; Steel Chimney-Welded; Genuine Wrought Iron Chimneys-Riveted; Genuine Wrought Iron Chimneys-Welded; Brick Chimneys; Reinforced Concrete Chimneys; Reinforced Brick Masonry Chimneys; Addenda A—Draft Gages, B—Pyrometer, for Steel, Brick, and Reinforced Concrete Chimneys; and Addendum C—Lightning Protection System for Brick and Reinforced Concrete Chimneys. Consequently, there is considerable amount of repetition in this material. After considerable work by members of the committee, an entirely new specification for all types of chimneys, flues, and vents has been prepared and it is recommended that the present specifications be deleted and that there be substituted therefor the specifications appearing in Exhibit "E" of the Bulletin, beginning on page 591, and I so move.

(The motion was regularly seconded, was put to a vote, and carried.)

Mr. Stephens: The section of Chapter 6 on page 6–225—Section Tool Houses, in its present form is entirely inadequate to cover the requirements for the present-day equipment and needs of modern railroad section forces and, having in mind that a new specification will be prepared and presented to the convention as soon as the committee can so handle, I move that this section be deleted.

(The motion was regularly seconded, was put to a vote, and carried.)

Mr. Stephens: It is recommended that the section on Determination of the Destructible Value of Structures Which Can Be Collected in Case of Fire, pages 6–260 and 6–261, be deleted and that there be substituted therefor the material appearing in Exhibit "F" of the Bulletin, beginning on page 599, and I so move.

(The motion was regularly seconded, was put to a vote, and carried.)

Mr. Stephens: Your committee recommends that the section on Platform Surfaces, pages 6–265 to 6–268, incl., be reapproved with the revisions shown on pages 570 and 571 of the Bulletin, and I move that this revision be approved.

(The motion was regularly seconded, was put to a vote, and carried.)

Mr. Stephens: Mr. President, this completes the recommendations of subcommittee 1, and I would like to express my sincere appreciation to all members of Committee 6 for their great assistance in making it possible to present this report.

Chairman Schaub: That may appear almost like railroading, but you men who have worked on committees know that it wasn't railroading when the work was being done.

Assignment 2—Specifications for Railway Buildings, was presented by Subcommittee Chairman S. E. Kvenberg (Milwaukee Road).

Mr. Kvenberg: The committee has prepared, and submits for preliminary consideration as Manual material, a specification for the application of asbestos cement roofing shingles. This specification appears in Bulletin 504, beginning on page 601, and covers types of asbestos-cement roofing shingles available, their handling and storage before application, and general instructions for their application.

This information is considered of sufficient general interest to be Manual material.

Mr. Chairman, I move that this specification for application of asbestos-cement shingles be accepted as information, looking to its inclusion in the Manual at a later date.

(The motion was regularly seconded, was put to a vote, and carried.)

(President Geyer resumed the chair.)

Assignment 5—Pile Foundations for Railway Buildings, was presented by Subcommittee Chairman L. B. Curtiss (Northern Pacific).

Mr. Curtiss: Mr. President, the only reference to piling in Chapter 6 in our Manual at the present time is in one paragraph—Art. 14, under Sec. II, Excavation Filling and Backfilling of the Specifications for Buildings for Railway Purposes.

Under the proposed revision of Manual, this article is to be deleted, and the specifications for Pile Foundations for Railway Buildings, as printed on pages 603 and 604 of Bulletin 504 is presented for later adoption and inclusion in the Manual under Part 3, Foundations, in the revised Specifications for Railway Buildings.

Mr. Chairman, the committee asks that this specification be received on this basis.

Assignment 6—Modernization of Station Buildings, was presented by Subcommittee Chairman J. J. Schnebelen (Missouri Pacific).

Mr. Schnebelen: Your committee submits as information a progress report on Modernization of Station Buildings to supplement a previous report by the committee appearing in AREA Proceedings, Vol. 52, 1951, pages 293–299. The report consists of bibliography on subjects pertaining to the Modernization of Station Buildings and appears in AREA Bulletin 504, pages 605–610.

The principles governing many of the problems encountered in the modernization of a station building can be found in this bibliography. Your committee recommends that bibliography be brought up to date at least every two years.

Assignment 9—Air Conditioning, was presented by Subcommittee Chairman J. W. Gwyn (Missouri Pacific).

Mr. Gwyn: The advent of air conditioning of passenger cars and of commercial installations, such as stores, shops, etc., has brought about the air conditioning of buildings on the railroads. With that in mind, a subcommittee of Committee 6 was formed to study this subject. As a starting point, we took up the small buildings encountered in railroad yards, such as yard offices and interlocking towers, and, to some degree, the offices in freight stations, and CTC offices at passenger stations.

We set the limit at about 45,000 cu ft of space. From that we have made a study entitled "Simplified Design of Small Air-Conditioning Installations Utilizing Package Air Conditioners."

(Mr. Gwyn then read in full the report under this title on pages 610–612 of Bulletin 504.)

Chairman Schaub: Mr. President, perhaps I shouldn't make such a statement at this time, but I would like to say, in conclusion, that being chairman of this committee is about the easiest job on the committee, especially when you have a committee like this, that really delivers the goods. I want to thank them again for the wonderful work they have been doing on this committee.

President Geyer: Thank you, Mr. Schaub, for the work this committee has done throughout the year, especially in connection with the review of your large chapter in the Manual. That has really been a big job.

Your committee is excused with the thanks of the Association.

Discussion on Maintenance of Way Work Equipment

(For report, see pp. 637–699.)

(President C. J. Geyer presiding.)

Chairman R. K. Johnson (Chesapeake & Ohio): Mr. President, members of the Association, and guests: The report of Committee 27 is found on pages 637 to 699, incl., of Bulletin 505. Your committee has nine assignments, and will report on all nine.

Before proceeding with the presentation, this committee wishes to report with sorrow the passing of Mr. George Westcott, one of its members, who died June 27, 1952. Mr. Westcott was a member of this Association for 33 years, and a member of this committee since its inception in 1931, serving as vice chairman in 1931 to 1937, and as chairman from 1938 to 1941. The committee has prepared a memoir for Mr. Westcott.

MEMOIR

George Rockwell Westcott

George Rockwell Westcott, a member of the American Railway Engineering Association for 33 years, died on June 27 at his home at Robinson, Ill. He was born at Goodwin, Dovel county, S. D., on August 18, 1878, and obtained his higher education at State College of South Dakota and at the University of Wisconsin.

Mr. Westcott's civil engineering activities began in 1906 when he became County and Deputy State Surveyor of Brookings County, South Dakota. His railroad career was started in 1909 when he accepted a position with the Missouri Pacific Railroad at St. Louis, Mo., which was followed by a long succession of responsible engineering positions. He retired from active railroad service on May 31, 1948, after completing 39 faithful and devoted years to one company.

The application of machinery to railway maintenance operations became Mr. Westcott's forte upon his appointment to the newly created position of assistant engineer—roadway machines on July 1, 1925. His untiring efforts in this pioneer field soon won recognition. To distribute his knowledge for the benefit of all, he spent many hours of his own time writing articles for publication relating to the application, maintenance and lubrication of roadway machines.

His untiring efforts to promote the best interests of the American Railway Engineering Association are reflected in his active participation in the affairs of various committees:

Committee 22—Economics of Railway Labor, 1930; Committee 27—Maintenance of Way Work Equipment, member, 1931 to 1948, chairman, 1938 to 1941, vice-chairman, 1931 to 1937; Committee 26—Standardization, 1938 to 1941.

As a member of the General Convention Arrangements Committee of the AREA for many years, Mr. Westcott enjoyed a wide personal acquaintance among the Association membership.

George Westcott was a valuable member of this Association and a Christian gentleman, devoted to his work, his God, and his family.

Assignment 1—Revision of Manual, was presented by Subcommittee Chairman S. E. Tracy (Burlington Lines).

Mr. Tracy: The report appears on pages 638–643 of Bulletin 505.

Your committee has reviewed all of the material in the Manual, and we have two recommendations to offer to bring it up to date.

First, for reapproval without change, we have four documents as follows:

Motor Cars, pages 27–1 to 27–8, incl.

Recommended Colors for Painting Motor Cars, Roadway Machines and Work Equipment, page 27–8.1.

Care and Operation of Maintenance of Way Work Equipment, pages 27–9 and 27–10.

Work Equipment Reports and Records, pages 27–11 to 27–23, incl.

Mr. President, I move the adoption of these Manual recommendations.

(The motion was regularly seconded, was put to a vote, and carried.)

Mr. Tracy: Our second recommendation covers the subject of Wire Rope Used With Work Equipment, pages 27–24 to 27–29, incl. We recommend that we withdraw the present material under this heading and substitute therefor the material appearing under the heading as shown on pages 638 to 643, incl., of Bulletin 505.

I move the adoption of this change in the Manual.

(The motion was regularly seconded, was put to a vote, and carried.)

President Geyer: Thank you, Mr. Tracy.

Assignment 2—Motor Cars, Trailers and Push Cars, was presented by Subcommittee Chairman C. E. Morgan (Milwaukee Road).

Mr. Morgan: On pages 645 to 647, incl., of Bulletin 505, you will find: Fig. 1—AREA 1 $\frac{3}{16}$-in axle and end nuts; Fig. 2—AREA 14-in bolted demountable plate insulated wheel and bushing for motor cars, trailers and push cars using 1 $\frac{3}{16}$-in axles; and Fig. 3—AREA 16-in bolted demountable plate insulated wheel and bushing for motor cars, trailers and push cars using 1 $\frac{3}{16}$-in axles.

Mr. President, I move that these be adopted as recommended practice and published in the Manual.

(The motion was duly seconded, was put to a vote, and carried.)

Mr. Morgan: Since our work was completed in 1952 we have completed data and obtained the necessary two-thirds majority vote of our committee for similar data on the axle, hubs and wheel plates for heavy-duty motor cars, push cars and trailers. This will be offered for adoption in our 1954 report.

President Geyer: Thank you, Mr. Morgan.

Assignment 3—New Developments in Work Equipment, was presented by Subcommittee Chairman H. E. Michael (Railway Track and Structures).

Mr. Michael: The report on New Developments in Work Equipment begins on page 648 of Bulletin 505. This report is a continuation of that made on the same subject last year, and supplements previous reports of a similar nature made in 1944, 1949 and 1951. Briefly, our report, this year gives thumb-nail descriptions of 44 new machines that have been marketed since the last report and acknowledges improvements that have been made to 5 machines.

It may interest you to know that in the 5 reports made since this assignment was first given to Committee 27 in 1943, your subcommittee has described a total of 119 new machines and 18 improvements to existing devices. More than 76 percent of these new machines and 89 percent of the improvements have been covered in our last two reports. While considering that these are, in themselves, large totals, one must also take cognizance of the fact that they have never included the roadway machines or work equipment covered by individual reports of other subcommittees.

From even a casual consideration of these facts, it is clear that the demand of MW&S personnel for machines and power tools is being met not only by a continuing supply of service-tested equipment, but by more and more new machines, many of which have been developed especially for railway use. In fact, about half of the new machines described in this year's report are in that category.

It is questionable whether any of these machines could have reached the degree of usefulness they now offer without a great deal of cooperation between the railways and supply manufacturers. That cooperation has often extended far beyond mere mutual aid in getting the "bugs" out of new machines. In many cases it may even have begun with a railroad actually building the first pilot model, which was later taken over by an interested manufacturer. However, once a final design has been established and a new machine is placed in production, cooperation sometimes slows to a walk.

It is at this point, if it should be reached, or later, that Committee 27 can be of great service to the railways and to equipment manufacturers by acting as a clearing house for improvements that may be needed to some machines to make them either more serviceable or safer, and undoubtedly more salable.

In that connection, Mr. President, it is with pleasure that I present this report as information, and call attention to the fact that the improvements that were made to two of the five machines listed at the end of the report were the direct result of cooperation between another subcommittee of Committee 27 and the individual manufacturers. Those examples are really just the beginning; more will undoubtedly follow.

President Geyer: Thank you very much, Mr. Michael. This report should be a great help to the railroad officers, if they will use it.

Assignment 4—Improvements To Be Made to Existing Work Equipment, was presented by S. H. Knight (Northern Pacific), in the absence of Subcommittee Chairman L. E. Conner (Seaboard Air Line).

Mr. Knight: The report on Assignment 4 is found on pages 666 and 667 of Bulletin 505. This is a progress report, offered as information.

In the previous report of this subcommittee, submitted to the Association last March, there were 12 machines which your committee decided could be made more efficient if certain improvements were made to them. The manufacturers of these machines were contacted with the idea in mind of persuading them to incorporate the suggested improvements in the manufacture of these machines. It was very gratifying to learn that the manufacturers were favorably impressed by our suggestions and promised their full cooperation in arranging to make the suggested improvements.

In this current report there are listed seven additional machines which your committee feels should be improved; namely, a rail saw, a power rail layer, a mechanical spike puller, a power adzing machine, an adzing bit grinder, certain machines incorporating hydraulic equipment, and a ballast removing machine. The improvements suggested to these machines were submitted to their manufacturers and, while all did not reply, it is indicated from the replies received that we will again have the coöperation we anticipate, and that the suggested improvements will be made.

President Geyer: Thank you very much, Mr. Knight.

Assignment 5—Instructions for Lubrication of Work Equipment, was presented by Subcommittee Chairman N. W. Hutchison (Chesapeake & Ohio).

(Mr. Hutchison submitted the following written comments for inclusion in the Proceedings):

Our present-day civilization owes much of its progress to man's mastery of mechanics, and the attendant development of machinery. Today we see, on every hand, machines large and small, complicated and simple, performing tasks which lighten man's burdens. The primary factor which contributed most heavily to the development of mechanical devices was that of diminishing the friction between their moving parts. This was accomplished through the application of lubricants, without which, these machines would soon become useless.

The railroads owe their existence not only to those benefactors of the distant past who created and developed the wheel, but to those who discovered that its efficiency could be greatly increased by lubrication. Except for the discovery of the wheel, there would have been no locomotives or cars; without lubricants, the wheels would be unable to function as they do. What applies to locomotives and cars also applies to our maintenance of way work equipment, in which the railroads now have a very sizable investment.

If the railroads are to realize the return that should be expected from their investment in work equipment, it is imperative that the machines be kept working. This cannot be accomplished unless they are adequately and correctly lubricated; otherwise, damage occurs to moving parts as a result of frictional resistance. There are an infinite number of ways in which a machine may be damaged, the chief one being faulty lubrication.

The importance of lubrication is clearly indicated by the great number of books, periodicals, and articles devoted to the subject. The machine manufacturers, whose reputation must necessarily depend upon satisfactory service from their machines, constantly stress the desirability of lubricating in accordance with the instructions contained in their operating manuals. The producers and refiners of petroleum products, while in business to market their products, also strive to improve them and to create new lubricants which will prove most suitable for the various parts of a machine which must be lubricated. For this purpose, the more prominent oil companies maintain extensive research laboratories, and have staffs of lubricating engineers who study the customer's problems and recommend suitable lubricants to solve these problems.

Such activity on the part of the machine manufacturers and the oil companies, while it benefits the owners of the machines, even though sometimes creating other problems, has made the subject of lubrication very complex and comprehensive, and one that cannot be covered adequately in the report of an AREA committee. Because of this fact, your committee, in its report, has made no attempt to cover the entire field of lubrication, nor to compile a complete list of lubrication instructions for the many types of equipment that are in use, most of which instructions are contained in the operating manuals issued by the manufacturers, and thus available to the machine operator.

The report of this subcommittee is confined to a list of general instructions to be used as a guide, for any railroad that so desires, to prepare a more complete set of instructions, which the committee recommends be issued to machine operators, as a supplement to the manufacturers' instructions. In addition, the report includes two charts, also submitted as a guide, the first of which would cover all of the roadway machines on a given railroad, and show by railroad item number the lubricant to be used on each part. This type of chart would be useful to all those concerned with the lubrication of work equipment. The second chart is designed to assist a machine operator in obtaining a suitable lubricant in an emergency wherein he either does not have access to a company lubrication chart, or cannot wait for a shipment from the stores department.

For those interested in the subject of lubrication, we should like to refer them to a previous report submitted by this committee, which dealt primarily with the description, selection, testing, and specifications for oils and greases. This previous report can be found in Vol. 43 of the Proceedings for 1942.

All of the members of this committee, most of whom are in direct charge of work equipment and have the responsibility of seeing that it is kept in service, agree that the intensity of their maintenance problems is in direct proportion to the care with which their machines are lubricated. In closing, we should like to leave with you this thought; that the moving parts of a machine, unless lubricated, will cease to move.

Assignment 6—Wire Rope Used on Work Equipment, was presented by F. L. Etchison (Atlantic Coast Line), in the absence of V. W. Oswalt (Southern).

Mr. Etchison: In view of the fact that we must have a little on-time performance, Subcommittee 6 is waiving its time so that we can get back on schedule. (Mr. Etchison's unread prepared comments are presented in the following):

In 1944 this committee presented a comprehensive report on wire rope, which dealt primarily with its description, specifications, safety factors, causes of failure, and lubrication. That report was adopted for publication in the Manual and was included with the report of Subcommittee 1, presented just a few moments ago by Mr. Tracy, as a revision of the Manual.

Wire rope is an essential part of many types of work equipment, notably those in the crane and shovel class. For efficient operation of work equipment requiring wire rope, and to insure that the service life of the rope be extended to the possible maximum, it is important that consideration be given to such things as diameter, length, kind of lay, kind of center, kind of steel, the number of wires and number of strands, and whether it is preformed. If the diameter, kind of center, kind of steel and the number of wires and strands are less than required, the rope may not be strong enough to handle the loads which a crane is capable of handling; if the length is too great, there will be considerable waste of rope, and if the lay is incorrect, the ultimate life of the rope may be sharply curtailed.

In general practice, it is difficult, or impractical, for a crane operator, for example, to determine all of the characteristics of the wire rope with which his crane is equipped.

Consequently, when necessary to replace the wire rope on his crane he is frequently at a loss to know just what to order. Your committee is of the opinion that operators of work equipment using wire rope, and others concerned with ordering it, should be provided with some sort of chart showing the characteristics of the rope specified for use with the machine involved, and with a company ordering reference. For this purpose, we have prepared a sample ordering and descriptive list for wire rope, to be used as a guide by any railroad which wishes to prepare its own. This sample list is shown on page 677 of Bulletin 505.

President Geyer: Thank you, Mr. Etchison. Your report will be published in the Proceedings as information.

Assignment 7—Special Bodies for Automotive Vehicles Used by Maintenance Forces, was presented by Subcommittee Chairman F. E. Short (St. Louis–San Francisco).

Mr. Short: In our report on Special Bodies for Automotive Vehicles Used by Maintenance Forces, the committee recommends the use of standard commercial body types, when adaptable to specific railroad requirements, rather than special built bodies. The use of standard commercial body types offers the advantages of lower initial investment, reduced maintenance expense, larger trade-in value, and the possible re-use of the bodies with new chassis and cabs. For many specific purposes, however, the standard body types are not suitable, and it is essential therefore, that bodies of special types be provided for various kinds of maintenance work. The report of this subcommittee is intended to describe and illustrate a number of special bodies, some of which, you will note, are conversions of one of the standard body types.

There are only two general vehicle classes. These are the service types and the transporter types, each of which may be divided into numerous sub-classes. The service type of vehicle includes those which are generally used for the transportation of signal maintainers, telegraph linemen, inspectors, equipment repairmen, welders, and similar employees, and are usually provided with special equipment or accessories to meet the needs of such employees. The transporter type of vehicle is generally used for the transportation of larger groups of men, heavy materials, tools and machines. This type may also be fitted with a variety of bodies for special purposes when the occasion demands.

The report on this assignment, giving more descriptive information and illustrations, is printed in Bulletin 505, pages 676 to 685, incl. It is a final report, submitted as information.

President Geyer: Thank you, Mr. Short. The report will be so received.

Assignment 8—Switch Heaters, Design, Location and Operation, Collaborating with Committees 5 and 14, was presented by Subcommittee Chairman A. W. Munt (Canadian Pacific).

Mr. Munt: The report on switch heaters is presented as information, and appears on pages 686 to 697, incl., of Bulletin 505.

In compiling the report your committee has endeavoured to present additional data available from experience gained through the use of switch heating devices over the past 15 years, and to describe the various types of units in use today. Embodied in the report is a brief description of their design, where they are generally located to best advantage, and how they operate.

It is the consensus that the two most successful types of switch heaters are the electric tubular type, and the propane gas-burning, long or fixed rail-head type, described on pages 689 to 692, incl.

A new type of electric switch heater is described on page 690. This unit is equipped with a timing device to provide for more economical operation.

Your attention is directed to page 692, where there is described the necessity for heating the propane tank or container to provide adequate vaporization and gas pressure for efficient operation of the heaters when low temperatures are encountered. Appearing on pages 692 and 693 is a description of remote control for gas-burning heaters. This device eliminates the necessity for manually igniting the heaters and should result in more economical operation.

Your committee hopes that the information contained in the report will be of some assistance to those concerned with the problem of melting snow from switches.

President Geyer: Thank you, Mr. Munt. Your report will be received as information.

Assignment 9—Means of Conserving Labor and Materials, Including the Adaptation of Substitute Noncritical Materials, and Specifications for the Reclamation of Released Materials, Tools and Equipment, Collaborating with Committee 3–A, General Reclamation, Purchases and Stores Division, AAR, was presented by Subcommittee Chairman W. M. S. Dunn (Nickel Plate).

(Mr. Dunn presented a liberal abstract of the subcommittee's report, as appearing on pages 698 and 699 of Bulletin 505).

President Geyer: Thank you, Mr. Dunn. Your report will be received as information.

Chairman Johnson: This concludes the report of Committee 27; also my term as chairman of the committee. During that 4-year period we have presented 37 reports, which certainly shows that this is a hard-working committee. I wish to thank each member of the committee for his cooperation.

I would now like to present the incoming chairman, Mr. C. E. Morgan, and the incoming vice chairman, Mr. N. W. Hutchison.

President Geyer: Mr. Johnson, your committee has done a very, very fine job this year and throughout your term as chairman of this committee.

In thanking this committee on behalf of the Association for what it has done, I cannot help but add a little extra pat on the back, because the chairman and I work for the same company, and we are buddies.

We also welcome to the committee the new chairman, Mr. Morgan, and the new vice chairman, Mr. Hutchison.

The committee is excused with the thanks of the Association.

Discussion on Economics of Railway Labor

(For report, see pp. 753–790.)

(President C. J. Geyer presiding.)

Chairman R. J. Gammie, Texas & Pacific): Gentlemen, this committee is just what its name implies. It is a committee on the economics of railway labor—primarily maintenance of way labor. Our subcommittee chairmen have contributed much to the work of this committee.

First we will call on C. G. Grove to present our report on Revision of Manual. Mr. Grove, as you all know, is chief engineer of the Western Region of the Pennsylvania.

Assignment 1—Revision of Manual, was presented by Subcommittee Chairman C. G. Grove (Pennsylvania).

Mr. Grove: The report of Subcommittee 1 may be found on pages 754–757 in Bulletin 505.

If you will refer to the Manual, pages 22–1 to 22–15, incl., you will find that it is necessary to change some headings and to rearrange the location of some material in order to bring about a more logical arrangement within the chapter.

(Mr. Grove then read the Table of Contents developed by Committee 22 for the new Manual, designed to bring about this more logical arrangement. He then called attention to the recommendations of the committee with respect to the material under Economics of Railway Labor, on Manual pages 22–1 and 22–2, and moved that the proposed revisions be adopted).

(The motion was duly seconded, was put to a vote and carried.)

(Then Mr. Grove read the proposed change on Manual pages 22–2 and 22–3 under the heading "D. Mechanical Equipment, involving the adoption of revised material as presented in Statement "A" on Bulletin pages 755 and 756, and in Statement "B" on Bulletin page 756, and moved the adoption of these recommendations).

(The motion was duly seconded, was put to a vote and carried).

(Mr. Grove then referred to the proposed changes in Manual material on Annual Track Inspection and Prize Awards; Diversion of Traffic; Programming Work; and Vegetation Control, pages 22–3, 22–4 and 22–5 in the Manual, as called for on page 755 of the report, and moved their adoption.)

(The motion was duly seconded, was put to a vote and carried.)

(Mr. Grove then presented the committee's recommendations with respect to the Manual documents on Programming of Bridge and Building Work; Combined or Separate Bridge and Building Gangs; Outfit Cars for Housing Maintenance of Way Employees; and Equated Track Values for Labor Distribution, as set forth in the report on page 755, and moved their adoption.)

(The motion was duly seconded, was put to a vote and carried.)

President Geyer: Thank you, Mr. Grove.

Chairman Gammie: One of the most important assignments of this committee is Analysis of Operations of Railways That Have Substantially Reduced the Cost of Labor Required in Maintenance of Way Work. In order to study this assignment this year, the committee made a trip over the Lackawanna, and the report resulting will be presented by G. A. Kellow, subcommittee chairman, who is special representative of vice president, the Chicago, Milwaukee, St. Paul & Pacific Railroad.

Assignment 2—Analysis of Operations of Railways That Have Substantially Reduced the Cost of Labor Required in Maintenance of Way Work, was presented by Subcommittee Chairman G. A. Kellow (Milwaukee Road).

Mr. Kellow: Your committee this year is reporting on a comprehensive system of programming roadway maintenance work developed by the Delaware, Lackawanna & Western Railroad. The full text of the report is contained in AREA Bulletin 505, pages 757–769.

The outstanding features of the Lackawanna's programming methods are the thoroughness of the programs, and that railroad's ability to complete all work scheduled. This railroad, at the beginning of a working season, has a clear picture of the work ahead and can work in a straight-forward manner toward accomplishing its goal.

Your attention is directed to line five in the last paragraph immediately preceding the center heading "Conclusions" on page 763 of Bulletin 505. In the interest of clarity, and avoidance of misinterpretation, this sentence might better have been made to read as follows:

> "On more than half the railroad, because of local fire restrictions, scrap ties cannot be burned where they are removed, but must be picked up and transported to other locations for disposition."

Subcommittee 2, in its study of the DL&W programming methods, reached the following conclusion:

The Lackawanna has been able to reduce the labor required for maintenance of way work by means of the detour method, the increased use of labor-saving equipment, and detailed annual programming of work. It is not possible to separate the labor saving among the three items. However, the detailed annual programming has resulted in:

1. More efficient and constructive use of labor.
2. Greater utilization of labor-saving machinery.

Committee 22 is deeply indebted to the officers of the Lackawanna for their whole-hearted cooperation in making the inspection trip and resulting report possible.

The report is submitted as information.

President Geyer: Thank you, Mr. Kellow. It will be so received.

Assignment 3—Organization of Forces for Track Maintenance Operations, was presented by Subcommittee Chairman H. C. Archibald (Boston & Maine).

Mr. Archibald: This report is found on page 770 of Bulletin 505. Subcommittee 3 of Committee 22 has been collecting information for the past two years on the subject of Organization of Forces for Track Maintenance Operations.

The subcommittee has endeavored to find out in some detail, and to place in the records for reference, the organizations used by Class I railroads in the maintenance of tracks. Other data as to length of track sections, methods of inspection, labor-saving machinery available, size of forces, and chain of supervision, were collected and tabulated.

It is felt that such an accumulation of general information as to "how the other fellow does it" might be useful to a maintenance officer for comparison with the methods and practices in effect on his own road. Of course, such comparisons should take into account such things as climate and traffic, which is the reason for the various groupings shown in the tabulations.

The report is submitted as information.

President Geyer: Thank you, Mr. Archibald. It will be so received.

Assignment 4—Economics of Methods of Controlling Vegetation, was presented by Subcommittee Chairman P. A. Cosgrove (Illinois Central).

Mr. Cosgrove: The report on this assignment may be found on page 783 of Bulletin 505, and is a progress report, presented as information.

The first phase of this subject—control of vegetation within the ballast and sub-grade—was presented by the committee at the convention held in March 1952, and is reported in the Proceedings, Vol. 53, 1952, page 363. This year the committee is presenting a study of the control of vegetation on the remainder of the right-of-way.

Responses to a questionnaire indicate that the general procedure by most railroads in controlling vegetation is hand mowing, machine mowing, and chemical weed or brush killer.

(Mr. Cosgrove then read the Conclusions of the committee as presented in the report on page 783.)

President Geyer: Thank you Mr. Cosgrove. This report will be received as information.

Assignment 5—Labor Economy of Renewing Ties by Use of Proper Equipment, Methods and Organization.

Chairman Gammie: Unfortunately, the chairman of this subcommittee, Mr. J. G. West, Jr., of the Santa Fe, at Galveston, Tex., has been sick for over a year, and we have no report to make. The subject is being continued over to next year.

Assignment 6—Economic Effect of Slow Orders on Maintenance Operations, was presented by L. F. Racine (Monon), in the absence of Subcommittee Chairman T. B. Hutcheson (Seaboard Air Line).

(Mr. Racine read selected paragraphs from the report of the committee as presented on pages 784 to 786, incl., in Bulletin 505, and stated that the report was presented as information).

President Geyer: Thank you, Mr. Racine. The report will be so received.

Assignment 7—Comparative Labor Economy in Maintaining Various Types of Railway–Highway Grade Crossings, Collaborating with Committee 9—Highways, was presented by Subcommittee Chairman M. H. Dick (Railway Track and Structures).

Mr. Dick: Although the intent of this assignment was to investigate the comparative labor economy in maintaining various types of railway–highway grade crossings, the committee decided at the beginning of the investigation that it would also have to give consideration to the other factors entering into the cost of crossings if the results were to have any significance. In other words, of necessity, the assignment had to be broadened into an investigation of the economy of various types of railway–highway grade crossings, taking all of the elements of cost into consideration.

For the purpose of the study the committee divided grade crossings into nine different types as follows: Plank (untreated), plank (treated), prefabricated treated wood, bituminous (without flangeways), bituminous (with flangeways), pre-cast concrete slabs, metal-rolled or cast, metal-grating type, and the solid rail type.

To obtain cost data on these various types a questionnaire was prepared and sent to 58 railroads. The information requested on each type included the present-day initial cost of construction per square yard, the estimated service life in years, and the annual cost of maintenance in man-hours per square yard. Information was also requested on the character and speed of both highway and railway traffic. Thirty railroads replied to the questionnaire, giving more or less information. The striking thing about the information received was the wide range in the cost figures for crossings of the same type on different railroads.

To some extent the reasons for these variations are not difficult to understand. Variations in construction standards for the same type on different roads are an obvious reason for variations in the initial cost. Methods vary for determining the service life, which, to a large extent, is a matter of judgment anyway. Since few railroads apparently keep cost figures on the maintenance of grade crossings, this factor is also largely a matter of judgment.

In view of the wide variations in the reported costs for crossings in the same category and the relatively small number of railroads reporting, the committee recognized that the use of averages is of little practical value. However, it was felt that averages of the figures obtained, rough as they may be, provided the only available means for making comparisons between the various types of crossings under study. Therefore, for each crossing, and using the data obtained through answers to the questionnaire, the committee figured the average initial cost of construction in dollars per square yard, the average service life in years, and the average cost of maintenance per square yard per year. From this information the total annual cost per square yard of each crossing was calculated, including interest at the rate of 5 percent on the investment. The results, of course, are far from being conclusive, but for what interest they may have the committee gives them in the report.

The conclusion arrived at by the committee is as follows:

There is a need for more accurate information on the cost of different types of grade crossings. The only way that such information can be made available is for individual roads to make careful cost studies of different types of construction under strictly comparable conditions of railway and highway traffic. All elements of the cost should of course, be included in such studies.

Mr. President, this report is presented as information.

President Geyer: Thank you, Mr. Dick. It will be so received.

Assignment 8—Means of Increasing or Conserving Labor Supply for the Duration of the Emergency.

Chairman Gammie: As we have had no labor shortage during the present emergency, this subcommittee has not taken any active steps to make a report, but it has been keeping up with conditions as they have developed over the country, and is ready to get information and make reports if they are required. The subcommittee is under the chairmanship of A. D. Alderson, maintenance engineer of the Soo Line.

Mr. President, Committee 22 now presents a special feature in the form of an address by one of its members, and a past chairman—Mr. H. E. Kirby, cost engineer of the Chesapeake & Ohio Railway.

Reducing Maintenance Man-Hours

By H. E. Kirby

Cost Engineer, Chesapeake & Ohio Railway

Everybody is interested in man-hours. Some of us may not be aware of it, but man-hours have a direct and very real effect upon our whole lives. What does this term "man-hours mean?" It's merely a little phrase, possibly devised by some obscure statistician, as a convenient means of designating a unit of time, usually the time of a worker at a particular task.

If it were possible for us to trace its development, the history and evolution of the man-hour should be of casual interest at least. We know, of course, that some of man's greatest works have been wrought with slave labor—in which the man-hour pay may be said to have cost practically nothing, and had a variable value, which to the slave laborer was zero.

This development of the man-hour, or rather the graph of its value through times of recorded history, must have been a very flat curve for 40 centuries or more, until the industrial revolution of the first half of the 19th century. And even then another century was to pass before that curve rose sharply. During the Second World War, however, the man-hour really came into its own. All of us know something about its cost and its worth today.

The statement that the man-hour has a direct and very real effect upon every individual is meant to emphasize the influence of the man-hour in every item of man's basic requirements of food, clothing and shelter, every facility for work and recreation, and every service from transportation to dentistry. The labor factor and the cost of the labor ingredient varies and fluctuates with every product or commodity. It follows natural economic laws, and thus is not susceptible to a co-efficient that we might apply. The man-hour's effect on the railroads is no less marked. It constitutes Item 1 in every budget, and it plays a large part in determining whether there will be a reasonable return on the investment.

All this is by way of conditioning you for the impact of 471½ million man-hours. That is the number worked in maintaining track and roadway on the Class I railroads in 1951. As an indication of use of the property, the railroads carried 1.6 trillion gross ton miles in 1951, and this amounted to 7.2 million gross ton miles per mile of road.

But, since a single figure—standing alone—is not of itself good or bad, and cannot thus provide a comparison or indicate a trend, let's look at 1951 against a background of 20 years ago. The year 1931 was both above the depression depth reached in 1932, and below the boom levels preceding it. During 1931, then, the track and roadway maintenance man-hours were 552 million, or 80½ million more than in 1951. Yet in 1951 the use of the property was 80 percent greater than in 1931, in terms of traffic density. It is obvious, then, that our track nowadays is subject to much heavier use, but its unkeep requires less labor than was needed 20 years ago.

These are, indeed, important figures. Particularly so if we assume no significant disparity in deferred maintenance as between the two periods. At all events, the traffic density or use differential is sufficient to offset a number of negative factors.

This evokes an immediate question—what brought about this reduction in man-hours over a period of two decades? It would be difficult if not impossible to evaluate the several forces involved, and I, certainly, shall make no attempt to do so. Railroad maintenance—in common with almost everything else—is not static. To generalize briefly, about the only thing we may be sure of is change. Nature takes care of this in plant and animal life. Not rapidly, nor conspicuously, but the evolutionary process never slackens, and as a result the species is being constantly improved. The process may also have certain industrial applications, including railroad maintenance. For example, it is possible that one of the causes of our improved man-hour situation may be traced to a constant inner urge to do things better and simpler, thereby increasing production. Progress thus continues, even if involuntarily.

The keynote of these times seems to be transition. Tools and materials are changing rapidly and, more slowly possibly, even our thinking. However, if we have not yet experienced a completely changed pattern of thought, at least our reaction has taken the form of a more general acceptance of the application of scientific methods in planning, organizing and performing our work. We will agree that this also indicates a measure of progress. While the basic materials of maintenance may appear to be relatively unchanged, all have been vastly improved. We could, in fact, discuss at great length the improved design of rail sections and rail joints; better welding and heat-treating processes; improved metallurgy and manufacturing; larger tie plates of functional design to provide better tie protection and live-load distribution; better track fastenings; improved specifications for ballast; better housing for labor; truck transportation for men and materials, where practicable; effectual chemical compounds for the control of weeds and brush; more effective wood and metal preservatives, and other means of conserving various materials. All of these have a direct effect on man-hour requirements.

Very important, and certainly the most dramatic, developments of the past 20 years have been technological. When a new tool or service or idea is needed, somebody produces it, and this has permitted widespread application of mass-production methods to some very important maintenance operations. This is, of course, characteristic of the competitive atmosphere in which our economic system is rooted. Known as a system of free enterprise, it has provided more people with more things for better living than any other system ever devised. At the same time it provides ideas and tools which make our industrial plant the envy of the world. So well known as to be axiomatic, reiteration of these truths still can do no harm.

This trend toward mechanization, which in recent years has had accelerated development, must of necessity continue since it is one of the few courses that hold any promise of future economies. The question now more often is not "can we afford to buy a machine for this job", but rather "can we afford not to mechanize this operation?" Even with the tremendous technological advances of recent years, many observers feel that this field is far from being fully developed. They also quickly point out certain prerequisites to maximum economy from mechanization, including, (1) any contemplated machine must possess demonstrated merit in the use for which it is designed, (2) a full return on its investment requires that the machine be used as much as possible, (3) to be able to use the machine full time requires that it be operated and maintained in a first-class manner, (4) preparation of definite and complete work program in advance, and, most important, (5) proper organization with adequate supervision.

Any evaluation of the forces which have affected the labor-man-hour situation cannot, of course, disregard the general economic conditions prevailing. Among other things these forces raised a wage index from 43.2 in 1931 to 147.7 in 1951, and, in 1949, came the 40-hour week which, in effect, reduced productive time, increased the overhead ratio, and caused more localized minor dislocations. Here a corollary should be added to the man-hour statement. It is that, although in 1951 80½ million fewer man-hours were required to maintain track and roadway under a greater volume of traffic than in 1931, the 1951 cost was $460 million more than in 1931.

Such an appraisal must also take into account the contributions made from within the American Railway Engineering Association, by its special and standing committees, by its able organization for conducting research, investigation and test, and by its highly efficient office staff whose duties include processing all of the Association's work and of distributing it in published form for effectual use. In discussing the work of the committees, however, may I recall to you some of the outstanding work of your Committee on Economics of Railway Labor? Observing this committee at work, I have been impressed by its deliberative manner of functioning, and by its objective treatment of assignments. Its recommendations have ranged from top policy matters to an outline for the efficient use of a single workman. Over the years this committee unquestionably has been responsible, through its published works, and the personal efforts of the membership, for economic improvement in several matters within its scope. In the aggregate these have produced important savings for the railroads. Moreover, this committee is the one agency of this Association which studies and interprets for the general membership the key points and important features of large-scale reorganizations of maintenance practices. This includes reviews of new or different systems of advanced planning, programming, and organizing by a particular carrier. A notable example is the current report by Subcommittee 2 covering such activities on the Lackawanna Railroad.

We have seen that the present trend is toward fewer maintenance man-hours at greater cost. There have been improvements in production, in the section-extra force ratio, and in the conditions under which men work—better tools, less arduous work, improved safety, better housing and transport facilities. Now, what of the future?

It is probably safe to hazard a guess that we shall see gradual improvement in maintenance organization at all levels, improvement and expansion of mechanical aids, refinement in scope and detail of work programs, and better planning and supervision. Beyond that, the next step may not be in sight. But, although it is a trite and timeless observation, since there is no limit to the ingenuity of man and his imagination, the future will be faced with complete confidence.

President Geyer: Thank you, Mr. Kirby.

This completes the report of the Committee on Economics of Railway Labor, and we thank you, Mr. Gammie, and your entire committee for the good work you have done. I think this committee is one of our most important because it deals with probably the largest single item of cost on our railways.

Mr. Gammie, your committee is excused with the thanks of the Association.

Discussion on Roadway and Ballast

(For report, see pp. 1085–1159.)

(President C. J. Geyer presiding.)

Chairman G. W. Miller (Canadian Pacific): Mr. President and members of the Association: This year's report of the Roadway and Ballast Committee is printed in Bulletin 507, with reports on 7 out of 12 assignments. We have a large number of items to review, and I will, therefore, call on the subcommittee chairmen to present their reports briefly so there will be sufficient time for the film on Earthquake Damage and Repair, and also for a short address on Installation and Inspection of Drainage Structures.

We will first handle the Manual material, to be followed by the film, and then followed by the balance of the reports.

Assignment 1—Revision of Manual, was presented by Subcommittee Chairman A. P. Crosley (Reading Company).

Mr. Crosley: The subcommittee report on Revision of Manual appears in Bulletin 507, pages 1087 to 1093, incl.

The recommendations dealing with Physical Properties of Earth Materials, on page 1087, and that dealing with Specifications for Metal Fence Posts, on page 1092, will be handled later by the respective subcommittees concerned.

The other recommendations for reapproval, deletion, revision, including additions, are included under each heading. It is therefore moved that these be approved.

(The motion was regularly seconded, was put to a vote, and carried.)

Mr. Crosley: This completes the report of the committee.

President Geyer: Thank you, Mr. Crosley.

Assignment 2—Physical Properties of Earth Materials, was presented by Subcommittee Chairman R. R. Manion (Great Northern).

Mr. Manion: Your committee reports this year on both of its assignments, the report being published in Bulletin 507, for February 1953, beginning on page 1093.

Part 1 of the report relates to Assignment (a) only, and is the fifth progress report on the measurement and study of soil pressures under normal rail traffic by means of pressure cells. The 1952 readings ran very close to those obtained in 1951. An analysis of all the data on this installation indicates that the elastic theory may be used satisfactorily for computing vertical stresses, but is not accurate in predicting lateral pressure intensities or shearing stresses in earth masses. This year's test bore additional evidence that the increase in soil pressures produced by steam locomotives over those under diesel locomotives was in greater proportion than the increase in axle loads. The only additional data now proposed to be obtained from this installation will be static loads produced by locomotives.

There are now plans for a pressure cell installation in a new fill during construction. Development work is under way on the measuring equipment, which it is expected will permit the recording of additional information not previously obtainable.

This portion of the report is presented as information.

Part 2 of the report relates to both Assignments (a) and (b) and to Assignment 1—Revision of Manual.

Last year, offered as information in Bulletin 500, and appearing in the Proceedings, Vol. 53, beginning on page 712, was the report on Physical Properties of Earth Materials. The additional material presented in this report, and appearing in Bulletin 507, on page 1109, is to be inserted after the first sentence, fourth paragraph under Sec. D, Exploration and Tests, of the material in Vol. 53, page 715. This additional information covers exploration of roadbed and foundation soils by test pits, wash borings, auger and core borings. The material thus presented last year, with the additions just mentioned, is now offered for publication in the Manual in place of the material now appearing in Secs. 101, 102, 103 and 106.

It is moved, therefore, that pages 1–6.1 through 1–6.63 be withdrawn, and that the information thus offered be approved for publication in the Manual.

(The motion was regularly seconded, was put to a vote, and carried.)

Mr. Manion: A new specification for soil test borings is being prepared in collaboration with Committees 6 and 8, with the expectation that it will be presented as information in our 1954 report, to be proposed as Manual material in 1955.

Assignment 8—Fences, was presented by Subcommittee Chairman L. V. Johnson (Soo Line).

Mr. Johnson: Subcommittee 8 has reports on two assignments. The first is Specifications for Metal Fence Post. These specifications, as published in Bulletin 507, pages 1137 to 1140, incl., are a revision of Manual specifications appearing on pages 1–71 and 1–72. It is moved, therefore, that the metal fence post specifications appearing on pages 1137–1140 of Bulletin 507 be adopted for publication in the Manual, and that present specifications occurring on Manual pages 1–71 and 1–72 be withdrawn.

(The motion was regularly seconded, was put to a vote and carried.)

Mr. Johnson: The second report is on Electric Shock Fences—Specifications. Last year your committee presented as information a tentative draft of specifications for electric shock fences, appearing in Vol. 53, 1952, of the Proceedings, pages 759 to 764, incl., and requested comments or criticism thereon. Having received no comments or criticism, it is moved that these specifications be adopted for publication in the Manual.

(The motion was regularly seconded, was put to a vote, and carried.)

Chairman Miller: If the projector is now ready, will Mr. W. M. Jaekle, assistant chief engineer, Southern Pacific, please come forward and comment on the picture to be shown.

Earthquake Damage and Repairs

By W. M. Jaekle

Assistant Chief Engineer, Southern Pacific Company

At 4:52 on the morning of July 21, 1952, an earthquake occurred at the southern end of California's great central valley, with its epicenter some 25 miles south of the City of Bakersfield and northwest of Tehachapi. Violont movement resulted along the little-known White Wolf or Bear Mountain fault which crosses the Southern Pacific's main valley line between San Francisco and Los Angeles, near the station of Bealville, and resulted in damage to our railroad along 50 miles of line.

On basis of the Richter scale of magnitude, which is a measure of the energy released, the shock was intermediate between the 1933 Long Beach quake, and San Francisco's great 1906 quake. On this scale, Long Beach is given as 6¼, Tehachapi as 7½, and San Francisco as 8¼. The strongest shock ever recorded was 8.6, which occurred in Tibet several years ago.

To the color-sound picture, which illustrates generally the damage which resulted to embankments, cuts, water tanks, and tunnels, and the restoration of traffic on a 15-deg shoo-fly, there have been added selected black and white scenes which show the details of the interior damage to tunnels and the subsequent reconstruction of Tunnel 5—pictures which have not been shown heretofore to any group.

The pictures deal principally with the four tunnels which were crossed by the fault zone, where the ground movement was extremely violent, with large differential movement between the two moving ground masses. In one case, the distance between the portals of Tunnels 3 and 4 was shortened several feet; the track in Tunnel 4 was raised out of surface nearly 5 ft; in Tunnel 5 the reinforced concrete walls of the tunnel were forced together until they touched at the bottom and were only 5 ft apart at the spring line.

Indicative of the violent movement which occurred, please note the scene in Tunnel 3, where the tunnel wall straddles the rail curved beneath it. The concrete wall at this point was raised more than 2 ft by the vertical movement, and at the same instant that the extreme compression forced the rail into a curve the wall dropped down over it.

While these pictures deal principally with the severe damage which occurred to railroad facilities, it was with real satisfaction that we found outside of the fault zone proper, where differential earth movement did not occur, other reinforced concrete tunnels, within 2 to 4 miles, which withstood the shock with only minor damage, such damage being confined to chipping at construction joints and minor cracks along the arch section.

This picture will show you, in 23 min, the results of 25 sec of earthquake, and details of the $2½ million worth of damage to railroad property with its subsequent reconstruction.

(Showing of motion picture.)

Chairman Miller: Mr. President, I would like to thank Mr. E. E. Mayo, chief engineer, of the Southern Pacific, and Mr. Jaekle, for permitting us to show this film.

This film clearly indicates the teamwork that can be obtained through the cooperation of the railway engineer, his contractor friends, and supply men.

President Geyer: I want to thank Mr. Jaekle for presenting the preliminary explanation of this film, and to congratulate those Southern Pacific officers responsible for the tremendous job that was shown here.

I see Mr. Mayo over here. I wish he would stand and take a bow. We are very proud to have Mr. Mayo as a member of this Association, and also as a member of our Board of Direction. He did a wonderful job on the earthquake rehabilitation work. Twenty-five seconds to tear it down and 25 days to build it back.

Thank you, Mr. Mayo, and your railroad. Your people are to be congratulated.

Assignment 4—Culverts, was presented by Subcommittee Chairman G. B. Harris (Chesapeake & Ohio).

Mr. Harris: This year your subcommittee makes a report on only one of its two assignments.

The report on Assignment 4 (b) may be found on pages 1110 through 1113 of Bulletin 507, published in February of this year.

Due to the increasing number of explosions in recent years on high-pressure gas and oil lines, it has been deemed advisable that further study be made of the present specifications covering underground pipe line crossings carrying inflammable materials.

Inasmuch as the present Manual material does not cover high-pressure lines, your committee, collaborating with Committee 15, has prepared a tentative specification for pipe line crossings under railway tracks for inflammable substances, which appears on pages 1110 to 1113, incl.

These specifications are presented as information, for the purpose of soliciting comments and criticism prior to submission in 1954 for adoption and inclusion in the Manual in place of the current specifications.

It is proposed to retain the present specifications for non-inflammable substances in the Manual as Sec. (b) of these specifications.

The report is submitted as information.

President Geyer: Thank you, Mr. Harris. The report will be so received, and I hope that members of the Association will communicate to the committee any suggestions they might have on the proposed specifications.

Assignment 6—Roadway: Formation and Protection, was presented by R. H. Beeder (Santa Fe).

Mr. Beeder: Assignment 6 (a) of your committee covers roadbed stabilization under the general head Roadway: Formation and Protection, and is shown on pages 1113 to 1136, incl., in Bulletin 507.

Assignment 6 (a) is divided into four parts, the first of which gives recommended practice for tie and pole driving, and is published in Bulletin 507, with the expectation that it will be presented for adoption as Manual material in 1954.

Part 2 is presented as information and describes a number of investigations into extensive slides and possible corrective measures.

Part 3, also presented as information, contains a detailed description of the measures taken in new yard construction on the Southern Railway and the Denver & Rio Grande Western to increase the stability and service behavior of the track structure to prevent the need for future stabilization. It also outlines some of the values to be obtained from soil investigation.

Part 4, also presented as information, is a record of pressure grouting projects brought up to date to show the great benefits to be obtained through proper stabilization.

All of these parts of Assignment 6 (a) are presented as information.

President Geyer: Thank you, Mr. Beeder. They will be so received.

Assignment 10—Ballast.

Chairman Miller: Since the chairman of this subcommittee—A. T. Goldbeck (National Crushed Stone Association)—is not present, I will hand the reporter the report for inclusion in the Proceedings.

(Following is Mr. Goldbeck's statement, which made reference to only Part 2 of the committee's report):

Part 2 of the report on Assignment 10 (a) describes an investigation in which an attempt was made to correlate standard laboratory acceptance tests with field performance. The tests were performed in the laboratories of the National Crushed Stone Association, National Sand and Gravel Association, and National Slag Association on samples of stone, gravel and slag ballast, respectively, submitted by the railroads cooperating in the investigation. Information with respect to field performance was submitted by the railroads.

The number of samples submitted for test was small in comparison with the total number of sources of ballast available over the country. Generally, it can be said that no correlation was found between the evaluation of the field performance for the samples and the test results. Undoubtedly, a contributory cause was the small number of samples. Further, the range in quality was narrow, most samples being rated at least satisfactory and in general meeting usual specification limits.

As a result of these factors the tests offer little by way of definite information which might be used in establishing realistic specification limits. It is felt that a more useful purpose might be served by testing the samples of individual ballasts which are known to have poor service records. Perhaps in this manner some basis for evaluating the causes of the poor performance of certain materials could be established.

Assignment 11—Chemical Control of Vegetation, was presented by Subcommittee Chairman C. E. Webb (Southern).

Mr. Webb: The progress report on Assignment 11—Chemical Control of Vegetation, appears in Bulletin 507, on pages 1148 to 1159, incl. The work is under committee sponsorship performed under the direction of the research staff of the Engineering Division, AAR. The report is divided into two parts.

Part 1 is the second annual report of the investigation performed at Iowa State College, and Part 2 is a resumé of field investigations on various railroads made by the research staff of the AAR.

Vegetation and climates differ widely throughout the country, and no one chemical has been found that can be used in economic dosages to provide good results on all types of vegetation and under all climatic conditions.

The scope of the work, and the number of test plots necessary to provide basic information on a nation-wide basis is such that no definite recommendations can be made at this time.

Some of the more promising compounds were tested in Montana and Florida, in collaboration with Iowa State College. Field investigations of the results of chemical formulations used by various railroads will also be made by the AAR staff.

This report is for information.

President Geyer: Thank you very much. It will be so received.

Chairman Miller: It was the intention of the committee to request W. T. Adams, specification engineer, Armco Drainage & Metal Products, to speak on "Proper Installation and Inspection Would Protect Your Drainage Investment," but owing to time limitations, this address will be presented in the Proceedings, and will not be read before the convention.

Proper Installation and Inspection Would Protect Your Drainage Investment

By W. T. Adams

Specification Engineer, Armco Drainage & Metal Products, Inc.

The fundamental reason for engineering is economical performance. From the chief engineer to the laborer, everyone is interested in having the drainage structures they install do the job for which they are designed.

Good culvert structures, with low maintenance costs, are the result of good installation. Poor culvert performance, with high maintenance costs, is the result of poor installation practices. This is confirmed by the examination of culverts of all types of construction. Poor installation seems to be due to a lack of realization of the importance of the details of good installation on the part of contractors, construction crews, and the field engineer.

Nearly all agencies have adequate construction specifications, but good specifications will result in good installations only when they are interpreted in the field by inspectors who have authority to act, and who understand the importance of the specification requirements.

Drainage structures need to be well located, properly bedded, properly assembled, and carefully backfilled. Yet, field inspections too often show that one or more of these items have been neglected. Backfilling and tamping are often done without any effective supervision, with the result that poor alinement, structural failures and excessive deflections show in the finished installation.

It is common to find fills being end dumped from one side of a structure. Sometimes this starts deep slides that throw the structure completely out of line; sometimes structural failure results. Frequently unsuitable backfill is used or it is improperly placed, often without any tamping. Structures are often placed on inadequate foundations.

The practical requirements of a good backfill are shown in Fig. 2. Regardless of whether the structure is rigid or flexible, if the backfill on each side of the structure is placed in uniform layers and thoroughly compacted, the ability of the culvert to carry the loads will be improved. The foundation under this compacted fill must have adequate load-carrying capacity. Preferably it should be firmer than the foundation material immediately under the structure, but the structure foundation should never be soft. The thoroughly compacted material on each side of the structure should extend to natural firm ground, to the trench sides, or far enough to support the fill loads over the structure without sliding. While the small area immediately adjacent to the structure will need some hand tamping, the important thing is to attain a large compact mass on each side of the structure. The fill over the structure can be compacted in any way that will develop the strength necessary to carry the fill and the live loads.

Fig. 1—Poor backfilling.

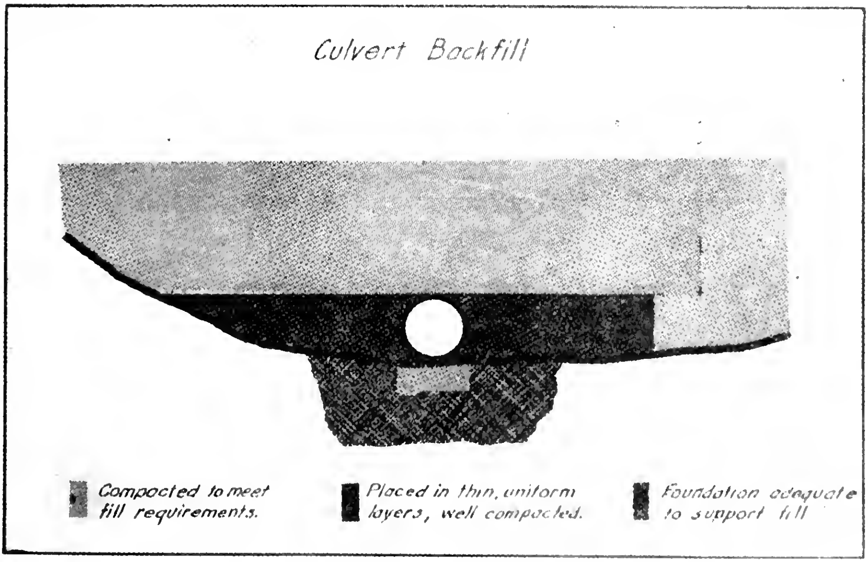


Fig. 2—Principles of good backfilling.

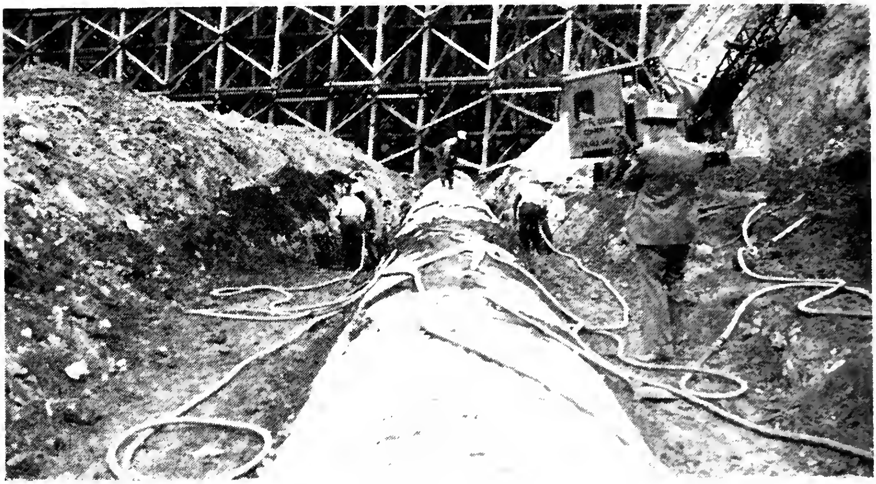


Fig. 3—Good backfilling.

Fig. 4—Good finished installation.

A well placed, thoroughly tamped backfill can be built economically and quickly with modern construction equipment. Suitable backfill material is generally available near the site of the drainage structure. While granular soils are preferred, most local materials can be made to work if they are properly handled. Pneumatic tampers make it easy to compact the backfill thoroughly adjacent to a structure or between closely spaced parallel structures. The earthmoving equipment can place the fill in shallow uniform layers with no delay, and a compacting roller will assure a dense stable fill.

A good compact backfill is neither hard to obtain nor expensive when suitable backfill material is used with modern equipment.

Good finished structures are the result of careful installation under adequate supervision. Whether it is a pipe of small diameter under a medium high fill, or a battery of very large pipes under a relatively shallow fill, or three medium size pipes under 135 ft of fill, the results of good construction can be seen in the finished job.

Not every structure that we see looks as well as those in the accompanying figures. Those that are in trouble almost always show evidence of poor installation. Careless backfilling, no foundation preparation, and wet fills are the most frequent faults.

Almost all installation specifications will overcome these faults if they are enforced in the field. These comparisons between poorly handled jobs and those where standard construction practices were followed, clearly point out the fact that the laborers, machine operators, foremen, superintendents, and contractors all need to understand the principles of backfilling if we are to have well installed drainage structures. The resident engineers and inspectors can be helpful in educating the crews as well as in enforcing specifications.

With proper installation your drainage structures will give you many years of trouble-free service.

Chairman Miller: In concluding the report of Committee 1, I would like to thank all the members of the committee for their assistance and cooperation during my tenure of office as chairman.

Mr. B. H. Crosland, assistant chief engineer, St. Louis–San Francisco Railway, becomes my successor as chairman of Committee 1. Mr. J. A. Noble, chief engineer, Western Lines, Santa Fe Railway, is the new vice chairman. Will both of those men please stand?

This concludes the report of Committee 1.

President Geyer: Mr. Miller, I thank you and your committee very much on behalf of the Association for the splendid work you have done in the past year, and particularly for the manner in which this report was presented today.

I congratulate you on your own behalf, as chairman of this committee, for the good work you have done for the past two years, and welcome Mr. Crosland as chairman of the committee in your place, and Mr. Noble as vice chairman.

The committee is excused with the thanks of the Association.

Gentlemen, this completes the reports for today, but I would like to call your attention to the fact that tomorrow we have some other very important reports by other committees, and it will be necessary to get started promptly at 9 o'clock. I hope everyone will be here on time.

The session is adjourned.

(The meeting adjourned at 0:05 o'clock.)

Morning Session—March 19, 1953

(The meeting reconvened at 9 o'clock, President C. J. Geyer presiding.)

President Geyer: The meeting will come to order. Will Committee 3 please come forward.

Discussion on Ties

(For report, see pp. 625–635.)

(President C. J. Geyer presiding.)

Chairman P. D. Brentlinger (Pennsylvania): Committee 3—Ties, reports on six assignments this morning. The first assignment, on Revision of Manual, will be presented by C. D. Turley.

Assignment 1—Revision of Manual, was presented by Subcommittee Chairman C. D. Turley (Illinois Central).

Mr. Turley: The report on Assignment 1 is found in Bulletin 505, pages 626 and 627.

Mr. Chairman, with your permission I shall read the proposed revisions and then make one motion for their approval. Any remarks or questions from the floor will be given attention as we proceed.

President Geyer: That will be all right, Mr. Turley.

(Mr. Turley then read, in full, the proposed revisions of the Manual on pages 626 and 627 of Bulletin 505, and then continued):

Mr. Chairman, that completes the report on Assignment 1.

I move that the deletions which I have read be approved, and that the revisions and reapprovals be approved for printing in the Manual.

(The motion was regularly seconded, was put to a vote, and carried.)

Assignment 2—Adherence to Specifications, was presented by Subcommittee Chairman P. D. Brentlinger (Pennsylvania).

Mr. Brentlinger: Field reports indicate an abundance of cross ties; in fact there are more ties than customers. When this situation prevails there are few outward signs of deliberate disregard for adherence to specifications. Any trend is usually toward closer observance of adopted specifications.

Constant readjustment of specifications to provide ties creates a situation that makes it extremely difficult for tie contractors to produce ties. When inspection is lax ties are manufactured accordingly, and a sudden tightening of inspection practices creates confusion, and leaves the producer with ties not acceptable according to correct interpretation of specifications.

It is strongly recommended that all railroads standardize on their acceptances, regardless of demand. Standardized inspection will provide ties of top quality and, in addition, will aid in the production of ties that will be acceptable to all railroads.

This report is offered for information.

President Geyer: It will be so accepted.

Assignment 4—Tie Renewals and Costs Per Mile of Maintained Track, was presented by Subcommittee Chairman L. W. Kistler (St. Louis-San Francisco).

(Mr. Kistler read the committee's report as published on page 628 of Bulletin 505 and stated that it was being offered as information.)

President Geyer: Thank you, Mr. Kistler. It will be so received.

Assignment 5, Methods of Retarding the Splitting and the Mechanical Wear of Ties, was replaced by a talk by G. M. Magee.

Progress in the NLMA—AAR Cross Tie Research Project

By G. M. Magee
Director of Engineering Research, AAR

This research project was initiated by the National Lumber Manufacturers Association and the Association of American Railroads as a joint undertaking in an effort to find means of prolonging the life of cross ties, especially as affected by checking and splitting. Checking and splitting of cross ties, especially creosoted oak, is one of the important factors determining their serviceable life. When this project was started it was contemplated that it would require five years for completion. Since last year marked the completion of the five-year program originally planned, it seems appropriate now to review, in a general way, the accomplishments of the project. The project was not terminated last year, however, and is being continued during 1953 with a budget equal to approximately one-half of that for each of the preceding years of the five-year program.

In some respects the results that have been obtained from this research have not been as much as were hoped for. On the other hand, there certainly has been enough knowledge gained to repay many times over the cost of the work and to make possible substantial economies in the cost of cross tie renewals, which at the present time is in excess of $150,000,000 annually.

One-Step Seasoning and Treating Process

This research work has developed along four different lines. Probably of most importance is the work on finding a means of seasoning or treating ties to minimize checks and splits. It was found that most of the checking and splitting that occurred in cross ties, or at least a substantial proportion of it, developed during the seasoning period in the tie yard. The tendency of the outermost fibers of the tie to dry and shrink more quickly than the interior fibers sets up differential strains in the wood of sufficient magnitude to produce surface rupture. Obviously, this condition can only be corrected by starting with the tie as soon as it enters the treating yard. Accordingly, work was started on a means of developing a process for treating the green timber before checking and splitting occurs. As a result of several year's work in the laboratory a one-step seasoning and treating process was developed which appeared to have promise.

Arrangements were made to treat a number of full sized ties in the Santa Fe experimental treating cylinder at Albuquerque, N. M. This cylinder had a capacity of about 16 ties in a charge, and necessary facilities were available for controlling the treating conditions. When the ties were charged into the treating cylinder, the regular treating mixture was added, but including approximately 10 percent glycol. The charge was then heated to a temperature of about 280 deg for the length of time required, from 11 to 16 hr, until the moisture content of the wood was sufficiently reduced. Glycol has the effect of replacing the water in the outermost fibers of the wood and of keeping these cells filled so that rupture does not occur before the water is sufficiently removed from the interior fibers. During last year 500 ties, consisting of 100 each of fir, pine, red oak, white oak and gum were treated by this one-step seasoning and treating process.

After treatment the ties were installed in the Santa Fe tracks near Topeka, Kan., for observation of their service performance.

Considerable information was obtained from this test. In general, it seemed that the process accomplished considerable towards retarding checking and splitting. However, the amount of glycol required for treatment and the cost per pound of the relatively pure glycol used in this test obviously made it uneconomical for general cross tie treatment. Work is being continued, therefore, to find a more economical glycol, or substitute therefor. Another important question about this treatment is whether the strength of the wood has been seriously impaired by the elevated temperaure used during treatment. This is being studied in the laboratory by means of rolling-load tests in which a 30,000-lb wheel load is applied to a tie plate supported on a specimen of wood treated by this process, for 2,000,000 cycles, to determine the resistance of the wood to crushing and wear from the tie plate.

Tie Coatings

The second important phase of this research is the work on tie coatings. This is important not only because of the protection possibilities for new ties, but also because it affords means of prolonging the life of the millions of ties now in track. An outdoor exposure test is being maintained at the Timber Engineering Company laboratory in Washington, D. C. All of the research work on this project has been carried out at the TECO laboratory, which is a subsidiary of the NLMA. In this laboratory exposure test, short sections of cross ties of full cross sectional area are placed in a bed of crushed rock in a manner simulating ties in ballast. Each tie coating being tested is applied on a tie specimen. A method has been developed of rating the coatings by the number and width of cracks that develop. Each specimen is observed and rated periodically in this exposure test. Some observations have also been made of coatings applied on ties in track. It has been definitely determined that a good tie coating will maintain a more uniform moisture content in the top portion of the tie during the seasonal changes throughout the year. These tests have indicated that with a coating the top tie fibers show less increase in moisture content following rains and less drying out following prolonged dry spells than do ties that are not protected by a coating. As a result of this work a tentative specification has been prepared by the TECO laboratory staff and this is now in the process of being reviewed by the Administration committee, whereupon it will be given to the Tie committee for their further consideration.

Laminated Tie

Another important phase of the research has been work on the development of a laminated tie. Cooperating with the AAR research staff, stress measurements were made on typical ties in track to determine the bending moments and bending stress developed under traffic. It was hoped that some departure from the customary shape and size of cross tie might be made to advantage since the use of laminated wood makes possible a different shaping of the tie. However, the results of the stress measurements indicated that the best procedure would be to continue with a rectangular section of tie, and the same cross sectional dimensions as now being used appeared to be necessary. Accordingly, 125 laminated ties are being manufactured using the latest gluing techniques, and arrangements have been made with the Pennsylvania Railroad to install these in one of its heaviest traffic density lines for observation of their service performance. The cost of lamination is so much that ties cannot be produced by this process today in competition with sawn or hewn ties. However, it is believed that this development is very much worthwhile because we will have actual data available on what service performance can be expected of laminated ties for our future guidance if the economic picture changes.

Chemical Deterioration of Wood Fibers

The fourth phase of the research has been the study of the effects on chemical deterioration of the wood fibers by the corrosive products of the tie plates and spikes. Studies of wood fibers of ties removed from track showed definite indications of iron compounds, and there was evidence that these had caused the deterioration of the cellulose in the wood fibers. Apparently the water that accumulates on the ties becomes acidic from certain chemicals dissolved from the wood fibers, and this acidic water produces corrosion on the bottom of the tie plate and at the surface of the spikes. The iron compounds so formed come into contact with the wood fibers and deterioration results. It has not been possible to evaluate just how important a factor this chemical deterioration is in producing tie cutting. However, it is hoped that this can be evaluated and that some practical means can be found for protecting the tie against this attack. A possible approach is to incorporate a corrosion inhibitor in the tie doping compounds used in connection with rail relaying.

Assignment 6—Bituminous Coating of Ties for Protection from the Elements, was presented by Subcommittee Chairman W. J. Burton (Missouri Pacific).

Mr. Burton: Within the last three or four years a number of tests have been started wherein thick bituminous coatings have been applied to the top faces of ties already in track or on bridges. The purpose of these coatings is to seal the surface checks against moisture and dirt.

It is well known that many ties have checks which tend to widen in dry weather and close up in wet spells. If these checks extend below the penetrated wood, as many do, decay organisms may be introduced into the untreated portion of the tie and begin to grow where the creosote did not penetrate. When checks are open, not only can moisture enter the tie, but usually dirt and grit so fills the checks as to prevent the checks closing up again as they would otherwise do when wet weather returns.

The idea of providing a plastic coating, which will be soft enough to keep the checks sealed against moisture, is sound, as far as the mechanics of decay is concerned. The only question is as to whether the added tie life is worth the cost. The cost of the labor and materials reported in the tests has been so great as to cast serious doubt that benefits will equal costs. However, the tests were started too recently to afford the basis for any estimate of the added tie life to be expected.

Besides these coatings, which were applied to ties already in track, the committee gave recognition to the coatings which some ties retain following treatment with certain mixtures of creosote and crude-oil residue or creosote and coal-tar. It is the universal opinion of those familiar with such ties that they last longer because of the coatings. The coatings are sufficiently hard to permit handling and insertion of the ties in track, something which is not feasible with the softer coatings. Besides this great advantage, the entire surface of these ties is coated and protected, instead of merely the top face

With cross ties costing as much as they do now, all efforts to obtain greater life should be watched. The committee recommends that the subject be continued and that the report be received as information, and I so move.

(The motion was regularly seconded, was put to a vote, and carried.)

Assignment 7—Causes Leading to the Removal of Ties, was presented by the Subcommittee Chairman L. C. Collister (Santa Fe).

Mr. Collister: The report on Assignment 7 is printed in the December Bulletin, 505, on pages 634 and 635. It is a summary of five reporting railroads that have kept records of removals and reported them.

Quite a few railroads answered our questionnaire with the statement that no records were being kept on the cost of removing ties. From our report and the lack of information coming in, it was quite evident that further study is necessary.

This report is submitted as information.

President Geyer: It will be so received. Thank you, Mr. Collister.

Chairman Brentlinger: That concludes the committee's report.

President Geyer: Mr. Bentlinger, we thank you and your committee for the fine work you have done, particularly on your chapter in the Manual. Ties form one of the large perennial items of cost in maintenance work, and this is a very important committee.

Your committee is excused with the thanks of the Association.

Discussion on Track

(For report, see pp. 969–1084.)

(President C. J. Geyer presiding.)

Chairman F. J. Bishop (Akron, Canton & Youngstown): Mr. President, fellow members: The Track committee report is included in Bulletin 507, starting with page 969.

We were unfortunate during the course of the year in losing two of our very valued members—Mr. James Arthur Blalock, of the Richmond, Fredericksburg & Potomac Railroad, and Mr. Charles W. Breed, of the Chicago, Burlington and Quincy Railroad. Suitable memoirs are prepared and are included in our report.

Your committee has worked diligently during the year on the review of the Manual material, the work having been divided among the subcommittees.

Our first subject is Revision of Manual which will be presented by C. R. Strattman, chairman of the subcommittee.

Assignment 1—Revision of Manual, was presented by Subcommittee Chairman C. R. Strattman (New York Central).

(Mr. Strattman read the entire report, appearing on pages 972 and 973 of Bulletin 507, and in a series of motions asked that all of the recommendations be adopted. All of the motions were duly seconded and carried.)

Assignment 2—Track Tools, was presented by Subcommittee Chairman Troy West (Union Railroad).

Mr. West: The published report of Assignment 2 is found in Bulletin 507, page 973 to 993, incl.

The three main subdivisions of this assignment are treated separately to show more clearly the recommendations of your subcommittee, all of which has been approved by letter ballot by the main committee.

First, Specifications, General, Manual pages 5–47 to 5–50, incl.

The recommended changes which we have submitted are mostly editorial, to clarify the intent of the general specifications, such as the changing of "open hearth" to "carbon" in properly designating the kind of steel desired.

We also recommend that Art. 27, on page 5–50 of the Manual, Rail Tongs for Use with Crane, be withdrawn, because the tool is considered unsafe for use.

All of these changes are written out in more detail in your Bulletin.

Mr. President, I move that the General Specifications for Track Tools appearing in the Manual, pages 5–47 to 5–50, incl., be reapproved with the minor revisions mentioned (and shown in detail in Bulletin 507, pages 973 and 974) for inclusion in the new Manual.

(The motion was regularly seconded, was put to a vote and carried.)

Mr. West: The second item in the assignment considered by the committee is Specification for Ash and Hickory Handles for Track Tools, Manual pages 5–51 to 5–53, incl. Mr. President, your committee has reviewed this thoroughly, and I have been instructed by the committee to move that the Specification for Ash and Hickory Handles for Track Tools be reapproved without change.

(The motion was regularly seconded, was put to a vote, and carried.)

Mr. West: The third and last item deals with Plans for Track Tools, Manual pages 5–54.1 to 5–70, incl. Bulletin 507, pages 975–977. We recommend that the index sheet, Manual page 5–54.1, be changed to show the revisions recommended on the individual track tool plans, and show accurate data for grade of steel that use has established.

Under Recommended Limits of Wear for Tools To Be Reclaimed, page 5–54.1 of the Manual, we recommend that reference to Plan No. 16, Tie Plug Driver, be deleted, since it is considered unnecessary to show the limit of wear on such a tool.

Where necessary, changes of an editorial nature are recommended in the notes on the individual track tool plans, to make clear the intent of their requirements. They comply with the changes in the general specifications.

We recommend the deletion of Plans 4 and 4–A, Track Wrenches, shown on Manual pages 5–55 and 5–56, and the substitution of Plan 4–53, to conform to recent convention approval of track bolt and nut sizes submitted by the Rail committee. (The proposed drawing appears on page 976 of Bulletin 507.)

We also recommend that Plan 7–46, Tie Tong (Manual page 5–57), be redrawn to show round handles, and to add the note, "Handles can be made from ½-in by 1-in bars, if preferred, instead of round as shown." This is recommended because the round handles are safer and are used by almost all railroads.

We recommend the revision of Plan 17–44, Track Chisel (Manual page 5–63), to change angle of cutting edge from 55 deg to 65 deg, and change radius of cutting edge from 1 in to 1½ in. This is recommended because use has proved that the blunt and flatter edge is safer and more durable.

We recommend the withdrawal from the Manual of Plan 23–47 (Manual page 5–67), Rail Tongs for Use With Crane, because it is considered unsafe for use.

I have tried to describe for you only the changes of material consequence in the track tool plans which we recommend. A detailed description of this appears in Bulletin 507, pages 975 to 977, incl.

Therefore, Mr. President, I move that the recommendations of your committee with respect to the changes in the track tool plans as described, and shown in further detail in the Bulletin, be approved for inclusion in the new Manual.

(The motion was regularly seconded, was put to a vote, and carried.)

Mr. West: We report progress in our development of a track spike starter.

We call your attention to our report on the use of aluminum alloy in making track tools, which appears in the Bulletin on pages 978–980, which includes a very interesting and instructive laboratory test on an aluminum lining bar conducted by Mr. Magee's forces.

Your committee is continuing its investigation of a weakness in the nipping end of the claw bar. A report by Mr. Magee of his laboratory investigations on this subject appears on pages 981 to 993.

This concludes my report.

President Geyer: Thank you, Mr. West. This part of your report will be received as information.

Assignment 3—Plans for Switches, Frogs, Crossings, Spring and Slip Switches, Collaborating with Signal Section, AAR, was presented by Subcommittee Chairman M. J. Zeeman, (Santa Fe).

Mr. Zeeman: The report on Assignment 3 is in Bulletin 507, pages 994–1036, incl.

Since the stock of Trackwork plans in the secretary's office was depleted, it became necessary last year to reprint the complete Trackwork Portfolio. It was, of course, highly desirable to have all plans brought up to date, for which reason each plan in the Portfolio was reviewed. This complete review disclosed a number of minor inconsistencies, due mainly to not having revised certain details to agree with similar details which were approved by the Association later on in other plans; also, it was found that reference to some items, such as rail sections, were not up to date.

Your attention is called to a printer's error in the plan number of the second item from the top on page 995. The number is shown as 1101–52, but should have been 1001–52.

While knowing that changes in plans require convention approval before they become effective, your committee, nevertheless, considered it essential to make these revisions before reprinting, feeling that you would want us to do so, and, considering the circumstances, would not spank us too hard.

Revisions have been made in eight plans, including two plans issued for information only, and the plan numbers, together with a detailed statement of the revisions made in each plan, are shown on page 994, and the top of page 995.

In order to make these corrections official, Mr. President, I move the adoption as recommended practice, for publication in the Portfolio of Trackwork Plans, Plans 190–52, 213–52, 220–52, 490–52, 690–52 and 793–52; also, for information only, plans 1001–52 and 1004–52, and the withdrawal of the previous issues of these plans.

(The motion was regularly seconded, was put to a vote, and carried.)

President Geyer: I think, Mr. Zeeman, the fact that the Association has approved what the Track committee did is ample proof of the fact that they thought you used good judgment.

Mr. Zeeman: Thank you, sir.

While reviewing each plan in the Portfolio in connection with the 1952 reprinting, it was found that 37 plans required minor corrections, some to incorporate previously authorized changes, some to correct inconsistencies with other approved plans, and others to correct drafting or printing errors. In order to reduce considerably the cost of the 1952 Supplement to present holders of the Portfolio, an instruction sheet was included with the 1952 Supplement, listing the plans and the changes to be made in each plan, and each purchaser of the Supplement was asked to make these changes himself, since only a little work was required. As a matter of record, the 37 plans involved and the changes made in each plan are shown beginning on page 995, with Plan 112–51, and ending on page 997 with Plan 1003–40.

Mr. President, the corrections made in these plans are submitted as information.

President Geyer: They will be so received.

Mr. Zeeman: Your committee wishes to acknowledge the hearty cooperation of the Standardization committee of the Manganese Track Society in the review and correction of the plans in the Portfolio.

Your committee wishes to present three progress reports, prepared by the research staff of the Engineering Division, AAR, under the general direction of Mr. Magee. The first report, Service Tests of Designs of Manganese Castings in Crossings at McCook, Ill., is shown as Appendix 3–a, beginning on page 997. The second report, Service Tests of Solid and Manganese Insert Crossings Supported by Steel T-Beams and Longitudinal Timbers, is shown as Appendix 3–b, beginning on page 999. The third report, Crossing Frog Bolt Tension Tests, is shown as Appendix 3–c, beginning on page 1001.

In connection with the third report, Appendix 3–c, we wish to correct a printer's error on page 1023. Unfortunately, in correcting an error in the first line of the second paragraph from the bottom of the page, the printer placed the corrected slug in the first line of the third paragraph from the bottom of this page as well as in its proper place. Therefore, the first line of the third paragraph from the bottom of this page is in error, and should read as follows: "The results in Series 3 demonstrated that 10,000-lb static bolt tension was inadequate."

Mr. President, these three reports, including the correction in Appendix 3–c, are submitted as information.

President Geyer: They will be so received, Mr. Zeeman.

Mr. Zeeman: Your committee also presents a report prepared by Mr. Orr of the Union Pacific Railroad concerning a grooved stock rail for switches. This report is presented as Appendix 3–d, beginning on page 1034.

Mr. President, this report is submitted as information.

President Geyer: It will be so received.

Mr. Zeeman: This concludes the report on Assignment 3.

President Geyer: Thank you, Mr. Zeeman.

Assignment 4—Prevention of Damage Due to Brine Drippings on Track and Structures, Collaborating with Committee 15 and Mechanical Division, AAR, was presented by Subcommittee Chairman W. E. Cornell (Nickel Plate).

Mr. Cornell: Report on Assignment 4 will be found on page 1036 of Bulletin 507, and is a progress report.

During the past year a laboratory has been built and equipped, and the Association's chemical engineer has spent considerable time reviewing contemporary information on the subject of corrosion. Also, a patent search was made covering the last ten years of all compounds and mixtures recommended for corrosion inhibitors on steel and alloys.

While progress may seem slow, the need for effective non-toxic inhibitors, from a relatively limited field, necessitates the greatest care and service. Your committee feels that the work done during the past year was very necessary, and was a worthwhile contribution to the progress of this work.

President Geyer: Thank you, Mr. Cornell. The report will be received as information.

Assignment 5—Design of Tie Plates, was presented by Subcommittee Chairman M. D. Carothers (Gulf, Mobile & Ohio).

Mr. Carothers: This report is found in Bulletin 507, pages 1037 to 1046, incl. In order to save time, I will try to give you a brief report.

Your committee offers the following recommendation with respect to the Manual:

Pages 5-1 to 5-3, incl., Specification for Low-Carbon Steel Tie Plates.

Pages 5-4 to 5-8.9, incl., Tie Plates for RA-A and RE Rail Sections.

Pages 5-14.1 to 5-14.3 incl., Specification for Hot-Worked High-Carbon Steel Tie Plates.

Mr. President, this committee recommends reapproval of the foregoing documents without change.

(The motion was regularly seconded, was put to a vote and carried.)

This committee submits as information (1) a progress report on the service test of seven designs of tie plates for the rail base width of 5½ in, and (2) the results of a field test in which the magnitude and eccentricity of tie plate loads in tangent track under diesel and steam power were measured with calibrated dynamometer tie plates.

The service test of seven tie plate designs is located in the southbound main of the Illinois Central, near Curve and Henning, Tenn. All traffic over the test section is being hauled by steam locomotives, except that four passenger train schedules have multiple-unit diesels. The 4-deg test curve has approximately 4 in elevation and some of the heavy tonnage freight trains operate as low as 20 mph. Both freight and passenger trains operate close to their maximum speeds over the tangent test section at Henning. Further data of the tests are shown in Bulletin 507, pages 1037–1044.

The first report on measurement of Tie Plate Loads, using calibrated dynamometer tie plates, was published in Proceedings, Vol. 50, 1949, pages 18–40. That report gives the results on the measurements of tie plate loads and eccentricities in a 4-deg curve and tangent track on Illinois Central near Curve and Henning, Tenn. The results given in the present report cover measurements of the tie plate loads in tangent track under both steam and diesel power and supplement the previous report.

The committee extends its appreciation to the Illinois Central and the Milwaukee Road for their assistance and cooperation in conducting the field test.

This report is submitted as information.

President Geyer: It will be so received, Mr. Carothers.

Assignment 6—Hold-Down Fastenings for Tie Plates, Including Pads Under Plates; Their Effect on Tie Wear, Collaborating with Committee 3, was presented by Subcommittee Chairman Blair Blowers (Erie).

Mr. Blowers: This progress report, presented as information, covers the service tests of hold-down fastenings, tie pads, coatings, etc., on the Louisville & Nashville Railroad, near London, Ky. It is to be found on pages 1047 through 1066 of Bulletin 507.

These investigations are to determine the most economical and effective methods for minimizing tie plate cutting and the frequency of regaging and readzing of ties on curves, thus increasing tie life.

Last summer the following additional sections were installed:

Burkart fiber pads with an adhesive coating on the bottom side in the 5-deg test curve.

Racor fiber-rubber tie pads, coated, and two each of cut line spikes and Racor studs as anchors in the 4-deg 30-min test curve.

A section containing 30 creosoted oak ties with two cut line spikes, and three Racor studs as anchors per tie plate, and an equal number of ties with four Racor studs as anchors in the long 4-deg, 30-min test curve.

The Racor studs replaced the old sections having the Racor Drive Tight spikes. These sections were damaged by a minor derailment and the sponsor desired to discontinue them.

To investigate the benefits of using compounds in spike holes of the ties, which application greatly increases the withdrawal power to cut spikes, a nine-panel track test was installed in the 5-deg 30-min curve north of East Bernstadt. Existing ties, averaging about 10 years old, were used, the cut spikes were pulled, the compounds added, and the cut spikes redriven. The north three track panels will be used for controls. No work was done, except to remove gage rods. In the next three panels to the south a wood hardener, known as Compound 8 and marketed by the Wood Treating Corporation, Cleveland, Ohio, was added to the spike holes. In the south three panels, Rust–Joint Iron and water were poured in the spike holes. Rust–Joint Iron is manufactured by the Master Builders Company, Cleveland, Ohio. The performance of the two compounds will be judged primarily from the annual measurements of the track gage, which are to be taken at six points in each panel of track.

Before retiring the sections having the Racor Drive Tight spikes in the 4-deg 30-min test curve, final tie plate penetration readings were taken in those two sections and also the adjoining section on the south which had two each of cut spikes for line and anchors. Where four of the special spikes per plate were used, the depth of plate cutting was about one-half of that for cut spike construction, as compared to one-third reduction in the section with two each of cut line spikes and Racor Drive Tight spikes as anchors.

A small amount of maintenance work was performed in retightening and tapping down four types of special anchor spikes. After five years' service, with over 100 million gross tons of traffic, no maintenance was required for the tie plate lock spikes in the long 4-deg 30 min test curve, and the Racor Drive Tight spikes in tangent and curved track; all of the latter were replaced after one year because the tie plate punching was on the larger side of the tolerance permitted. In most of the sections having special anchor spikes the gage on the curves had changed little, and was more uniform than in many of the sections with cut spike construction.

The sections having Koppers No. 16 sealing compound on the ties for the purpose of preventing checking and splitting of new and existing hardwood ties were in good condition after a 2-year service period, and had provided a cover over 63 to 85 percent of the cracks in newer ties and from 75 to 89 percent of the older ties. The coating was effective in maintaining a higher moisture content in the upper 3⁄8 in of the ties. The 2-year old coated ties had 21 percent moisture as compared with 11 percent for the uncoated ties.

Two of the adzed surface coatings had the longest service life. AREA Bridge Waterproofing Asphalt was beneficial for 4 years and Solvated Seals for 3 years. Although these coatings were beneficial in keeping the water and sand from the underplate area, some tie abrasion had occurred. Final appraisal of the value of this method of tie protection will depend on developments in the future.

No conclusions as to the more effective and economical methods for extending tie life can as yet be made as these test results cover only a 5-year period.

Assignment 7—Effect of Lubrication in Preventing Frozen Rail Joints and Retarding Corrosion of Rail and Fastenings, was presented by Subcommittee Chairman J. W. Hopkins (Bessemer & Lake Erie).

Mr. Hopkins: The report of Subcommittee 7 appears on page 1066 of Bulletin 507. The recommendations for Track Bolt Tension Practice are on page 5-20 of the Manual. It is recommended that these practices be reapproved, and I so move.

(The motion was regularly seconded, was put to a vote and carried.)

Mr. Hopkins: The remainder of the report is presented as information, and contains data covering the second year of service of rail joint lubrication tests on the Illinois Central Railroad. A longer service period will be required before any definite conclusions can be drawn, and it is planned to continue the tests.

This completes the report of the subcommittee.

President Geyer: Thank you, Mr. Hopkins. The report will be so received.

Assignment 8—Field Measurement of Forces Resulting from Rail Anchorage, was presented by Committee Chairman Bishop in the absence of Subcommittee Chairman J. P. Hiltz (New York Central).

Mr. Bishop: This subcommittee carefully reviewed the material in the Manual, pages 5–17 and 5–18, Rail Creepage—Number and Position of Rail Anchors, and recommends that it be reapproved without change, and I so move.

(The motion was regularly seconded, was put to a vote and carried.)

Assignment 9—Critical Review of the Subject of Speed on Curves as Affected by Present-Day Design, was presented by Subcommittee Chairman J. W. Fulmer (Southern).

Mr. Fulmer: Our work coincides with a similar assignment of the Joint Committee on Relation Between Track and Equipment, and is being carried on by the AAR research staff under the general direction of Mr. Magee. Data are being compiled from the eight test runs that have been made. The nature of the subject makes it desirable to present a complete report on the results of all the tests on all railroads, rather than to present the data in partial reports. The test program as originally outlined has been nearly completed, and unless further testing is found to be necessary, the program can be completed shortly and a full report made.

A more complete report on this assignment appears on page 1081 of Bulletin 507.

Your committee offers the following for further revision of the Manual:

1. Reapprove the recommended Elevations and Speeds for Curves, as shown in table 507, page 5–43 of the Manual, with the 11 changes shown on page 1082 in Bulletin 507.

2. Reapprove the recommended table of Speed of Trains Through Turnouts with Straight Switch Points, as shown on page 5–37 of the Manual, with the changes shown on page 1082 of Bulletin 507.

3. Delete from the Manual the present table of Recommended Speeds Through Turnouts with Curved Switch Points, as shown on page 5–37, and substitute for it the recommended speeds through turnouts with curved switch points as shown on page 1083 in Bulletin 507.

4. Reapprove without change the recommended establishment of permanent monuments at points of tangency and at other points, as shown on page 5–37 of the Manual.

Mr. President, I move that these changes in the Manual be made.

(The motion was regularly seconded, was put to a vote and carried.)

Assignment 10—Methods of Heat Treatment, Including Flame Hardening of Bolted Rail Frogs and Split Switches, Together with Methods of Repair by Welding, was presented by the Subcommittee Chairman S. H. Poore (Chesapeake & Ohio).

Mr. Poore: This committee assignment is a new one and embraces the heat treatment or the use of bolted rail frogs made of heat-treated rail and flame-hardened rail, as compared with "as rolled" rail. The assignment is new, and we can only report progress.

It may be of interest to you that the Milwaukee Road—through Mr. Christianson and Mr. Magee's staff—is going to make several test installations of frog elements or frog intersections, each intersection to be one-fourth of a crossing, and be all on one rail, so that we may get comparative tests of all three types of material—heat-treated rail, flame-hardened rail, and "as rolled" rail—that carry the same traffic.

We hope that by next year at this time we can have a more full report.

Assignment 11—Means of Conserving Labor and Materials Including the Adaptation of Substitute Noncritical Materials, and Specifications for the Reclamation of Released Materials, Tools and Equipment.

Chairman Bishop: This report requires no comment.

Chairman Bishop: As a special feature of the Track committee report, we desire to present at this time G. M. Magee, director of engineering research, AAR, to give us a talk on prolonging the life of ties through the use of tie pads versus plate fastenings.

Tie Pads vs. Tie Plate Fastenings

By G. M. Magee

Director of Engineering Research, AAR

The increase in cost of ties in the last ten years has focused attention upon the need for prolonging tie life. Information available from several railways has indicated that there are two principal causes of tie removal. One of these causes is abrasion from the tie plate and the other is checking and splitting. The latter being especially important in treated oak ties. The Association research work on ties has, in general, been divided into two phases. One phase is the joint cooperative research with the National Lumber Manufacturers Association, which is devoted primarily to discovering means of seasoning and treating ties to protect against checking and splitting. The other phase consists of research projects which have been sponsored by the Track committee for the purpose of reducing tie abrasion and minimizing this is a cause for tie renewal. The Track committee research has consisted of studies to determine the most effective design of tie plate and the possibilities in the use of hold-down fastenings and tie pads, and to make accelerated tests in the laboratory with a rolling-load machine which simulates, as well as possible, the loading conditions to which the tie is subjected in track.

In our research work we have been attempting to learn as much as we can about the mechanics of tie abrasion or tie plate cutting. From this work we have learned there are several different factors which have an influence. It would be thought that the intensity of bearing pressure on the tie plate on the tie is of first importance; however, laboratory work has indicated this is not true. In these tests as many as 40,000,000 repetitions of bearing pressure of comparable intensity to that in track have produced almost no apparent wear or deformation on an untreated soft wood tie when the test was made on dry wood. It seems unlikely that bearing pressure is a very important factor in the tie wear unless there are other contributing factors.

For many years, and especially since Dr. von Schrenk's treatise on the subject, it has been considered that the lateral motion of the tie plate on the tie is of major importance in producing tie wear. In our work we have not been able to segregate and evaluate entirely the importance of lateral motion from other causes, but there is evidence to indicate that it does have a substantial effect. The amount of this motion probably would not have to be very great to produce tie wear. Measurements we have made indicate that the lateral motion of tie plates in track normally would be on the order of 0.005 to 0.01 in.

Our work has indicated that water is a very important factor in producing tie wear. It not only softens and weakens the wood fibers, but also acts as a lubricant so the lateral motion of the tie plate is increased and a more destructive rolling action of the wet tie fibers ensues. Water has a further action in producing tie wear. Dirt and fine grit mix with it to form a liquid bearing erosive materials. This liquid tends to fill any void between the tie plate and the tie. The pressure from each passing wheel load tends to squeeze this liquid out, which runs back upon the release of the pressure. This transitory motion of the liquid produces a very decided erosion of the wood fibers. Still a further action of water occurs because of its corrosive effect upon the tie plate and spikes. The corrosion product, iron compounds, contact the wood fibers and chemically attack them, resulting in a deterioration of their strength and resistance to pressure.

Summarizing, we may say, therefore, that there are at least five factors influencing tie wear: pressure, lateral motion, water softening, water erosion, and chemical deterioration. These factors may well be considered in evaluating the possibilities and relative effectiveness of tie pads versus tie plate fastenings for reducing or controlling tie wear.

In the service tests installed on the Louisville & Nashville Railroad near London, Ky., we have several different types of hold-down fastenings and tie pads under observation. The hold-down fastenings may be divided into two different types: those that restrain lateral motion of the tie plate by friction resulting from a clamping force, and those that accomplish this by wedging tightly into the spike hole. The following types of fastenings included in the London test utilize the clamping principle:

Through bolts—This fastening consists of a U-shaped bolt placed through the tie. It provides a positive clamping action.

Screw Spikes and Spring Washers—This consists of two ordinary type screw spikes with double-coil helical washers. The spikes must be driven with a torque wrench.

Dowel Stud—This spike is driven into the tie by vertical blows and the nut can be tightened to obtain and maintain clamping force.

Drive Screw—This spike is also driven into the tie with vertical blows.

Round Head Cut Spike—This is an experimental design of square shank spike with a round head for use with double coil washers.

Cut Spike with Rubber Cushion—This is a regular type of cut spike driven through a collar-like pad or cushion of rubber.

AAR Spring Clip—This is a regular screw spike driven by torque wrench through a special spring clip which provides a clamping force to hold the tie plate to the tie and the rail to the tie plate.

Two devices are included in the London tests of the wedging type:

Racor Stud—This is a short spike with a round shank having a series of collars under the head. These collars can be distorted by driving to wedge tightly into the spike hole.

Lock Spike—This spike wedges into the spike hole by spring action. Since the original installation the manufacturer has improved the design, but the principle is substantially the same.

The service tests have not yet indicated any conclusive differences in the effectiveness of any of these types of fastenings. Generally, they have effected a reduction in the rate of tie wear of about one-half compared to ordinary cut spike construction. The clamping action fastenings would be expected to have advantages over the wedging type because they give less change in bearing pressure under traffic, and perhaps will better keep water from under the plate. Their first cost will likely be greater however, and the period of maintaining their clamping force is problematical.

Most of the tie pads included in the London test have entirely eliminated tie wear in the relatively short service period to date.

Because many more years will be required in the service tests to produce conclusive results, the use of laboratory repeated-loading machines, which simulate track loading on an accelerated basis, are of value. The American Brake Shoe laboratory at Mahwah, N. J., has developed and built an excellent testing machine especially for this purpose. This machine develops a repeated loading with a 20,000-lb vertical component and a lateral component of alternately 5000 lb inwardly of the track and 10,000 lb outwardly. In a period of 210 hr, 5,000,000 loadings are applied. From our track measurements, this number of loadings would simulate the loadings in 15 to 20 years of service on a moderately heavy-traffic railway.

Tests on a creosoted Douglas fir tie with a 7¾-in by 14-in tie plate, using water and sand continuously, with 2 cut spike rail fastenings and 2 cut spike plate fastenings, developed about ½ in tie wear. Similar tests with 2 screw spike plate fastenings with spring washers showed a tie wear of only ¼ in. With 2 Racor stud plate fastenings the amount of tie wear was also about ¼ in. With 2 through bolt plate fastenings the amount of tie wear was about ⅛ in. With a tie pad the amount of tie wear was somewhat less than ⅛ in.

These tests have been partially duplicated in the AAR testing machines. These machines apply a repeated vertical loading of 30,000 lb with no lateral component. Water and sand are also used with the machines and the same number of cycles of loading (5,000,000). In tests on treated red oak ties with the same size tie plate, the amount of tie wear was about ⅛ in. With a tie pad having a seal coating, the tie wear was only about 0.02 in. The tests in these laboratory repeated-loading machines have indicated that a tie pad is effective in providing a cushioning action for the lateral motion of the tie plate. In these tests it was apparent that certain types of tie pads would adhere to the tie and to the tie plate and effectively absorb the lateral motion so that none of this motion was transmitted to the tie. A further advantage of a tie pad is that if it is of a suitable composition, or if it is provided with an adequate sealing coating, it will effectively prevent water from contacting the tie fibers directly under the tie plate. This is, of course, of great importance in preventing weakening of the fibers, water erosion and chemical attack. Based upon our knowledge of what causes tie wear it would be expected that tie pads would be very effective in eliminating it, and this is confirmed by the laboratory and service tests. The principal question with tie pads is whether they will last sufficiently long to protect the tie and whether their cost is economically justified.

Service tests have not been of sufficient duration to determine definitely what life and what years of protection may be expected from tie pads. However, it is possible in laboratory tests to at least determine whether tie pad material can withstand the intensity of loading and the number of cycles of loading which it will have to withstand in many years of service. It also seems possible that perhaps other tests, such as chemical analysis and Weather-o-meter tests, to weather artificially the tie pads in the laboratory, will be a valuable indication of their service performance.

One principal objective of our research on tie pads is to develop a suitable laboratory acceptance test or specification which may be used in the purchase of tie pads to insure that the pad will have the necessary characteristics to protect the tie for the service period required. Laboratory tests have indicated that several of the types of pads available today have the necessary strength characteristics to resist these repeated loadings for 5,000,000 cycles, and afford good tie protection even when these tests are run in combination with constant water and sand application.

The function that a tie plate hold-down fastening serves in preventing tie wear is that these fastenings restrain the tie against lateral movement. They will probably be of some advantage in keeping moisture from accumulating between the tie plate and the tie, but it is not likely that they will serve this purpose as well as tie pads, unless used in conjunction with some sealing compound. We have not made any service tests using sealing compounds in conjunction with hold-down fastenings, but we have made these tests with ordinary cut spike fastenings, and we have not found any sealing compound to date which is effective for more than three or four year's service. However, both the service tests and the accelerated tests in the laboratory have indicated that a good design of tie plate hold-down fastening will reduce the rate of tie plate cutting by approximately one-half. Another advantage of the hold-down fastening is the added holding power which it gives to maintain gage. It seems likely that separate hold-down fastenings may be used at considerably less cost than tie pads, which is a further advantage for the hold-down fastening.

In my opinion, there is a definite field for the use of both of these protective devices. It would seem advisable to me to use tie pads for protecting bridge ties, ties on sharp curves where the wear is excessive, and on joint ties. It seems to me that the more effective protection afforded by the tie pad makes its added cost justified for these uses. On the other hand, I would consider that hold-down fastenings might be used to advantage on light curves and on heavy-traffic tangent track where there is some difficulty with plate cutting. I can even visualize that there would be some locations where both tie pads and hold-down fastenings would be economically justified, as, for example, on very sharp curves where excessive tie cutting and difficulty in maintaining gage would justify the use of both.

President Geyer: Thank you, Mr. Magee.

Chairman Bishop: Thank you, Mr. Magee, for a very instructive talk.

This concludes the report of the Track committee, Mr. President, and also concludes my tenure as chairman. I would like to introduce my successor, Mr. L. L. Adams, of the Louisville & Nashville Railroad; and the new vice chairman, Bill Cornell, of the Nickel Plate.

I would be remiss if I didn't think this fine committee for the cooperation and the excellent work it has done while I have been chairman.

President Geyer: Mr. Bishop, on behalf of the Association, I wish to thank you for your able leadership of Committee 5—Track. This committee is very close to me, because I "cut my teeth" in committee work on the Track committee. I am glad to see many of the members still on this committee who were members when I was there, including yourself.

The committee has done excellent work this past year, for which the Association is duly grateful.

We welcome Mr. Adams as the new chairman, and Mr. Cornell as the new vice chairman.

The committee is dismissed with the thanks of the Association.

Discussion on Continuous Welded Rail

(For report, see pp. 1161–1173.)

(Vice President Miller presiding.)

Chairman H. B. Christianson (Milwaukee Road): Mr. Chairman, members of the Association: All five of our subcommittee chairmen will present reports on their respective assignments.

We have made progress during the past year in the study of continuous welded rail. The railroads were very generous in providing us with information on costs and methods, and this, in turn, has been relayed to every member of the whole committee.

Assignment 1—Fabrication—Encompassing Methods of Welding, Space and Facilities Required, Organization, Procedure and Costs, was presented by Subcommittee Chairman F. W. Creedle (Chicago & North Western).

Mr. Creedle: The second progress report of Subcommittee 1 on Continuous Welded Rail is shown on pages 1161–1162 of Bulletin 507, and is self-explanatory; therefore, I will not read it.

I just want to remark that while the quality of gas pressure welds has improved steadily as we have gained knowledge of some of our difficulties, the committee does not intend this report to indicate that we are satisfied with the over-all quality of the weld—that is, as far as finish is concerned, the lip of the weld, both vertically and horizontally—and we think that this work should be continued until we have a weld which will compare very favorably with the line of the rail itself.

This report is presented solely as information, and the subject will be continued. During the coming year we hope to get a sufficient number of reports from roads that are making various installations to give you a little better idea of how the costs vary at the present time, depending on the number of welds being made.

Vice President Miller: Thank you, Mr. Creedle. Your report will be received as information.

Assignment 2—Laying—Encompassing Track Preparations, Transportation and Distribution of Long Rails, Installation in Track, Temperature Considerations, Closure Welds, Disposition of Rail When Continuous Rail is Replaced, Length Limitations, Procedure at Insulated Joints, Switches, Railroad Crossings and Drawbridges, and Cost Data, was presented by Subcommittee Chairman F. G. Campbell (Elgin, Joliet & Eastern).

Mr. Campbell: Report on Assignment 2 begins on page 1162 of Bulletin 507. This is a progress report summarizing data submitted by 24 railroads in response to a questionnaire circulated in July 1951, and by 17 of these same railroads to a supplemental questionnaire issued in June 1952. The total mileage of continuous welded rail covered by these responses was 248, of which 209 miles are in open track and 39 miles in tunnels. This mileage had been laid at various times from 1933 to 1951, incl., and includes rail sections varying from 90 to 140 lb.

The longest reported continuous rail length in track is 19,812 ft. Continuous welded rail has been laid on gradients as great as 1.6 percent and on curvature as great as 12 deg 30 min.

Continuous rails have been installed at rail temperatures as low as 28 deg F and as high as 130 deg F. It is recommended, however, that, wherever practicable, continuous rail be laid in the summer season, and it is further recommended that in most of the

United States and Canada such rail be anchored at temperatures between 70 deg and 90 deg F.

It was found that no unusual preparation of track was made prior to the laying of continuous rail. Some roads surfaced out-of-face prior to laying, but others made no special preparations of any kind.

Three principal methods of transporting continuous welded rail were reported. These included the use of flat cars or open-end gondola cars, push cars propelled by motor car or rail crane, and the dragging of the welded strings in the track or on the shoulder with a locomotive. The hauling of the strings of continuous welded rail on flat cars was the method most commonly used and was apparently the most economical. Fastenings were distributed in the same manner as for jointed track.

The gang organizations used in laying continuous welded rail varied both in size and in equipment used just as it does in the laying of conventional jointed track. It is apparent that no special organizational problems have arisen on account of the laying of continuous welded rail, although the actual technique of laying is somewhat different than that used in laying conventional bolted rail.

Some roads use a joint at the ends of the continuous rails as they come from the welding plant. Others use tie-in or field welds to join these long strings of rail into still longer rails. Where tie-in or field welds are used, they are made as soon as possible after the rail is laid.

The length of strings fabricated by the various roads in the first instance varied from approximately 500 ft to 1600 ft. These lengths were apparently controlled to a large extent by the space available at the welding site, transportation facilities and traffic conditions.

Generally speaking, no change was made in the ballast section where continuous welded rail was used, although three roads reported extending the shoulders from 5 in to 10 in.

Your committee endeavored to obtain some information as to methods used and costs incurred in removing and relaying continuous welded rail. However, so little of this work has actually been done, and what has been done has been in such small quantities, that it is believed that the costs would be much reduced, and possibly the methods of doing the work changed, if done under normal conditions.

Assignment 3—Fastenings—Encompassing Rail Expansion, Types and Number of Anti-Creeping Devices on Welded Track and Adjacent Jointed Track, Type of Joint Bar at Ends of Welded Sections, Tie Plate and Spike Requirements, and Cost Data, was presented by Subcommittee Chairman J. W. Hopkins (Bessemer & Lake Erie).

Mr Hopkins: The report of Subcommittee 3 appears on page 1168 of Bulletin 507, dated February 1953. This subject includes rail expansion, types and number of anti-creeping devices, type of joint bar at ends of welded sections, tie plate and spike requirements, and cost data.

This is a progress report and is submitted as information. However, your committee believes that it has sufficient data to make specific recommendations covering certain subjects under its assignment. These recommendations are contained in the report, and it is hoped that members of the Association will give the committee the benefit of their comments and criticisms during the coming year, and that recommendations may be submitted to the membership for approval at the next convention.

Assignment 4—Maintenance—Encompassing Maintenance of Rail, Track, Fastenings, Ties and Ballast, Including Out-of-Face Resurfacing and Reballasting, and Cost Data, was presented by Subcommittee Chairman C. E. Weller (Illinois Central).

Mr. Weller: Out-of-face resurfacing, reballasting, general tie renewals, etc., may be made provided temperatures are the same, or lower, than the temperature at which the continuous welded rail was initially laid. If such operations are carried out at higher temperatures than when the rail was laid, sufficient precautions must be taken to guard against buckling of the track.

The ballast section of continuous welded rail must be maintained to full standard section.

Spot tie renewals may be made, except that disturbance of the ballast for long stretches at temperatures above that at which the continuous welded rail was laid, and pulling of spikes on several adjacent ties, must be avoided.

The replacement of broken or defective rail in stretches of continuous welded rail may be handled by cutting in a length of rail. Permanent cuts should be made by a rail saw. Since welded rail usually is in tension a majority of the time, when a section of welded rail is replaced at a temperature appreciably below that at which it was initially laid, a shorter rail should be inserted at the first opportunity when the temperature is near that at which the continuous welded rail was laid in order to avoid the possibility of concentrating compressive stresses in the rail. It is recommended that a permanent record of the laying temperature be kept in the proper division office, where it will be immediately available. It is also recommended that the laying temperature be painted on the rail, or otherwise indicated, for the benefit of the forces making future changes.

Rails shorter than 39 ft should be installed adjacent to insulated joints to permit proper maintenance.

To date no unusual detrimental maintenance experiences have developed due to derailments.

Experience with welded rail in open track today indicates that maintenance savings of approximately 25 percent may be possible in comparison with jointed track under the same conditions.

This report is presented as information.

Assignment 5—Economics of Continuous Welded Rail Versus Jointed Track, was presented by Subcommittee Chairman I. H. Schram (Erie).

Mr. Schram: Mr. Chairman and members: The report of Subcommittee 5 is found on page 1170 of Bulletin 507. This report is an effort to employ all the information available at this time, secured through the questionnaires that were sent out, with the idea of acquainting the membership—as far as information is available—with the economics of welded rail.

Of course, some of the information received is quite accurate. For example, we think that all the costs of laying the welded rail and the costs of laying similar rail in standard lengths are accurate and good, but some of the information had to be estimated. It just wasn't possible to wait until the end of the 26 years that we think the heavy welded rail will last to get this information. By that time it probably wouldn't be of any use.

In these questionnaires we asked each chief engineer to estimate certain things, and from that we were able to indicate or figure the net annual saving from not having bolts to tighten or joints to tamp up, and the annual saving on account of longer rail life and less frequent out-of-face surfacing programs.

In addition, we know that it costs a little more to get the released welded rail out of the track and cut up; there is a difference there, which we deducted. These figures are all given in the table which is attached to this report.

Speaking a little more definitely, about the rail of the 132-lb section or thereabout, we found that it costs approximately $3872 more a mile to lay that rail. Therefore, you have to overcome that by economies if it is going to be worth while to spend this additional money.

It comes out as shown on this statement. We figure that the savings for the 131-lb section, or thereabout—after you figure all the additional savings, such as the increased life of the rail and other savings you make through those bigger sections—amount to $671 a mile annually, and for the lighter sections—the 112 and the 115-lb—about $630 a mile. These are annual savings per mile.

There is this word of caution that I want to give in connection with these figures—that in the case of almost all the welded rail that has been laid in the Middle West, there hasn't been the heaviest concentration of traffic. The figures given are largely for that kind of rail because that is the kind of railroad from which we had to get the figures.

The experience on the Delaware & Hudson, which laid more welded rail on heavy grades and heavy curves than any other road, was a little different. There is some doubt whether welded rail would reach its full service life on curves, due to curve wear, so we think at this time that such rail is best adapted to the type of railroad on which it has been laid—that is, mostly tangent track, with not too heavy grades.

I want to caution everybody that these figures are from only ten railroads. On the roads that had information on stretches over two miles long, some of the figures were incomplete, and we just couldn't use them. On others the stretches were too short. Therefore, we used the best information available at this time, using the best judgment of all the chief engineers who reported to us, as well as of members of the committee, to try to get a picture for the membership of the economies of welded rail.

As time goes on and there are more installations, and changes in the methods of laying the rail, or in maintaining it, I have no doubt that these figures will change, but I do think that the method of calculation we have used will stand up. If someone has different figures, he can use the same formulas, which will serve as a guide. I think it will be a number of years before better information is available, because, as you all know, tests take a long time.

This report is submitted as information.

Vice President Miller: It will be so received.

Chairman Christianson: Members of this special committee are, for the most part, also members of the standing committees on Rail, Track, and Economics of Railway Labor. The interest they have taken and the amount of work they have done on this special assignment has been wonderful. It is very unfortunate for us that we have lost five of them during the past year—E. C. Vandenburgh formerly chief engineer of the C&NW; E. E. Martin, assistant engineer of the Pennsylvania; C. R. Strattman, special engineer for the New York Central; A. A. Cross, division engineer, retired from railroad service; and C. E. R. Haight, who was chairman of Subcommittee 4, and who was promoted from division engineer on the Delaware & Hudson to assistant superintendent, and felt obliged to resign from committee work. His wide experience with welded track and his devotion to work and sense of responsibility made him a hard man to replace. However, we were most fortunate to have C. E. Weller of the Illinois Central take over his assignment. I don't know where we could have found a better man.

Mr. President, this completes the report of our assignment.

Vice President Miller: Mr. Christianson, your committee has only been established for about two years, but during that relatively short time you have thrown valuable light on this new subject. We appreciate the work which you have done.

You are now excused, with the thanks of the Association.

(President Geyer resumed the chair.)

Discussion on Rail

(For report, see pp. 1175–1264.)

(President C. J. Geyer presiding.)

Chairman C. J. Code (Pennsylvania): Mr. President, gentlemen: Most of you heard the very fine tribute to Mr. Herbert R. Clarke delivered by Mr. Grove on the first day of the convention. There is not very much that I can add to that, except to say that the members of the Rail committee feel very deeply the loss of Mr. Clarke as a fellow member, a counsellor and friend.

The report of Committee 4, Rail, will be found on pages 1175 to 1264, incl., of Bulletin 507. Like most committees, the revision of the Manual has been our biggest job this year, and all of our subcommittees have contributed to it.

I will ask Mr. Meyers, of the Chicago and North Western, to present the report of Subcommittee 1—Revision of Manual.

Assignment 1—Revision of Manual, was presented by Subcommittee Chairman B. R. Meyers (Chicago & North Western).

Mr. Meyers: The report on Assignment 1—Revision of Manual, starts on page 1176 of Bulletin 507. The recommendations contained therein have been made after careful study of the Glossary and Manual material involving the Rail committee, and are for the purpose of clarification, deletion of obsolete items, and the addition of certain new material.

It is recommended that all items in the Glossary referring to Chapter 4 be reapproved, with changes in definitions for "Cant", "End Hardening", "Compromise Joint", "Cropping", "Crushed Head", and "Split Web", and the addition of new definitions for "Decarburized Surface". "Platens", and "Tread". I move the reapproval of Committee 4 items in the Glossary, with the changes and additions indicated.

(The motion was regularly seconded, was put to a vote, and carried.)

On page 1177 it is recommended to reapprove the Specifications For Open-Hearth Steel Rails, with two changes. The first is the deletion of center headings, which is an editorial change for uniformity. The second is a revision of Art. 203 to permit ladle analysis to be made spectrographically, as an alternate to present requirement of chemical analysis. I move the reapproval of the Specifications For Open-Hearth Steel Rails with changes indicated.

(The motion was regularly seconded, was put to a vote, and carried.)

On pages 1177 and 1178 it is recommended to reapprove Recommended Rail Sections, Application of Welded Bonds, General Requirements of a Rail Joint, Beveling or Slotting of Rail Ends, and Specifications for Drop Test Machine, with minor editorial changes shown. I move the reapproval of these five documents with the changes indicated.

(The motion was regularly seconded, was put to a vote, and carried.)

In 1951 this convention approved the revision of Specifications For Quenched Carbon-Steel Joint Bars. It is recommended that Specifications For High-Carbon-Steel Joint Bars be revised in the same manner, such revisions being editorial in nature to bring them up to date. All changes are shown in detail in Exhibit "A", starting near the bottom of page 1181. I move the reapproval of Specifications For High-Carbon-Steel Joint Bars, with the changes set forth in Exhibit "A".

(The motion was regularly seconded, was put to a vote, and carried.)

There are only two minor editorial changes proposed for quenched joint bars, and I move the reapproval of Specifications For Quenched Carbon-Steel Joint Bars, with the two changes indicated.

(The motion was regularly seconded, was put to a vote, and carried.)

At the bottom of page 1178, it is recommended to reapprove the various drawings for joint bars, with editorial changes for uniformity, and changes in track bolt nuts so they will agree with revisions approved at the 1952 convention. I move the reapproval of Figs. 10 to 16, with the changes indicated.

(The motion was regularly seconded, was put to a vote, and carried.)

At the top of page 1179, it is recommended to add a new page setting forth Recommended Head Easement For Joint Bar. This drawing is shown as Exhibit "B" on page 1184, and represents the present mill practice where head easement is specified. I move the adoption of this new page covering Recommended Head Easement For Joint Bar.

(The motion was regularly seconded, was put to a vote, and carried.)

In the upper portion of page 1179, certain changes are recommended in the material on pages 4–28.4 and 4–28.5 of the current Manual to bring same up to date, and I move the reapproval of Fig. 17, with plans for track bolt and nuts deleted, and the reapproval of Rail Drillings, Bar Punching and Track Bolts, with the editorial changes indicated.

(The motion was regularly seconded, was put to a vote, and carried.)

Starting in the middle of page 1179, it is recommended to reapprove Specifications For Track Bolts, Design For Track Bolts, and Specifications For Steel Washers, with minor changes, most of which are editorial in nature, for uniformity. I move the reapproval of these documents, with the changes indicated.

(The motion was regularly seconded, was put to a vote, and carried.)

On page 1180, it is recommended to reapprove all material under Rail Record Forms, with certain changes. A proposed revision of Form 401–D is shown as Exhibit "C" on page 1185. The changes proposed in Form 402–C(a) are made for the purpose of clarifying instructions for sending rail to the laboratory at Urbana, and reporting rail failures. The proposed change in Par. 14 is to bring this data up to date. I move the reapproval of the Rail Record Forms, with the changes indicated.

(The motion was regularly seconded, was put to a vote, and carried.)

I move the reapproval of Measurement of Profiles and Batter of Rail, without change, except remove center headings to left-hand side of page for uniformity.

(The motion was regularly seconded, was put to a vote, and carried.)

At the top of page 1181, it is proposed to delete Building Up of Rail Ends in Track and to substitute therefor the new title Reconditioning Rail Ends, with recommended practice as indicated, and I move the adoption of this change.

(The motion was regularly seconded, was put to a vote, and carried.)

To satisfy various requests for a uniform practice covering End Hardening of Rails at Mills, the recommended practice set forth in the middle of page 1181 has been developed by the Joint Contact Committee. I move the adoption of End Hardening of Rails at Mills.

(The motion was regularly seconded, was put to a vote, and carried.)

This concludes the report on Assignment 1.

Chairman Code: Thank you, Mr. Meyers.

It has sometimes been said that if you want to get a job done, get a busy man to do it.

Assignment 2 is Conditions Affecting Service Life of Rail, Causes of Rail Failures and Defects, In Collaboration with AISI Technical Committee on Rail and Joint Bars. That somewhat formidable title covers what we call the Joint Contact Committee. We meet annually with representatives of the American Iron and Steel Institute and discuss problems that are common to us.

Some of the members of AISI who meet with us are present here today, and I am going to ask them to stand and take a bow.

L. H. Winkler, of Bethlehem Steel Company, chairman of the Joint Contact Committee.

J. R. Trimble, Tennessee Coal & Iron Company.

J. R. Zadra, Colorado Fuel & Iron Company.

C. W. Tuttle, U. S. Steel, representing G. T. Jones.

W. Warner, Inland Steel Company.

R. B. Stampfle, Bethlehem Steel Company, who serves as secretary of our Joint Contact Committee.

Assignment 2—Conditions Affecting Service Life of Rail, Causes of Rail Failures and Defects, In Collaboration with AISI Technical Committee on Rail and Joint Bars, was presented by Subcommittee Chairman C. J. Code (Pennsylvania).

Mr. Code: The report of this subcommittee is found in Bulletin 507, pages 1186 to 1193, incl. A part of the report is Prof. Cramer's remarks on rail failures, and they will be combined with his remarks on the shelly rail investigation, which will be presented a little later in the committee's report.

Chairman Code: Assignment 3 covers rail failure statistics. I am going to ask Mr. Magee, the director of engineering research, AAR, to present the report on this assignment.

Assignment 3—Rail Failure Statistics, Covering (a) All Failures, (b) Transverse Fissures, (c) Performance of Control-Cooled Rail, was presented by G. M. Magee (AAR).

Mr. Magee: As you know, there is a report of rail failures submitted each year to our laboratory by all the Member Roads, AAR. We analyze those failures and prepare a report from the statistics. The purpose of these statistics covers many fields. For one thing, we are interested in finding out how the transverse fissure problem is being progressed, and the number of transverse fissures that are reported are shown in a graph, separated between service failures and detected failures.

The principal thing I want to say about the service failures and the detected failures is to emphasize the importance of continuing our detector car testing. We are getting control-cooled rail in track, and it is doing a good job, and we are not having any transverse fissures in it, to speak of, but it is very important that we keep up our detector car testing on all the other rail in track if we're going to continue to improve our record of reduction of the number of service failures from transverse fissures.

The reports are also set up to show the excellence of mill performance, and the performance from the various mills has continued to be good on the control-cooled rail. As pointed out in the report this year, there are a few isolated cases where one mill, in one year's rolling, has had difficulty, but those are rather minor and, in general, the indications are that the mill performance is holding up to the standard that we like to see.

The failures are also shown separately by the different types of classifications. This is important to us, because it gives an indication of whether any type of failure is becoming sufficiently important that we need to go to work on it.

The report indicates that failures from within the joint bar limits—bolt hole cracks and rail end fillet cracks—constitute our most important types of failures, along with shelly rail. These two types of failures comprise about two-thirds of the number of failures we have had in control-cooled rail.

As you know—and as will be discussed in some of the other reports of the Rail committee—we have research investigations under way in an effort to improve the situation with respect to these two types of failures.

Chairman Code: Thank you, Mr. Magee.

Assignment 4—Rail End Batter; Causes and Remedies.

Chairman Code: We have no report this year on this assignment. However, we have a new subcommittee chairman, and I would like to introduce him and have him take a bow at this time—Mr. K. K. Kessler, of the Baltimore & Ohio.

Ray McBrian, engineer of standards & research, Denver & Rio Grande Western Railway, has agreed to give us a talk today on Rail Problems in the Moffat Tunnel. I will ask Mr. McBrian to deliver his talk at this time.

Rail Problems in the Moffat Tunnel

By Ray McBrian

Engineer of Standards & Research, Denver & Rio Grande Railway, Denver, Colo.

The Moffat tunnel is located in Gilpin and Grand Counties in Colorado, and was finished and laid with 110-lb rail in 1928. The top of rail elevation at the apex is 9239 ft. The grade from the east to the west portal of the tunnel from the apex varies from a 0.30 percent ascending to 0.80 percent descending. The tunnel is on a tangent. The temperature in the tunnel is practically constant at 58 deg F, but from the west portal, and inside the tunnel for ½ mile or more, the temperature varies from the 58 deg F to 50 deg F below zero. The tunnel is ventilated by fans located at the east portal. A curtain is raised and lowered at the east portal to close the tunnel opening so as to provide for ventilation.

I have been associated with the rail problems in this tunnel since the tunnel was opened in 1928 for rail traffic. I inspected for the Moffat Tunnel Commission the 110-lb rail first laid in the tunnel. We have termed the tunnel the great corrosion test laboratory.

The principle problem we have had with the rail sections and rail fastenings since the start of tunnel operation has been that of corrosion. Unfortunately, these have been complicated corrosion problems that have not been easily solved. Of course, the real answer would be to maintain a dry tunnel; with steam operation the humidity in the tunnel remained practically at 100 percent. In the last few years, with the advent of the diesel locomotive, this has radically dropped and the corrosion problems are lessening.

The types of corrosion problems encountered with tunnel operation have been as follows: First, that of corrosion-abrasion of the running or contact surface of the rail;

second, stress-corrosion at high points of stress; third, electrolytic type of corrosion where the rail and fastenings are in contact; and fourth, general overall corrosion of the rail surfaces.

These are the general rail problems, and our methods of study as to solution and inspections are what I wish to discuss, using slides to illustrate.

The first rail placed in the Moffat tunnel, AREA 110-lb section, was removed from service in May 1938. This first rail had a life span of 10 years, but the traffic was light as the Denver & Salt Lake Railroad operated few trains daily. The rail was removed because of the start of an exceptionally large number of rail failures from stress corrosion failures originating through the bolt holes. This first 110-lb rail was rolled with conventional drilling and in 66-ft lengths. Contributing to these failures was the very heavy corrosion abrasion of the running surface to the rail. The amount of head wear from corrosion abrasion amounted to 0.40 in.

This resulted in increasing the stress concentration around bolt holes and the subsequent very rapid failures. It became necessary then to inspect all rail ends individually, requiring the removal of the joint bars. I had the opportunity to make this inspection with the help of the tunnel section forces. Because the inspection problem was slow and complicated it became necessary to develop portable fast inspection tools. The first developed was a hand portable, pocket-size Magnaflux inspection kit.

Because of the failures at the joints and the badly battered joint conditions from this corrosion-abrasion problem, it was decided to weld the rail and eliminate the joint condition. In the spring of 1938, 112 RE rail, rolled in 39 and 60-ft lengths, was welded by the Thermit method, and this rail replaced the 110-lb section. The Denver & Rio Grande was now operating through the tunnel in addition to the Denver & Salt Lake trains. Unfortunately, one bolt hole for welding clamping purposes was required in each length of rail. There were no rail joints used nor bolts required; nevertheless, we began in the short span of two years to find stress corrosion cracks in the web of the rail at the bolt holes.

This necessitated the further development of fast inspection methods and we made a portable Magnaflux machine mounted on a push car, the power source being gasoline drive. One method was to use the wood clamps to make contact with the rail, and the other was to use a portable electro magnet for the power application around the bolt hole.

With this 112-lb rail the rate of corrosion-abrasion on the running surface was ⅛ in per year, despite any methods tried for protection. It was considered that an alloy steel, such as stainless, would stop this condition, but when it was realized that stainless steels obtain their resistance to corrosion through the formation of an oxide film, in service such as required for rails this film would be removed continuously by the wheels in contact with the rail, and corrosion would occur at a greatly accelerated rate.

Along with this bolt-hole stress corrosion cracking, some welds were found to be developing stress corrosion cracks, the origin usually occurring in some porosity or other sharp stress raiser conditions. This rail was ready for renewal after five years, during which time heavy war traffic was hauled, because of the corrosion abrasion wear of the running surface of the rail.

In November 1943 the 112-lb rail was replaced with 130 PRR section, rolled in 39-ft lengths and Thermit welded. This 130-lb section was selected because of the heavy metal head section. In other words, the only solution we had found to reducing the corrosion abrasion was to "beef up" or secure more metal thickness of the head. We had made several attempts to reduce this corrosion wear but none was successful.

One method we used was to feed lime with the coal as it went through the stoker into the fire box, thus hoping the lime would neutralize the sulfurous acids from the stack gases. We did neutralize these acids but we also got a lime soap on the rail which resulted in heavy slipping, thus our method was unsuccessful. Tests were made on various types of cathodic protection; every well known corrosion agency was consulted, but the problems arising from this operation in the tunnel were too great for any practical solution.

Since the 130 PRR section was to be Thermit welded, and to reduce the type of weld failures which had occurred with the first welds, it was decided to Gamma ray all welds before they were placed in service. All rejected welds were to be cut out and rewelded.

In a cooperative research program with the Metal and Thermit Corporation this problem was investigated and decided feasible. Accordingly, we rented from the radium people 250 milligrams of radium and inspected all the welds before application in the tunnel. This method was very practical, not expensive, and resulted in improvements in weld design and technics.

As is the case with all welded rail, tie-in welds must be made, so the tie-in welds of Thermit had to be radiographed in the tunnel. The time required to radiograph the head of the rail was 35 to 45 min. The exposure time for the base was 5 to 15 min. This PRR section lasted until 1950.

Early in 1950 the AREA 133-lb section was rolled in 39-ft lengths and was pressure welded by gas. This was laid in the tunnel in the summer and fall of 1950. The problem of tie-in welds was again of importance, and these were gas welded by hand. We have replaced the radium rental by the purchase of radio-active cobalt 60. Instead of 250 milligrams, we have 500 milligrams, which has cut the exposure time for the welds by 50 percent.

We have found as yet no successful tie-in method for welded rail and we have radiographed all tie-in welds on this new 133-lb section. Thus we are confronted with the same similar corrosion fatigue cracks. Practically all these tie-in welds have now been drilled and angle barred. The gamma ray inspection, using the radio-active cobalt is very satisfactory and, incidentally, is portable enough that inspections can be made at any place of most any kind of materials through which gamma rays will pass.

It is very evident that with diesel operation our corrosion problems are being materially reduced, and that our major problem, as found with the former rail sections, which determined rail life—abrasion corrosion and stress corrosion—will possibly not be the determining factor in the life of the rail. The other factor which occurred with all the other rail sections and which will probably be present with the 133-lb section is that of the electrolysis type of metal-to-metal corrosion. Wherever the tie plate was in contact with the rail, the rail section had been reduced by 50 percent in all other rail sections. Wherever the spikes are in contact with the rail base, the base is sometimes completely corroded away.

Possible solutions to these problems have been under constance study by our research engineer, W. B. Leaf, and the most successful answers to date seem to be a rubber-type tie pad between the rail and tie plate, and to galvanize the spike. Many types of coatings, platings and composition pads have been studied, but for the tunnel operation it is apparent that whatever the solution would be for ordinary outside rail problems, it will not be satisfactory for our tunnel rail.

Another major problem has been to find a coating which can be placed on the web of the rail and fillets, both base and head, to reduce any corrosion-fatigue horizontal-

(Text continued on page 1423)

Fig. 1—The first rail laid in the Moffat Tunnel—110 AREA section—was removed after 10 years of service because of a large number of failures due to stress corrosion. This view shows a typical specimen of this type of failure.

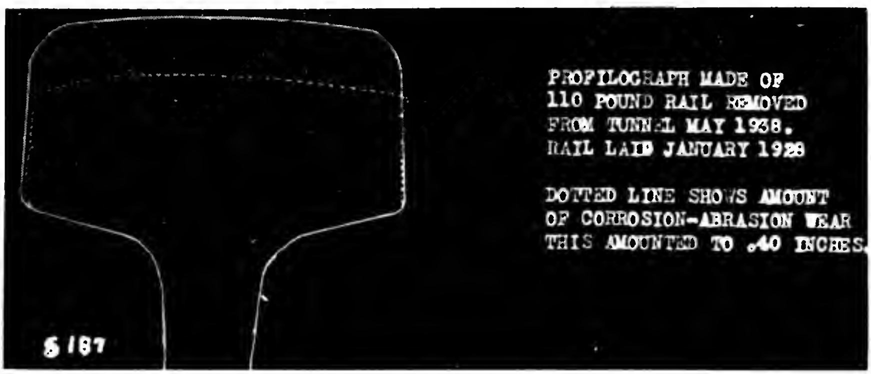


Fig. 2—Profilograph showing the heavy corrosion abrasion of the running surface of the original 110-lb rail.

Fig. 3—The 112 RE rail laid in the tunnel in 1938 was welded by the Thermit method, which required one bolt hole in each rail length for welding clamping purposes. After only two years stress corrosion cracks showed up in the web of the rail at these bolt holes, as shown here.

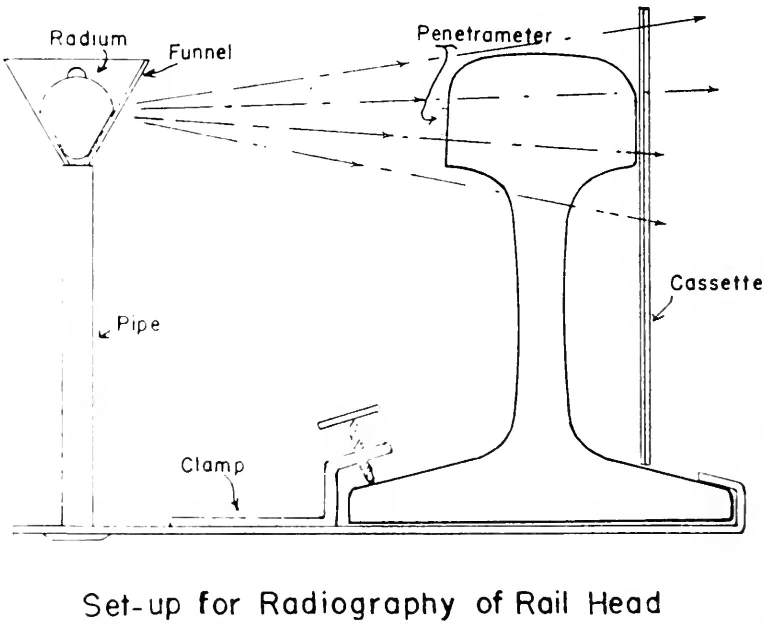


Fig. 4—After the Thermit-welded 130 PRR section rail was laid in 1943, all tie-in welds were radiographed in the tunnel. This view shows the set up for radiographing the head of the rail. Exposure time was 35 to 45 min.

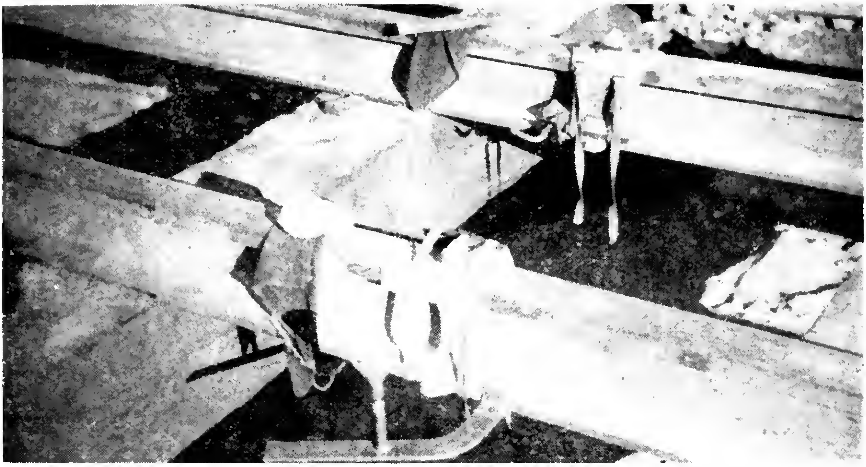
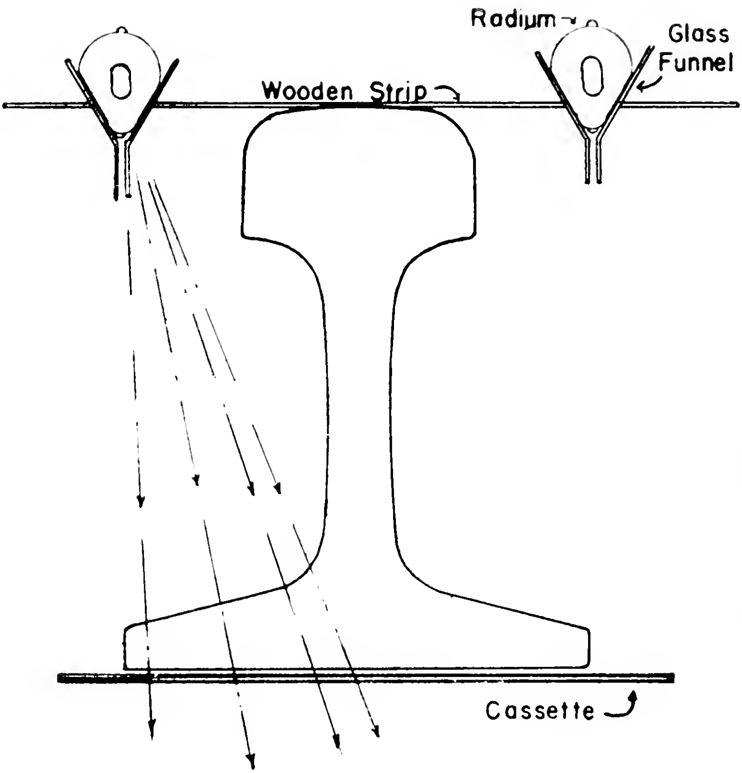


Fig. 5—Showing how the X-Ray films were held to the base of the rail.

Fig. 6—Radiograph of an unsatisfactory head weld.



Set-up for Radiography of Rail Base

Fig. 7—Set up required for radiographing the base of the rail. Exposure time was 5 to 15 min.

Fig. 8—Typical type of failure found in tie-in welds.

type cracks. This is the type of fatigue cracks which is found on the gage side of a low rail on curves.

To date the most satisfactory material has been the petrolatum or inhibited petrolatum combination, but much more work will be necessary before the perfect material is found.

In general, these are the rail problems which we have encountered in the Moffat tunnel, which has been a laboratory where many types of problems can be studied. It appears that our dieselizing of this operation, with the resultant reduced humidity and sulfurous gas conditions, will be the greatest factor in securing longer rail life and in answering our problems.

Chairman Code: Thank you, Mr. McBrian, for a very interesting paper.

Assignment 5—Economic Value of Various Sizes of Rail, was presented by Subcommittee Chairman A. A. Shillander (Illinois Central).

Mr. Shillander: For this study two sizes of rail, 112 RE and 131 RE sections were selected. These are in the same track in two stretches, 20 miles of 112-lb adjoining 20 miles of 131-lb in the northward track between Mattoon and Champaign, Ill. They are in an excellent location for comparison because of the same track condition and same annual traffic density, which is about 28 million gross tons.

This report is principally a continuous record of man-hours, cross ties and ballast used for maintenance. An average of these items for the 8 years that the rail has been in track shows an appreciable saving in favor of the 131-lb in comparison with the 112-lb. This average, therefore, indicates that the 131-lb section will be more economical in a track having about 28 million tons of annual traffic.

Eight miles of 112-lb, to which RMC plastic joint packing had been applied, were removed in 1952 due to an excessive number of split webs through bolt holes. The remaining 12 miles of 112-lb and the 20 miles of the 131-lb are in good condition and records will be continued until condition of rail warrants its removal from this track.

This is a progress report.

Chairman Code: Thank you, Mr. Shillander.

Assignment 6—Service Tests of Various Types of Joint Bars, was presented by Subcommittee Chairman T. A. Blair (Santa Fe).

Mr. Blair: You will find the report of the subcommittee starting on page 1213 of Bulletin 507.

This report results from the installation of test sections in 115-lb rail on the Chicago & North Western, and in 132-lb rail on the Santa Fe. There are four types of joints, with three different patterns of bolt-hole spacing.

The report results from field measurements made by Mr. Magee's staff, which have been analyzed by them. It is a little early to draw any conclusions, and this progress report, therefore, is submitted as information.

Chairman Code: Thank you, Mr. Blair.

Assignment 7—Joint Bar Wear and Failures; Revision of Design and Specifications for New Bars, Including Insulated Joints, and Bars for Maintenance Repairs, was presented by Subcommittee Chairman E. E. Chapman (Santa Fe).

Mr. Chapman: The report begins on page 1221. This is a continuing progress report, submitted as information.

With this are included the reports of Prof. R. S. Jensen, and also the report of the service tests on the Burlington Railroad near Fort Morgan, Colo., on 112-lb joint bars, for your information.

Also, proposed revisions in Specifications for Quenched Carbon-Steel Joint Bars are given for information, as follows: The change in tensile qualities, to make the psi between the tensile strength and yield point compatible. It is recommended that this be taken up with the Joint Contact Committee for handling.

Paragraph 8 (b)—we are in favor of retaining this paragraph as written, and not changing it, as had been recommended.

During the past year, laboratory and service tests were planned on two groups of 132 RE bars, which at the present time are being applied to Santa Fe track just west of Kansas City. The four groups from which samples have been sent to the University of Illinois, are as shown on page 1222.

Future tests should include a study of the maximum easement length and depth permissible that will not materially reduce the fatigue life of the bar; this information to serve as a guide when grinding out cracks on the top fishing surfaces at bar mid-length. Preliminary tests on 112-lb bars conducted at the University of Illinois have indicated that a maximum ground area $2\frac{13}{16}$ in. in length and $\frac{9}{32}$ in. in depth required to eliminate an existing crack did not shorten the fatigue life of the bar.

The sketch on page 1222 is being presented to the Association for study, with a view to have it placed in the Manual as recommended practice, but this should not be done until further studies have been made.

President Geyer: Thank you, Mr. Chapman. The report will be received as information.

Assignment 8—Causes of Shelly Spots and Head Checks in Rail; Methods for Their Prevention, was presented by Subcommittee Chairman L. S. Crane (Southern).

Mr. Crane: The report on this assignment is found in Bulletin 507, beginning on page 1239.

Your subcommittee's principal work during the past year has been to continue to follow the installations of the various heat-treated rails which have been installed on the Norfolk & Western, the Pennsylvania, the Chesapeake & Ohio, and the Great Northern.

These installations, which have been in service for approximately four years, have shown up well, in that the control-cooled rail, which has served as the control in the tests, in many cases has been removed or has shown severe signs of failure, whereas the new treated rail, in most instances, is relatively untouched at the present time from the standpoint of developing shelly spots. It seems to be doing a very good job.

In addition to those tests, there is a test on the Norfolk & Western where an alloy type of rail has been used, identified as chrome-vanadium. This test, which is somewhat younger than the other tests, is also performing well, whereas the control-cooled rails have already begun to show signs of failure.

Although we are following this work closely, we might say that, unfortunately, these two alternatives—or palliatives—to the shelly rail situation do not appear to be too promising, because of the economic questions which are involved in their use. Alloy and heat-treated rails are more expensive than plain carbon-steel rail. It is for this reason that your subcommittee has continued to initiate research work directly toward finding some possibly simpler solution to the problem.

I have reported to you on many occasions previously that many of the investigative alleys into which the research work has turned have proved fruitless, and many of them continue to do so.

As an example, the Battelle Memorial Institute during the past year did some investigative work to see if it were possible, by heat treatment, to relieve some of these stresses that were induced in the rail, causing the shelly rail failures. That work proved negative in nature.

At the present time, in an effort to try to develop some definite understanding on our part of the effect of plastic deformation due to traffic on rail steel, Battelle Memorial Institute is making preliminary investigations along two lines—one using salts of silver chloride, which possess certain photo-elastic properties, or photographic properties, combined with mechanical properties of a metallic nature, and another investigation in which they are using low-carbon steels and what is known as the Fry "strain-etch" method, in an effort to be able to depict or to learn how the stresses actually are set up within a rail.

An additional study is being undertaken by Prof. Max Frocht of Illinois Institute of Technology. Professor Frocht, incidentally, is an acknowledged world authority on the theoretical type of photo-stress analysis, and recently developed a technic for three-dimensional photo-stress analysis. We have retained him for the purpose of constructing a model of rail head and wheel, in an effort—through this three-dimensional photo-elastic stress analysis—to see if he can depict and possibly give us an idea of the magnitude of the stresses which occur in the railhead, in the hope that with that basic knowledge we may be in a better position to attack this problem.

In addition to the work of Battelle and I.I.T., we continue to have our own road tests conducted by Prof. Cramer of the University of Illinois, and it is my pleasure to present Prof. Cramer to you, who will talk to you on rail failures, and, in addition, of his work on shelly rail investigation.

Professor Cramer talks to you on behalf of Subcommittee 8, and I want to say on behalf of the entire Rail committee—that we are most appreciative of his unfailing and diligent work on behalf of the committee.

Rail Failures and Shelly Rails Investigation

By R. E. Cramer

Research Associate Professor, University of Illinois

The first part of my report is printed beginning on page 1186 of Bulletin 507. My work is to investigate the cause of failure of all control-cooled rails that are classified as transverse fissures. The instructions were changed this year to ship such rails to our laboratory when found, without writing for instructions. Also, we ask that you mark the rails to show mill, heat number, and date of rolling. It also helps considerably if your engineers will send me a copy of your rail failure report.

I would like to emphasize that rails found by detector cars should not be broken by chiseling the base and web, but should be bent with the head in tension. This can be done either with a rail bender or by dropping them with a crane. The rail will then usually break at the defect, while if the base is chiseled, the defect in the rail will very often be missed.

Table 1 (see page 1187) shows what we found this year in examining 48 failed rails sent to our laboratory. There were two transverse fissures from shatter cracks in improperly control-cooled rails. This is a very small number compared to the millions of control-cooled rails now in service. We also found 13 transverse fissures from hot-torn steel which was an increase over last year. However, only three of these were in rails rolled after 1946, when the cause of such failures was found to be accidental overheating of the rail blooms during the rolling of the rails.

There were two transverse fissures which developed from large non-metallic inclusions in the steel, one of which is shown in Fig. 1 (see page 1189). Part (a) shows the fissure with a small nucleus. Part (b) is a photomacrograph at 4X magnification showing a longitudinal section through the nucleus. It also shows another large inclusion just behind the nucleus. This appears to be a piece of firebrick which became trapped in the steel.

Fig. 2 (see page 1189) shows, in Part (a), one of four fractures which we examined from welded engine burns. Part (b) is an etched slice just back of the fracture, showing the weld deposited metal. These failures were orginally classified as transverse fissures until laboratory investigation proved that they were fractures from welded engine burns.

We examined during the past two years a number of bolt-hole failures which have become rather numerous in service. The rail shown in Part (a) of Fig. 3 (see page 1191) has a diagonal crack starting at the end bolt hole. Part (b) shows the steel around the bolt hole with aluminum pressed into the hole for polishing. We examined a number of such specimens but found no martensite or other unusual microstructures on the surface of the bolt holes. When the cracks were opened up as shown in Part (c) it was noted that the fractures had practically all started at one corner of the bolt hole or at the side of the rail web. We consider that corrosion from the side of the rail web and, at the same time, from the inside of the bolt hole, make stress-raising pits at this sharp corner, which start small fatigue cracks in service.

If pitting corrosion is the basic cause of bolt-hole failures, then the indicated prevention would be chamfering of the edges of the bolt holes. Certainly this would be a step in the right direction, and I predict that it would prevent many bolt-hole failures.

Fig. 4 (see page 1192) is a photomicrograph at 30X magnification of a lap near the tread of a rail, which was found by a detector car. No failure had resulted from this defect, but it is interesting to note that a detector car could locate this lap, which extended only about ¼ in below the rail tread.

Fig. 5 (see page 1193) shows in Part (a), a transverse progressive fracture which developed about 1 ft from the end of this rail that had been built up by electric arc welding. Part (b) is an etched cross section showing the welding beads with vertical cracks near the center of three beads. Part (c) shows the same cracks on the tread of the rail opened up by etching in acid. Apparently the electric welding was done without preheating the rail. We understand that this method of building up rail ends is satisfactory when the rails are properly preheated.

The second part of our research report is on shelly rails and detail fractures from shelling, and starts on page 1243 of Bulletin 507. I believe most railroad engineers are discovering that these two types of failure are the way many control-cooled rails are failing after fairly long service in tangent track, or rather short service as the high rail on curves. The AREA rail failure statistics show 9526 detail fractures and compound fissures in 1951. However, these statistics do not include the rails replaced out-of-face on curves due to shelling or black spots on the rail treads. If these figures were available, I believe the total would be very high.

We have been making shelly rail failures in the laboratory in two cradle-type rolling-load machines for the past 10 years. Ordinary rails last from 800,000 to 1,200,000 cycles, using a 50,000-lb wheel load. Last year we reported rolling-load tests on 2 intermediate manganese-chrome-vanadium alloy rails which ran from 5 to 9 million cycles, and on 1 heat-treated or oil-quenched 115-lb rail which also ran 9 million cycles. This year we made a repeat test on the same heat-treated rail, and it again ran to 9 million cycles, when a crack developed in the rail web. The rail head did not develop a shelling crack in this test. We therefore hope more railroads will try these alloy and heat-treated rails in curves where shelly rail failures have been a problem.

This year we also tested two groups of flame-hardened rails. The etched cross sections in Fig. 1 (see page 1245) show the shelling cracks developed in four specimens of one group.

No. 28 ran for 554,000 cycles,
No. 29 ran for 960,000 cycles,
No. 30 ran for 1,900,000 cycles.
And No. 31 ran for 4,068,000 cycles.

This test of 4 million cycles is the best we have made on a flame-hardened rail.

Fig. 2 (see page 1246) shows the other group of flame-hardened rails produced by another company. The top two specimens, Nos. U 12 and U 34, were not tested, but are etched to show the flame-hardened area on the rail treads. None of the four lower specimens ran over a million cycles before the shelling cracks developed. Since we use a wheel load of 50,000 lb, which is about twice the average wheel load in service, we do not want to draw any positive conclusions on how these flame-hardened rails will stand up in service. We certainly would expect them to last longer than ordinary standard rails in track.

During the last two years we have been running a third cradle-type rolling machine to develop detail fractures from shelling. This is a difficult laboratory operation. as it is necessary to form the shelling crack first due to flow of the steel and, at the same time, have enough direct bending on the specimen to cause the detail fracture to develop. During the past year we were successful with seven specimens, as shown in Table 2 (see page 1247). When we used only a 45,000-lb wheel load, the specimens ran over 2 million cycles, which makes a comparatively long test for standard rail specimens. Using a 50,000-lb wheel load, the detail fractures were produced between 700,000 and 1,900,000 cycles, also in standard carbon-steel rails.

Fig. 3 (see page 1248) shows four of the detail fractures produced in the laboratory. In each specimen there is a horizontal shelling crack under the gage corner of the rail and detail fractures of various sizes growing from the shelling cracks. It is planned to make similar tests in this machine, using heat-treated and alloy-steel rails to study their resistance to the development of detail fractures from shelling.

Recently G. M. Magee arranged with the Matisa Equipment Corporation to supply us with high-frequency or electric flash butt-welded 132-lb rails for laboratory tests. The rolling-load test on the first specimen ran to 2 million cycles, or comparable to satisfactory welds that we tested back in 1938 and 1939. Physical tests on specimens cut from the welds in these rails have given results comparable to standard rail steel. Further rolling-load tests are in progress, and if the future tests are as good as the first specimen, the railroads may have available a new method of making continuous welded rail.

President Geyer: Thank you, Mr. Cramer. I want to say that you have presented the best set of slides we have had for a long time. They aided very much in the presentation of your report.

Chairman Code: Thank you, Prof. Cramer, and thank you, Mr. Crane.

Assignment 9—Recent Developments Affecting Rail Section, was presented by Subcommittee Chairman W. J. Cruse (Great Northern).

(Mr. Cruse commented as follows, accompanying his remarks with slides of some of the illustrations shown in the report appearing on pages 1256 and 1257 of Bulletin 507):

I would like to comment briefly on the work done on two of these assignments. First, the stresses around the bolt hole of a rail with the joint in tension. This work was carried out at the Central Research Laboratory, using 7 rail joints from the 132 RE rail section, assembled with 132 RE headfree, 36-in 6-hole joint bars.

The specimens were placed in the grips of a Baldwin testing machine to produce tension in the joint. The strains were measured by means of SR-4 wire-resistant strain gages, attached to the web of the rail as close to the hole as possible. In order to investigate the effect of bending movement on the joint, as well as the effect of tension, wedges were driven into the rail joint gap until the SR-4 gages indicated a contact of the bolt with the edge of the hole. The joint was then supported at each end of the joint bar and loaded in the center.

The major static stresses are produced by the bolts at the point of contact in the hole when the rail contracts. To simulate this condition, the joint assembly was put in tension at various loadings. After analyzing the results from this test procedure, it was decided to check the location of the gages by applying "Stress-Coat" to rail joint assemblies and subject them to tension. During the investigation it was noted that the bolts did not bear on the side of the hole to the full thickness of the rail web, in spite of the careful lining and setting of the joint bars. This unequal bearing condition has also been noted on a considerable number of bolt hole failures in track. From these tests it was concluded that tensile stresses are developed around most of the circumference of the bolt hole when the bolt comes to a solid bearing as a result of the rail contraction in cold weather. These stresses are a maximum directly at the point of bolt bearing and may exceed the yield point. They diminish rapidly each way from this point and become zero, or even compressive, directly opposite. Although of moderate intensity at 45 deg from the horizontal, they may be a factor in the development of bolt hole cracks which frequently occur at this location.

A second very interesting assignment being studied by this subcommittee is the rail web bolt hole finish, as related to fatigue failure. The subject of rail breakage originating in the bolt holes has been of serious concern to the railroads for some time, and it is felt that this fatigue investigation will give some definite evidence as to possible damage caused by faulty drillings which produce gouges and fins on the edges of bolt holes.

During January of this year a Sonntag Universal Fatigue Testing Machine was installed at the Central Research Laboratory. This machine is designed so that a repeated force can be applied to a rail specimen, simulating the repeated stresses experienced in service. This force can have any combination of static tension or compression, and any alternating force within the range of the machine. The alternating forces can be applied 1800 times a minute, and can be adjusted between zero and 5000 lb. The static force applied to the test specimen can be adjusted between zero and 5000 lb, either in tension or compression.

For this particular investigation a bending jig was designed which can accommodate full size cross-sectional rail specimen 3 in long of the 100-lb to 140-lb rail sections. The stresses are determined with wire-resistant strain gages and the necessary electronic recording equipment. In addition to making fatigue tests of rail web sections with burred and gouged bolt holes, it is planned to test rail web sections with acceptable bolt holes and with bolt holes with milled surfaces, bolt holes with 1/8-in chamfer, and bolt holes with shot-peened surfaces.

We look forward to some very interesting and valuable data to be derived from these tests.

Chairman Code: Thank you, Mr. Cruse.

Assignment 10—Service Performance and Economics of 78-ft Rail, Collaborating with Committee 5, was presented by Subcommittee Chairman L. R. Lamport (Chicago & North Western).

Mr. Lamport: The report of Assignment 10, found in Bulletin 507, pages 1262 to 1264 incl., is presented as information.

As indicated in the report, the Engineering Division research staff of the Association of American Railroads, under direction of G. M. Magee, has begun the service tests of 78-ft rail on the Chicago & North Western Railway near Calamus, Iowa, and on the Pennsylvania Railroad between Hamlet and Hanna, Ind. The data obtained in the initial tests in 1952, together with subsequent tests, should furnish us with much information to substantiate a recommendation for adoption of 78 ft as a desirable length of rail.

Due to the limited length of time installations of 78-ft rail have been in track, and the fact that many of such installations are over unstable roadbeds, it has been difficult to obtain substantial figures on the cost of maintaining track with 78-ft rail as compared to 39-ft rail. It is hoped, however, that before the next convention we will have cost data which will be of value.

The assignment of the Subcommittee for the ensuing year will include specifications for 78-ft rail.

Chairman Code: Thank you, Mr. Lamport.

In concluding the report of Committee 4—Rail, I want to thank the members of the committee, and, in particular, the subcommittee chairmen, Prof. Cramer, Prof. Jensen, Mr. Magee and his staff, and Mr. Howard and his staff, for their splendid cooperation throughout the year.

President Geyer: Mr. Code, we are much indebted to you and your committee for the fine report you have made here, and for the work you have done during the past year.

The committee is dismissed with the thanks of the Association.

Closing Business

President Geyer: Is there any other business to come before this annual meeting?

J. B. Akers (Southern): Mr. President, may I have the privilege of the floor?

President Geyer: You may.

Mr. Akers: Mr. President, members and guests: I would like to have a word or two with my friend Charlie, here, and I want you to hear it.

Charlie, in just a few minutes you will join the ranks of has-beens. We call you "Mr. President" now, but in a few moments you will just be Charlie again, just like I'm Jim, and we'll love you just as much.

I want to tell you that everyone to whom I have spoken about the progress of this convention and your year as president has been very complimentary. We think it is all due to your experienced hand and your love of humankind. So we want to reward you, Charlie. We want to give you something to make sure you know that the Association appreciates what you have done for it, and to show you that we have a high regard for you.

I want to present you with this plaque, which officially records you as a president of this Association. It is for your den or wherever Mrs. Geyer will let you hang it. It reads, "The American Railway Engineering Association records its grateful appreciation to Charles James Geyer for his able administration of the affairs of the Association during his term as President, 1952–1953."

Charlie, I congratulate you, and wish you well. (Applause)

President Geyer: Jim Akers, members of the Association: I can't tell you how much I have enjoyed and appreciated the honor of being the president of this Association during the past year. I would much rather be a has-been of this Association than an is-been of most any other association.

I will pass from this chair with the best of feeling and gratitude toward every officer and every member of the Association with whom I have worked during the past year. I could have asked for no greater support. I thank you very much for that support, and know that my successors, particularly the one coming up, with your continued support, will lead our Association to far greater heights than it has reached before.

Thank you very much.

The closing moments of this convention will end the service of one of our past presidents as a member of our Board of Direction. Mr. H. S. Loeffler, assistant chief engineer of the Great Northern Railway, will complete his term of office on the Board of Direction. As you know, a past president serves two years on the Board after his term of office.

The Association is deeply indebted to Mr. Loeffler for his long service in official capacity. His work as chairman of the Board Committee on Manual for the past year has been particularly outstanding.

I would like to have Mr. Loeffler stand and be recognized by the members of our Association. (Applause)

The terms of office of four other members of our Board of Direction terminate with this meeting. These directors are R. P. Hart, Clark Hungerford, W. J. Hedley and G. M. O'Rourke. All four of these directors have served your Association faithfully and efficiently.

Mr. Hart, Mr. Hungerford and Mr. Hedley are retiring from the Board after their terms of three years. Will these three gentlemen stand and be recognized? (Applause)

Mr. O'Rourke, as we announced yesterday, is remaining on the Board, and we will recognize him later.

I can't pass up this occasion without expressing the deep appreciation of our entire Association—and of myself, personally—to Chairman Bob Bardwell and all of the members of the Arrangements Committee for their splendid work during our convention this year. Only by working with this group can one appreciate the multitude of details which they handle in order that our convention may run smoothly and reach a successful conclusion.

I thank you, Mr. Bardwell, and every member of your committee for the fine job you have done.

Your retiring president has the privilege and honor, and the great pleasure, of introducing to you the Association's new officers for the coming year.

Our senior vice president for the coming year is Mr. G. W. Miller. He is engineer maintenance of way of the Eastern Region of the Canadian Pacific Railway, at Toronto, Canada. Mr. Miller, will you please come to the platform? (Applause)

Our newly elected junior vice president is Mr. George M. O'Rourke, assistant engineer maintenance of way of the Illinois Central Railroad, here in Chicago. Will Mr. O'Rourke please come to the platform? (Applause)

Mr. Miller and Mr. O'Rourke, I congratulate you both upon your elevation to high office in this Association. I wish you every success in your efforts for the Association in the year immediately ahead.

The man you have chosen as your president is Mr. Charles G. Grove, chief engineer, Western Region, of the Pennsylvania Railroad, located here in Chicago. I will ask Past Presidents Blair and Loeffler to escort Mr. Grove to the platform. (Applause)

Mr. Grove, it is indeed a great honor to turn this chair over to you, the new president of the American Railway Engineering Association. I thank you personally for your support during my year in office, in which you served as senior vice president, and I wish you every success in conducting the business of this Association during the coming year.

President-elect Grove: Thank you very much.

S. R. Hursh (Pennsylvania): Mr. President, may I have the privilege of the floor for a minute?

President Geyer: You may.

Mr. Hursh: You have just elected Mr. Grove as president of your Association. I know that he will do a splendid job, and will carry on in the able manner in which President Geyer has performed. And I know that he will receive the support of all the Directors and members.

While he may be president by virtue of election, it is only proper that he have a symbol of that office in the form of a gavel, so I want to give him one. For the benefit of the audience, I might say that there is historical significance to the gavel I am about to present to him.

You have all read, of course, in Modern Railroads and Railway Age, that the Pennsylvania Railroad is tearing down the old landmark in Philadelphia known as the Broad Street Station. It has been the privilege of all of our officers, while in training—including Mr. Grove—to pass through Broad Street at some time or other, before they were sent out on the line as an assistant supervisor. For that reason, we thought it quite fitting and appropriate that we take some of the oak paneling of the old Board Room of the Pennsylvania Railroad, on the third floor of old Broad Street, and make a gavel from it for Mr. Grove. After it has served him in his term as President, he may take it home and put it on the mantel as a remembrance of a significant place where he spent some time years ago.

Mr. Grove, in token of the esteem in which your fellow employees hold you, it is my great privilege to present to you this gavel, as a symbol of authority, that you may conduct the office of president of this Association in a manner befitting that high office. (Applause)

President elect Grove: Thank you very much Mr. Hursh. This gavel will mean much to me in the years to come, as well as in the next year, not only because of its beautiful workmanship and utility, but because of its source.

I am very happy to receive this from Sam, because, as I have learned in my association with him, he has believed in the practice of living and helping other people to live, I sincerely thank him and my other friends on the Pennsylvania.

This gavel will, of course, bring back memories of old Broad Street Station. To the generation of young railroaders who entered the service of the Pennsylvania about 40 years ago, Broad Street was the seat of our system officers, and the place where the Board of Directors met was almost a "holy of holies," before which we stood in great awe. It was the source of all authority.

When the new office building was built across the way, which now houses our system offices as well as the Board room, the old Board meeting room in old Broad Street was no longer used by the Board, but was used by many organizations and committees. When I was in the passenger transportation department, we held our timetable meetings in that room. Sam will remember that, because he was superintendent of the Maryland Division when I was superintendent of passenger transportation.

This gavel will also remind me of my membership in the American Railway Engineering Association, and my friends, and it will be a constant challenge for me, especially during the year ahead, to put forth my very best efforts to further the interests of this Association.

I realize the position in which I am placed today, and it is with a deep sense of humility that I accept the honor that has just been conferred upon me as president of the American Railway Engineering Association. The responsibility of this office is great, and I pray that I may be able to carry on in a manner worthy of the illustrious and able men who have preceded me. I ask the support which you have always given to your executives, and in return, I shall do all in my power to merit your helping me.

We know that this year is significant in the life of our country. We know not what lies ahead in the way of changes or momentous decisions. There seems to be a getting back to realities in the essential things of life. Let us, as citizens, as well as members of this Association, dedicate ourselves—by our words, by our thoughts and by our deeds—to hold up the hands of our national leaders who are taking this stand for our country. Let each one of us be sure that his desire is in every way worthy of the high conception and courage of our founding fathers, who laid the secure foundation of justice for a mighty nation based upon the fear of God.

Our retiring president has just piloted our Association through an unusually active year. The Centennial of Engineering gave us pause to review our engineering of the past and to look ahead. The "Bible" of our Association, our Manual, has been carefully reviewed and revised so that, when reprinted, it will represent the latest in railway engineering information and specifications. Our committees may now turn their energies to solving current and new problems that confront our industry.

In the early days of railroading, the term, "highballing," meant to move ahead at full speed. The term originated before we had modern signaling. At a block station full speed ahead was indicated by raising a large ball to the top of a mast. And so I give you a "highball" for full speed ahead in the Association year just starting! (Applause)

It is now my privilege to introduce to you the four men who have been elected as new members of your Board of Direction. I will ask each of them to rise as his name is called, and I request that you refrain from applause until all have arisen.

Mr. E. S. Birkenwald, engineer of bridges, Southern Railway System.

Mr. F. G. Campbell, chief engineer, Elgin, Joliet & Eastern Railway.

Mr. B. R. Meyers, chief engineer, Chicago & North Western System.

Mr. G. E. Robinson, engineer of structures, New York Central System. (Applause)

If there is no further business to come before this meeting, I now declare the Fifty-Second Annual Meeting of the American Railway Engineering Association adjourned.

(The meeting adjourned at 12:50 o'clock.)

MEMOIRS

MEMOIR

Herbert Rentoul Clarke

Died February 18, 1953

Herbert Rentoul Clarke, retired chief engineer of the Burlington Lines, and past president of the AREA, died at his home in La Grange, Ill., on February 18, 1953. He is survived by his wife, Mrs. Nora Scantlin Clarke, two daughters, Mrs. Helen Clarke Keough and Mrs. Gertrude Clarke Skade, and five grandchildren.

Mr. Clarke was born near Belfast, in County Donegal, Ireland, on November 15, 1882, the son of James Clarke and Annie Rentoul Clarke. When he was six years old his parents moved to America and settled near Princeton, Ind., where he received his early education. He attended Monmouth College, from which he was graduated in 1906, Summa Cum Laude. He was a big, vigorous man, physically as well as mentally, and was a star member of his college football team, of which he was captain during his senior year.

Shortly after graduating from college Mr. Clarke entered railroad service as a chainman and rodman with the Missouri Pacific. In 1908 he joined the Burlington in the

Herbert Rentoul Clarke

same capacity, and remained with that road until his retirement on December 31, 1952. He served in many capacities on the Burlington and progressed steadily from the bottom to the top in his chosen field of railroad engineering and maintenance. He was successively a rodman; instrumentman; extra-gang timekeeper; extra-gang foreman; resident engineer of construction; roadmaster; general roadmaster; district engineer maintenance of way; engineer maintenance of way, Lines West; general inspector permanent way, Burlington Railroad; engineer maintenance of way, Burlington Railroad; chief engineer maintenance of way, Burlington Lines; and chief engineer, Burlington Lines, with jurisdiction over engineering and maintenance, the position he held at the time of his retirement.

Mr. Clarke was always a man of abstemious and exemplary habits. One of Mrs. Clarke's proud possessions is a place card for a banquet which he attended as a young and budding engineer in the days when beverages somewhat stronger than water were commonly served. The card reads: "Mr. H. R. Clarke (Fruit Juice)."

Mr. Clarke was a hard worker, striving constantly for improvement in whatever he undertook. With his keen mind he had the knack of getting at the roots of a problem and solving it from the ground up. There was nothing he liked better than to tackle a tough one and wrestle with it until he could come up with the right answer. Along with his capacity for work he had a high sense of humor and always appreciated a good joke or witty story, and could tell them with the best. Though he applied himself unstintingly to his work he always seemed able to find time to help and advise young men starting their careers, especially those under his jurisdiction. He was their leader, adviser and trainer. Because of the generous help he gave them many have risen to positions of responsibility on their railroads. The list includes several railroad presidents.

Mr. Clarke was a devout Christian and an active member of the Methodist Church. He was a member of the Board of Stewards of the First Methodist Church of La Grange for a quarter of a century, president of the Board of Trustees, chairman of the Insurance Committee, member of the Finance Committee, and a member of the Building Committee that only recently completed construction of a new church sanctuary. His service to his church, like his service to his company, was characterized by vigor and accomplishment.

He was active in numerous railroad associations and engineering societies. He became a member of the American Railway Engineering Association in 1922, and subsequently served on a number of the Association's committees, including Ballast, Ties, Track, Rail, and Cooperative Relations with Universities. He was a member of the Board of Direction in 1936, 1937 and 1938, vice president from 1940 to 1942, and president for two terms during the war years of 1942–1944, discharging the duties of that office, under critical conditions, with distinction to himself and the Association. Honorary membership in the Association was conferred on him in 1949.

As a member and officer of the AREA, Mr. Clarke was vitally interested in railroad engineering research as the key to many engineering and maintenance problems and economies, and had a large influence in setting up and guiding the early research activities of the Association and the Association of American Railroads. In 1941 he was chairman of the AREA's newly constituted Committee on Research Administration, the function of which was to consider research proposals of AREA committees and to recommend them to the Board of Direction.

Simultaneously, in 1941, as vice president of the Association, he became a member of the Research Committee of the Engineering Division, AAR, and in 1942 became chairman of that committee. In 1944, when this committee was reconstituted to consist of three chief engineering officers located in Chicago, Mr. Clarke was appointed chairman, and continued as such until the time of his retirement from railroad service.

In the words of some of Mr. Clarke's closest associates in the research activities of the Association, his efforts, good judgment, advice, and administrative ability were outstanding factors in setting up these activities on such a firm foundation and in progressing their development to their present large scale.

As president of the AREA during the war years 1942–1944, Mr. Clarke also played a most important part in meeting the war emergency. Under his direction, four emergency committees were appointed and empowered to ratify emergency recommendations of the standing committees to minimize the use of critical materials. Here again, he gave unstintingly of his time and energy, which resulted in the most successful handling of all war emergency problems.

Mr. Clarke was also a member of the American Society of Civil Engineers, the Western Society of Engineers, the Western Railway Club, the Roadmasters' and Maintenance of Way Association, of which he was president in 1929, and the Maintenance of Way Club of Chicago, of which he was president in 1940–41.

Through his association work Mr. Clarke did much to advance knowledge pertaining to the economic location, construction, operation and maintenance of railways. He lived a full and useful life devoted to his family, his church and his work. He leaves a host of friends whose lives are fuller and richer because of having known and worked with him. His sound knowledge, leadership and genial ways will be missed in the years ahead.

Armstrong Chinn, *Chairman,*
T. A. Blair,
H. S. Loeffler,
Committee on Memoir.

MEMOIR

Hermann von Schrenk

Died January 30, 1953

Hermann von Schrenk, son of Prof. Joseph and Anna (Bandtke) von Schrenk, was born March 12, 1873, at College Point, Long Island, N. Y. He received a Bachelor of Science degree from Cornell University in 1893, a Master of Arts degree from Harvard in 1894, and a Doctor of Philosophy degree from Washington University in 1898.

For a number of years Dr. von Schrenk was an instructor in plant pathology at Washington University, and at the same time was pathologist in charge, Mississippi Valley Laboratory, Bureau of Plant Industry, U. S. Department of Agriculture. For five years, 1901 to 1906, he was chief of the Division of Forest Products, U. S. Bureau of Forestry. During the ten years from 1900 to 1910 he was lecturer on diseases of trees and timbers, wood preservation and related subjects at Yale, University of Wisconsin, and the Biltmore School of Forestry.

In 1907 Dr. von Schrenk withdrew from the Department of Agriculture to form a partnership with Dr. Alfred L. Kammerer, known as Von Schrenk and Kammerer,

Hermann von Schrenk

Consulting Timber Engineers, and located at St. Louis, Mo. He was a member of this firm until his death. From 1907 to the date of his death Dr. von Schrenk had been consulting timber engineer for a great number of the country's leading railroad systems, advising them on timber utilization, wood preservation, protection against fire, prevention of marine borer damage and kindred problems. During his professional career he was very active in carrying on research projects in his chosen field, the results of which have proven highly valuable to the railroads.

Since 1901 Dr. von Schrenk had been very active in the American Railway Engineering Association. Although he did not become a member until February 18, 1905, he had participated as a representative of the U. S. Bureau of Forestry in the deliberations of the Tie committee from 1901 to 1905, and had made contributions which appeared as appendices to the annual reports. In 1906 he became a member of Committee 3—Ties. In 1909, when the subject of Wood Preservation was transferred from the Tie committee to the new Committee 17—Wood Preservation, Dr. von Schrenk became a member of that committee and was a member until his death. He was vice chairman from 1919 to 1920. In its 1909 report Committee 17 presented for adoption the first Standard Specification for Coal Tar Creosote of the Association. It is of interest that this specification was the one suggested by Hermann von Schrenk, E. B. Fulks and A. L. Kammerer in their paper, "Changes Which Take Place in Creosote During Exposure," Appendix to Report of Tie Committee 1908, Vol. 9, p. 738.

Dr. von Schrenk was a member of Committee 5—Track, 1935–1943. His main interest on this committee had been in connection with tie plate design, rail fastenings and corrosion due to brine drippings.

In 1928 Dr. von Schrenk prepared a monograph entitled "Mechanical Wear of Ties," summarizing his extensive researches, observations of ties in track on railroads in this country and in Europe and the results of special track tests. This monograph was printed in AREA Bulletin No. 306 and contained 180 pages and 177 photographs and figures. Unfortunately it was not included in the Proceedings of the Association "to obviate printing the Proceedings in two volumes." This Bulletin became a standard reference work in its field and has been in great demand over the years.

Dr. von Schrenk was a director of the AREA 1933, 1934 and 1935 and was a member of the Special Committee on Grading of Lumber, 1911–1917, and chairman, 1912–1917. He became a Life Member in December 1939.

Dr. von Schrenk had been active in many scientific and technical societies and organizations, including:

American Railway Engineering Association
American Wood Preservers' Association—Honorary and Life Member
American Society for Testing Materials—President 1934–1935, chairman Com. D-7 on Wood 1904–1948, Honorary Member 1944
American Railway Bridge and Building Association
American Society of Civil Engineers—Life Member, chairman Com. on Timber, 1928–1950
American Society of Naturalists
American Forestry Association
American Association for Advancement of Science—Fellow
Academy of Science, St. Louis
Audubon Society of Missouri—President
Botanical Society of America
Deutsche Botanische Gesellschaft
Missouri Botanical Garden—Pathologist, 1907–1953
Missouri Forestry Association—President
National Research Council, Division of Engineering
Ornithologists Union
Delegate to International Railroad Congress, Madrid, Spain, 1930

In 1929 Dr. von Schrenk called a conference at the Missouri Botanical Garden, St. Louis, Mo., to develop taximetric methods for wood preservatives. He called a similar conference in Berlin in 1930. Twenty-five leading European wood pathologists attended, representing ten countries.

Dr. von Schrenk found time in his busy career to do much writing, including the following books: "Decay of Timber and Methods of Preventing It", and "Diseases of Hardwood Trees". His published papers cover 85 titles. He was in great demand as a speaker, because of his proficiency in that art. He made numerous trips to Europe between 1901 and 1930 to observe railway developments in wood preserving and maintenance of way practices, making reports to various railroads and associations. He also had correspondents all over the world.

Dr. von Schrenk married Mary Kimball of St. Louis, February 22, 1909. They had no children. They resided at Florissant, Mo., on an estate which he and his wife had beautified with landscaping and a garden.

Dr. von Schrenk had an attractive and stimulating personality. He was full of enthusiasm—a man of vision and imagination. He had a great capacity for friendship, and had many real friends in every walk of life. He was a keen lover of nature, and a man of broad culture and urbanity. He was an honored and valuable member of the AREA, not only because of his extensive technical knowledge, but also because he had many intangible qualities based on his unusual personality and his cultural background.

Alfred L. Kammerer, *Chairman,*
Clarence S. Burt,
W. H. Fulweiler,
Committee on Memoir.

MEMOIR

Edwin Frederick Wendt

Died October 1, 1952

Edwin Frederick Wendt, a charter member and past president of the American Railway Engineering Association, was born May 12, 1869, at New Brighton, Pa., a suburb of Pittsburgh, Pa., the son of Christian I. Wendt and Agnes Scott Wendt. He died on October 1, 1952.

Mr. Wendt was educated in the public schools of New Brighton, and was graduated from Geneva College, Beaver Falls, Pa., in 1888, with highest honors, and the degree of Bachelor of Arts. He also passed the examinations and registered as a student of Law of the Bar of Beaver County, Pa., in 1893.

In 1913 Beaver College conferred upon him the honorary title of Doctor of Science. He also served as a trustee of Geneva College from 1907 until the time of his death.

Mr. Wendt entered the service of the Pittsburgh & Lake Erie Railroad, a subsidiary of the New York Central System, in 1888, in the engineering corps, as an axeman in the construction department, and shortly thereafter became a chainman and rodman in that department. After ten years' experience as levelman, draftsman and office assistant he was advanced, on October 1, 1898, to the position of assistant engineer in charge of maintenance of way forces, construction forces and equipment, contract work, inspectors, field engineers, and engineering accountants.

Edwin Frederick Wendt

During the time of Mr. Wendt's services the Pittsburgh & Lake Erie was reconstructed and highly developed from a single-track to a four-track main-line railroad, fully equipped with new yards and terminals, bridges of heavy, modern design, new passenger and freight stations, round houses and turntables, locomotive and car shops, electric power houses, water and fuel stations, signal and interlocking plants, and auxiliary facilities, necessary for a modern economical transportation machine.

The extensive development of the line is indicated by the growth of its traffic, earnings and mileage between 1888 and 1912, as follows: Average tons per train mile, from 360 to 1215; gross earnings per mile of road, from $20,000 to $81,000; mileage of all tracks, from 135 to 1028.

In 1912 and 1913 Mr. Wendt was assistant engineer in charge of the construction of the Lake Erie & Eastern Railroad, a new double-track road of heavy construction extending from Struthers, Ohio, to Girard, through the industrial district of Youngstown, Ohio, involving complex legal and engineering problems. During a visit to Europe in 1903, he made a study of the railroads in England, France, Holland and Germany.

Mr. Wendt became a charter member of the American Railway Engineering Association May 12, 1899, and in 1936 became a Life Member.

He served as a member of the Board of Direction in 1908, 1909 and 1910; became second vice president in 1911, first vice president in 1912, and in 1913 became president.

He served as a member of various committees of the Association, as follows: chairman, Committee on Records and Accounts, 1902–1907; chairman, Committee on Publications, 1913–1919; member, Committee on Signals and Interlocking, 1907–1913; and member, Committee on Waterways and Harbors, 1936–1946.

He was an active and diligent worker on all of the committees with which he served, and took a prominent part in the discussions of committee reports on the floor of the conventions.

On May 1, 1913, Mr. Wendt was appointed as a member of the Engineering Board on the Valuation of Railroads, Interstate Commerce Commission, and was placed in charge of the Eastern Division, Bureau of Valuation. He remained in this capacity until 1921, when he resigned from government service.

After leaving government service he established an office as consulting engineer, specializing in the valuation, appraisal and cost analysis of railroad and public utility properties, for which his past experience had well qualified him. In 1929 he was made a practitioner before the Interstate Commerce Commission.

Mr. Wendt was a member of the following organizations:

Charter member, American Railway Engineering Association
Past President, American Railway Engineering Association
Member, American Society of Civil Engineers
Member, Engineering Society of Western Pennsylvania
Member, American Academy Political & Social Sciences
Member, Railway Signal Association
Member, Railway Club of Pittsburgh
Member, Cosmos Club of Washington, D. C.
Member, Board of Trustees, Geneva College

He was the author of numerous articles on engineering, transportation, and valuation and depreciation of railroads and public utility properties. He also contributed liberally to the publications of the AREA through its Bulletins and Proceedings. He made valuable contributions to the subject of railroad economics, particularly with reference to the gross and net earnings of railroads with relation to operating expenses.

Mr. Wendt was one of the "Wheelhorses" of the American Railway Engineering Association, which owes to him a great debt of gratitude for his almost perfect record of attendance at its conventions from the beginning, his active participation in the discussions at these conventions, and his indefatigable work on committees.

L. C. Fritch, *Chairman,*
G. J. Ray
D. J. Brumley
Committee on Memoir.

REPORT OF THE SECRETARY

March 1, 1953

To the Members:

The following report covers the calendar year 1952 with respect to finances, the 12 months from February 1, 1952, to February 1, 1953, in the case of the membership record, and the period from March 1, 1952, to March 1, 1953, so far as the other activities of the Association are concerned. In summary, it can be said, as has been the case in so many years in the past, that the report in all respects is "good". That this can be said is not due to the special interest or effort of any small group within the Association, but rather to the continued interest, efficient management and diligent effort of the Association's officers, its committee chairmen and committee members, and of its membership generally.

Looking back over the year, it is not without great significance that it can again be said, as was stated in the secretary's report for 1951, that "The Association has grown numerically and in the scope of its usefulness, and has become financially stronger." The facts are that membership in all categories has again increased; the total personnel serving on committees has been still further enlarged; research efforts have been further broadened and expanded; and the work of committees, as measured by the number or printed pages of reports in the Bulletins, and especially by the amount of Manual material offered for adoption, reapproval, or revision, has been unusually intensive and productive; and receipts have again exceeded disbursements.

Supplementing the many measures adopted by your Board of Direction in 1951 to strengthen the Association, both from within, and in its relationship to the work of other groups, as noted in the secretary's report for last year, your officers have again, during the past year, adopted further measures to enhance the prestige of the Association and its usefulness through its committee work and its various publications. Among these measures, they re-established Committee 25—Waterways and Harbors, which had been discontinued in 1947, in order to permit the effective review and revision of Chapter 25—Waterways and Harbors, in the Manual, and to keep the Association abreast of new developments in the field of Federal waterway projects; circumvented normal procedure and assigned three new subjects to three standing committees during the course of the year, to permit early consideration to matters of timely interest to members and the railroads; authorized the sending of copies of the AREA News issued immediately preceding and following annual meetings to the chief executives and chief operating offices of all Member Roads of the AAR, in order that these officers might be better informed with respect to the Association and the scope of its activities, especially as revealed in its convention program and reports; appointed A. B. Hillman, chief engineer of the Chicago & Western Indiana and Belt Railways, as treasurer of the Association, succeeding J. D. Moffat, resigned; and initiated measures which led to the designation of your secretary as executive vice chairman of the Engineering Division, AAR, and your assistant secretary as secretary of the Engineering Division—titles corresponding to those existing in the other Divisions of the AAR.

In addition, as recent as February 1953, the secretary's office, with the cooperation of the Committee on Convention Arrangements, and especially G. P. Palmer and Past Secretary W. S. Lacher, issued a completely revised and enlarged Manual of Practice covering in detail the duties and responsibilities of the secretary's office, and of each subcommittee of the Committee on Convention Arrangements, in connection with the planning for and running of the annual conventions of the Association.

Committees of the Board of Direction

Outline of Work

W. J. Hedley (chairman), R. P. Hart, A. N. Laird, W. C. Perkins, S. R. Hursh

Personnel of Committees

G. M. O'Rourke (chairman), G. W. Miller, W. J. Hedley, H. S. Loeffler, Ray McBrian

Publications

R. J. Gammie (chairman), C. Hungerford, G. M. O'Rourke, L. L. Adams, M. H. Dick

Manual

H. S. Loeffler (chairman), A. N. Laird, R. J. Gammie, M. H. Dick

Membership

T. A. Blair (chairman), R. P. Hart, Ray McBrian, L. L. Adams, E. E. Mayo

Finance

C. G. Grove (chairman), G. M. O'Rourke, S. R. Hursh

Special AREA Services

G. W. Miller (chairman), C. G. Grove, W. C. Perkins, E. E. Mayo, T. A. Blair

---

But possibly the two most important and effective special activities of your Board during the past year were its aggressive participation in the plans for the Centennial of Engineering, held in Chicago, September 3–13, which gave railroad engineers a prominent place in the celebration, and its continued planning for the reprinting of the Association's Manual of Recommended Practice in 1953.

Under the direction of the Board the Association not only participated continuously in the development of the over-all plans for the Centennial of Engineering, but initiated and carried through plans which brought 21 of the Association's 23 committees to Chicago on September 8–10, with a total registration of 554, and which resulted in a Railroad Engineering Banquet at the Palmer House, with a total attendance of 580 members, their wives, and guests, including all classes of railroad engineers and many railway supply men—filling the Red Lacquer Room to capacity.

Respecting the work of reprinting the Manual, the Board not only set up an organization within the secretary's office to carry out this work, but approved detailed plans incorporating many new features, which, together with the extensive work that has been done by commttees during the year on their respective Manual chapters, assures that the new volume, when issued, will be more comprehensive, better organized and arranged, more completely up to date, and more readily usable than ever before. A series of four articles, outlining in some detail the plans for the reprinted Manual, including the new features being adopted, was presented in the AREA News, beginning with the November 1952 issue.

Membership

Completely allaying the fear that existed that the membership of the Association would fall off following the big membership drive in 1948, immediately preceding the Golden Anniversary Year (1949) of the Association, when 852 new Members were taken in, the membership of the Association has continued to grow in each succeeding year, including 1952, although the net gain in that year was not as large as in the immediately preceding year. Specifically, the net gain for the year ended February 1, 1953, was 47, bringing the total membership as of February 1 to 3237. This compares with net gains in the three immediately preceding years of 98, 37 and 45, respectively.

The net gain of 47 in 1952 was smaller than the 98 gain in 1951, primarily because 30 fewer new members were taken into the Association during the year, but it reflects also a greater loss of membership during the year of 10 due to deaths, resignations and memberships dropped.

Indicating a continued interest in early membership in the Association among the younger technical men entering railroad service, and likewise of higher engineering officers in having their newer and more promising technical employees take early advantage of the benefits to be gained through affiliation with the Association, 66 new Junior Members were taken in during the past year, adding to the 93 such members taken in during 1951 and the 92 enrolled in 1950. However, the net gain in the number of Juniors for the year was only 4, to a total of 261, since a total of 62 Juniors were transferred to a higher grade of membership or discontinued their membership during the year. Thirteen of this number were transferred to the grade of Member, having attained the age of 30, eight were transferred to Member account of having attained the requisite experience; and one became an Associate, having gone into commercial engineering—a total of 22. The remaining 40 dropped out of the Association, in most cases because they left railroad service.

The changes in the status of membership during the past year are set forth in the following:

Membership

(February 1, 1952, to February 1, 1953)

Members on the rolls February 1, 1952	3190
New members	237
Reinstatements	35
	3462
Deceased	43
Resigned	40
Dropped	80
Juniors transferred and dropped	62
	225
Net gain	47
Membership February 1, 1953	3237

Membership as of February 1

	1948	*1949*	*1950*	*1951*	*1952*	*1953*
Life	294	325	339	355	361	375
Member	1686	2263	2276	2243	2284	2312
Associate	317	275	280	274	288	289
Junior	37	145	158	220	257	261
Totals	2334	3008	3053	3092	3190	3237

In spite of the fact that the Association is now completing its 54th year, its membership role, happily, still includes 5 charter members, although it is with deep regret that this report must record the passing during the year of 2 charter members—E. F. Wendt, who was president of the Association in 1913–1914, and who had a long record of committee activity, and Andrew D. Schindler. Our living charter members are:

T. L. Condron
L. C. Fritch, past president and past secretary
E. C. Macy
William Michel
F. L. Nicholson, past director.

Deaths among the membership during the year totaled 43, as is recorded in the roster of deceased members appearing at the end of this report. Among those who died during the year, in addition to Mr. Wendt and Mr. Schindler, were J. L. Campbell, who was president of the Association 1922–1923, and who was elected an Honorary Member in 1938; G. L. Sitton, who was elected president of the Association for the year 1950–1951, but who resigned early in the year because of illness; and G. R. Westcott, who was a member of Committee 27 for 19 years, and its chairman 1938–1941, and who for many years was a valued member of the Committee on Convention Arrangements, and its chairman 1945–1946.

Work of Committees

As evidence of general appreciation of the value of participating in committee work, the number of members serving on committees again reached a new high in 1952, even after taking into consideration the large number of changes in committee personnel under the rule which seeks up to a 10 percent change each year, primarily to pass membership around and to inject new blood into committee work, and to rid committee rosters of members who have not been active for one reason or another. One committee (Committee 25—Waterways and Harbors) was re-established during the year (having been discontinued in 1947), and almost immediately built its membership up to a total of 38. Another committee (20—Contract Forms) built its membership up from 27 to 37 during the year.

According to the records, on February 1, 1953, 986 members were serving on committees, occupying a total of 1119 places on these committees, since a number of members serve on two committees. This compares with 949 members who occupied 1067 places on committees on the same date in 1952, and with 910 members who served in 1035 places two years ago.

In addition, many committees carried "Guest" members on their rosters during the year, who were potential members awaiting definite assignment to the committees with the roster changes last fall and the publication of the 1953 Outline of Work pamphlet. Also, a number of committees welcomed "Visitors" to their meetings, including interested outsiders, retired members, and other members, including Juniors, who for one reason or another could not be assigned to the committees, or who wished to sit in on specific meetings.

While the normal work on all committee assignments went on uninterrupted in most committees, all committees gave special consideration to the review and revision of their respective Manual chapters, looking to putting their various specifications or recommended practices in the best possible shape for inclusion in the Manual as to be reprinted in 1953. The magnitude of this phase of their work is seen in the fact that, as a whole, the committees in their reports for presentation to the 1953 annual convention presented recommendations affecting approximately 500 Manual documents—a number of committees reviewing and revising their entire Manual chapters. In addition, looking to a more coherent and otherwise effective arrangement of their Manual material, each committee submitted to the secretary's office a new Table of Contents for its reprinted chapter, which in many cases calls for a complete recasting or rearrangement of material.

Classification of Material in Committee Reports

(Figures Shown Indicate the Number of Manual Documents Affected or New Reports)

	1946	*1947*	*1948*	*1949*	*1950*	*1951*	*1952*	*1953*
Revisions of the Manual	17	24	58	37	24	20	19	257
Reapproval of Manual Material	..	..	23	7	5	5	2	243
New Manual Material	3	5	5	4	6	5	6	12
New Manual Material —Tentative	1	5	7	2	4	2	8	6
Information	32	33	29	35	49	57	43	49
Reports on Research Work	14	15	16	19	18	23	15	18
Reports on Service Tests	5	6	3	7	7	1	10	13
Statistical Data	2	2	3	4	2	3	9	5
Analytical Studies	2	2	8	14	7	2	2	5
Bibliographies	2	2	2	2	3	3	2	2
Brief Reports of Progress	7	13	16	20	13	8	16	11
War Emergency Provisions	1	..	..	..	..	1	..	..
	86	107	170	151	138	130	132	621

Committee Meetings

Measured by the number of committee meetings, the Association had a record year of activity in 1952. Altogether, there were 79 meetings of full committees, compared with 69 such meetings during 1951, 59 during 1950, and 51 in 1949—this number in each case including the increasing number of luncheon meetings being held during the March conventions, and in the case of 1952 the large number of meetings held during the Association's participation in the Centennial of Engineering, in Chicago, in September. Each of two committees held six meetings, one committee held five meetings, seven committees held four meetings each, nine committees held three meetings each, three held two meetings each, and one held only a single meeting.

Of the 79 meetings, 53 were held in Chicago, 3 were held in Montreal, New York City, New Orleans and St. Louis, 2 were held in Cleveland, and 12 were held in as many different places. As a part of these meetings 9 committees held a total of 10 inspection trips, supplementing their studies and investigations with on-the-ground observations of railway and manufacturing facilities and operations. In addition, many subcommittees held meetings during the year under a growing recognition of the desirability of expediting and consummating subcommittee work prior to, and with least loss of time at, general committee meetings.

Again, the Board of Direction and the secretary's office endeavored to cooperate with committees in bringing about a clearer understanding of their assignments and of the rules governing committee procedure, especially in the preparation of reports and with respect to matters pertaining to the reprinting of the Manual in 1953. To this end, continuing a procedure started in 1947, the president, the chairmen of all Board Committees, and the secretary and assistant secretary, met with all committee chairmen in Chicago on April 28. Following this meeting, the secretary's office, with the cooperation of the Board of Direction, again carefully reviewed and revised the "Information and Rules for the Guidance of Committees", and reprinted this material in the 1953 Outline of Work pamphlet.

In an effort to assist the committees in the extensive work which they carried out in reviewing and revising their Manual material, and especially as to the form to be adopted for publication in the Bulletins and the reprinted Manual, the secretary's office sent to all chairmen a synopsis of the standards for the new Manual and several letters of instructions respecting style and arrangement.

Publications

The seven Bulletins, ending with the February 1953 issue, contain 1595 pages of text matter and illustrations, exclusive of advertising, compared with 1185 pages for the seven Bulletins ending with the February 1952 issue, and 962 pages for the Bulletin ending with the February 1951 issue.

The committee reports published for presentation at the March 1953 annual meeting occupy 848 pages in Bulletins 504 to 507, incl., to which should be added the 428 pages of reports on research projects sponsored by AREA committees, or groups in which AREA committees are interested, which appear in Bulletins 502 and 503, the 88 pages of the monograph entitled "The Federal Valuation of the Railroads in the United States," by B. H. Moore of the AAR, which appear in Bulletin 503, and the 8 pages in Bulletin 504 which contain the address presented by H. R. Clarke, chief engineer, Burlington lines, at the Railroad Engineering Banquet, Palmer House, Chicago, sponsored by the AREA as a part of its participation in the Centennial of Engineering. The title of this address is "Contributions of Railroad Engineers to the Welfare of the Country Over the Last 100 Years."

Contents of Bulletin 502, June–July 1952

Rigid Frame Analysis for Members of Variable Moment of Inertia, Directed Especially Toward Floorbeam Hanger Frames and Counterweight Trusses; Analytical and Experimental Studies

Tie Renewals and Costs per Mile of Maintained Track

Contents of Bulletin 503, September–October 1952

The Effect of Grip on the Fatigue Strength of Riveted and Bolted Joints

Tests on Waterproofing Coatings for Concrete Surfaces—Final Report

Description and Analysis of Impact Tests Made on Reinforced Concrete Bridges Under Diesel and Steam Locomotives

The Federal Valuation of the Railroads in the United States

The Manual and Portfolio of Trackwork Plans

The Supplement embracing the revisions authorized at the annual meeting in March 1952 contained 139 new sheets for insertion in the loose-leaf Manual, and was accompanied by instructions for the removal of 137 old sheets. The Manual now has been in loose-leaf form for almost 17 years, and in that time 2154 new sheets have been issued and 1960 have been withdrawn, resulting in a net increase of 194 sheets. The work of issuing the Supplement, which reflects work done in 1951, was supplemented by the extensive work of committees in reviewing and revising their respective Manual material during 1952, looking to the reprinting of the Manual in 1953, as is referred to under the heading "Work of Committees."

Record of Manual Supplements

Supplement	*New Sheets Issued*	*Old Sheets Withdrawn*	*Net Increase*
1937	110	69	41
1938	151	121	30
1939	128	95	33
1940	185	139	46
1941	148	120	28
1942	144	149	—5
1943	176	158	18
1944	131	109	22
1945	44	45	—1
1946	127	147	—20
1947	167	184	—17
1948	135	132	3
1949	151	144	7
1950	105	105	0
1951	113	106	7
1952	139	137	2
Total	2154	1960	194

In addition to the Manual Supplement, there was issued during the year a supplement for the Portfolio of Trackwork Plans, containing 10 revised plans, 2 entirely new plans, a new Contents sheet, and 5 Appendix sheets covering revisions in AREA Specifications for Special Trackwork and definitions of terms relating thereto. Also during the year the complete Portfolio of Trackwork Plans was reprinted to replenish the supply in the secretary's office.

While reviewing each plan in the Portfolio in connection with the reprinting, the Track committee found 37 plans which required minor changes, some to incorporate previously authorized changes, some to correct inconsistencies with other approved plans, and others to correct printing and drafting errors. To reduce the cost of the Supplement to holders of the Portfolio, an instructions sheet was included with the Supplement listing the plans and the changes to be made in each plan, and each holder of the Portfolio was asked to make these changes himself, as little work was required to do so.

Sale of Publications

As an Association whose objective is "the advancement of knowledge" with respect to specific phases of the railroad industry, the Association can take great pride in the widespread distribution of its various publications over and above those copies going to its own large membership. During the past year, again, more than 30,000 copies of the Association's publications were sold and distributed from the secretary's office to, among others, the American railroads, colleges and universities, students, government agencies, engineers in industry generally, and railroad men in many foreign countries. And large as this distribution was, it was again restricted in at least one respect as the Association continued to refuse to fill many foreign orders which did not have the full sanction of the Office of International Trade at Washington, D. C. Following is a tabulation of the sales made in 1952:

SALES OF ASSOCIATION PUBLICATIONS—1952

Specifications (Bridge)	1,289
Manual chapters	590
Manual specifications and partial chapters	1,361
Bulletins	1,341
Bulletin reprints	152
Special reprints in large orders (100 or more)	18,100
Proceedings	146
Revisions to Manual	552
Manuals (complete)	171
Revisions to Portfolio of Trackwork Plans	920
Complete Portfolios of Trackwork Plans	146
Individual track plans	811
Instructions for Mixing and Placing Concrete	202
Instructions for Care and Operation of Maintenance of Way Work Equipment	666
Federal Valuation of Railroads	1,525
Achievement of Grade Crossing Protection	2,413
	30,385

In addition, a large number of free copies of all Association publications were sent out.

Finances

Both the receipts and expenditures of the Association were substantially greater in 1952 than in 1951, but, for reasons readily explainable, the excess of receipts over disbursements was considerably smaller than in 1951. These facts are indicated in the following summary:

	1951	*1952*
Receipts	$69,044.99	$77,514.44
Disbursements	62,368.74	76,964.07
Excess of receipts over disbursements	$ 6,676.25	$ 550.37

As is shown in the detailed Financial Statement for the calendar year 1952, which appears on a following page, the increase in receipts for the year over 1951 ($8,469.45) was due primarily to a larger refund to the Association from the AAR to cover the major part of the costs involved in printing in full in AREA publications the various research reports developed through the AAR Engineering Division research office, which costs were higher due to the greater number of pages published and increased printing costs. The balance of the larger receipts was due largely to an increase in membership receipts, and to a substantial increase in receipts from the sale of publications, as well as to increased revenues from advertising accounts. Another item that added materially to the receipts was the sale of tickets for the Railroad Engineering Banquet held in conjunction with the Centennial of Engineering celebration, in September, which receipts are contained in the large Miscellaneous Receipts for 1952, but, as indicated in the comments respecting disbursements, these receipts were necessarily a suspense item.

The increase in disbursements for 1952 over 1951 ($14,595.33) was due largely to an increase in the items of Proceedings, Bulletins, Manual Reprinting, and Extraordinary. An increase in overall printing costs necessarily resulted from increased prices, the greater number of printed pages (primarily research reports), with resultant higher Proceedings binding costs (Vol. 53 containing some 300 more pages than Vol. 52), and the continuing larger number of publications necessary for distribution.

The unusually high Extraordinary Expenditure was due entirely to AREA participation in the Centennial of Engineering celebration, and was offset in very large part by the high Miscellaneous Receipts explained in a foregoing paragraph.

While $5000 was estimated to be expended in 1952 for Manual Reprinting, the actual expenditures were $4908.09. This was necessarily an increased expenditure as there was no comparable budget item for 1951. However, $1790.52 of the total expense for Manual Reprinting was expended for Manual paper stock, to be used in the reprinting of the Manual, and is reflected in increased physical assets of the Association, the balance expended accruing as an eventual asset upon completion of the revised edition of the Manual.

That there was any excess of Receipts over Expenditures in 1952, in view of the amount expended account of Manual reprinting, and generally increased costs, gives the year a very favorable comparison with past years. This is shown in the following table:

Comparison of Receipts and Disburements for an 18-Year Period

	Receipts	*Disbursements*	*Net Gain*
1935	$29,001.00	$30,110.00	$1,109.00*
1936	28,643.00	34,662.00	6,019.00*
1937	36,523.00	32,200.00	4,323.00
1938	28,422.00	23,394.00	5,028.00
1939	28,189.00	23,847.00	4,342.00
1940	28,272.00	26,451.00	1,821.00
1941	32,433.00	29,384.00	3,049.00
1942	31,500.00	26,692.00	4,808.00
1943	28,736.00	23,809.00	4,927.00
1944	30,492.00	26,534.00	3,958.00
1945	32,305.00	29,305.00	3,000.00
1946	28,836.00	34,583.00	5,747.00*
1947	46,993.00	46,989.00	4.00
1948	57,741.00	53,062.00	4,679.00
1949	62,081.00	57,075.00	5,005.00
1950	59,752.00	51,795.00	7,957.00
1951	69,045.00	62,369.00	6,676.00
1952	$77,514.00	$76,964.00**	$ 550.00

* Deficit.
** Manual revision and reprinting $4,908.09.

Research Work

With the aid of the research staff of the Engineering Division, AAR, working through its facilities at the AAR Central Research Laboratory at Chicago, and the facilities of several colleges and research institutions, the research work of the Association's committees was at a peak during 1952, with the prospect of a continued large program in 1953. During the past year, as indicated in the accompanying table, the total sum allocated for research work of the Engineering Division was $381,400, which compares with $354,770 in 1951. In the light of the greatly expanded Mechanical Division research program planned for 1953 (to $523,596), and a large sum to be expended for added facilities at the AAR Research Center during the year, the total amount appropriated for research on Engineering Division research projects for 1953 is slightly less than in 1952, amounting to $364,100. However, with a certain amount of carry-over money, a large program of highly important projects is assured.

Total Allotments for Research Work, Engineering Division, 1938–1953

1938	$ 78,158	1946	$159,510
1939	77,650	1947	234,428
1940	69,250	1948	291,840
1941	95,150	1949	372,457
1942	87,932	1950	294,045
1943	98,445	1951	354,770
1944	109,050	1952	381,400
1945	138,110	1953	364,100

A summary of the 1953 research program, compared with the 1951 and 1952 programs, with new projects indicated by daggers, is presented below.

Engineering Division Allotments for Research

	1951 Budget	1952 Budget	1953 Budget
Committee on Rail			
Transverse Fissure Investigation	$ 5,500	$ 5,500	$ 5,500
Shelly Spots Investigation	18,500	17,500	14,500
Rail Failure Statistics	8,970	8,600	8,600
Service Tests of Joint Bars	4,500	6,500	4,000
Rolling-Load Tests of Joint Bars	9,000	9,000	11,500
*Driver Burns Investigation	4,000	2,000	0
Rail Design Investigation	11,800	9,300	9,300
Tests with 78-ft Rail	5,000	3,000	5,000
Total	$ 67,270	$ 61,400	$ 58,400
Committee on Track			
Tie Plates, Stresses	$ 8,000	$ 6,000	$ 6,000
Bolt Tension and Joint Lubrication	5,000	5,000	4,000
Corrosion from Brine Drippings	12,000	12,000	10,000
Stresses in Manganese Frogs	5,000	7,000	6,000
Tests of Rail Anchorage	5,000	9,000	5,000
Tie Plate Fastenings	9,000	8,000	8,000
†Welded Carbon Steel Frogs and Switches	0	0	5,000
Total	$ 44,000	$ 47,000	$ 44,000
Relation Between Track and Equipment			
Relation Wheel Load to Wheel Diameter	$ 5,500	$ 5,000	$ 5,000
Relation of Wheel Pressures to Track Curvature	7,500	10,000	10,000
Total	$ 13,000	$ 15,000	$ 15,000
Committee on Roadway and Ballast			
Roadbed Stabilization	$ 24,900	$ 25,000	$ 24,000
Ballast Tests	5,000	6,000	6,300
Vegetation Control by Chemicals	5,000	12,500	12,500
Total	$ 34,900	$ 43,500	$ 42,800
Committee on Ties			
Wear and Splitting of Ties	$ 20,000	$ 20,000	$ 10,000
Total	$ 20,000	$ 20,000	$ 10,000
Structural Projects			
Bridge Impact Investigation	$ 80,000	$ 80,000	$ 78,000
Stress in Bridge Frames	10,000	8,000	8,000
Riveted and Bolted Structural Joints	10,000	10,000	10,000
Column Research Council	6,000	8,000	3,000
*Finishing Structural Plate Edges	3,000	0	0
Steel Structures Painting Council	2,000	10,000	10,000
Timber Stringer Tests	7,500	5,000	5,000
Performance for Fire-Retardants	5,000	5,000	5,000
Concrete Deterioration	9,000	10,000	10,000
*Tests of Waterproofing Paints	5,000	0	0
Reinforced Concrete Research Council	0	5,000	5,000

	1951 Budget	*1952 Budget*	*1953 Budget*
Strength of Timber Bolted Joints	0	2,000	3,000
Tests of Membrane Waterproofing Material	0	3,000	5,400
Tests of Bituminous Materials	0	7,000	8,100
†Wind Loads on Buildings	0	0	1,000
Total	$137,500	$153,000	$151,500
Administration			
Research Office	$ 30,900	$ 34,000	$ 34,900
Research Publications Cost	7,200	7,500	7,500
Total	$ 38,100	$ 41,500	$ 42,400
Grand Total	$354,770	$381,400	$364,100

* Completed in 1951 or 1952.
† New Projects in 1953.

This report of your secretary, which reflects the general healthy state and accomplishments of your Association during the past year, should again be highly gratifying to the officers and members of the Association, who gave so much to make this possible. Yes, progress has been made, new records have again been attained, but working diligently together, there is every reason to believe that the new year—1953—will bring new peaks of achievement.

Respectfully submitted,

Neal D. Howard
Secretary

Deceased Members

E. H. BERGER

Consulting Chemist, Waterproofing Roofing Material, Johns Manville Corporation, 22 East 40th St., New York 12, N. Y.

J. A. BLALOCK

Division Engineer, Richmond, Fredericksburg & Potomac Railroad, Richmond 20, Va.

C. W. BREED

Retired Engineer of Standards, Chicago, Burlington & Quincy Railroad, 4803 Lawn Ave., Western Springs, Ill.

B. L. BUGG

Retired President, Atlanta, Birmingham & Coast Railroad, 34 Inman Circle N. E., Atlanta, Ga.

J. L. CAMPBELL

Retired Chief Engineer, Northwestern Pacific Railroad, 1737 Hillside Drive, Glendale, Calif.

R. E. CAUDLE

Assistant Engineer—Structures, Missouri Pacific Lines, Box 2052, Houston 1, Tex.

R. R. CUMMINS

General Manager, Central of Georgia Railway, Savannah, Ga.

J. H. DAVIS

Assistant to Division Engineer, Illinois Central Railroad, Waterloo, Iowa

J. V. DILLABOUGH

Retired Transportation Engneer, Canadian National Railways, 288 Broadway, Winnipeg, Man.

E. A. DOUGHERTY

Chief Engineer, New York Central System, Lines West of Buffalo, Chicago 5, Ill.

W. A. DUFF

Retired Engineer Bridges and Roadway, Canadian National Railways, 1455 Drummond St., Montreal, Que.

F. O. DUFOUR

527 Arch St., Bethlehem, Pa.

J. M. FAIR

Retired Assistant Chief Engineer Maintenance of Way, Pennsylvania Railroad, 6859 Reynolds St., Pittsburgh 8, Pa.

O. E. HAGER

Engineer Bridges and Structures, Chesapeake & Ohio Railway, P. M. District, Detroit 2, Mich.

H. E. HALE

1165 Fifth Ave., New York 29, N. Y.

H. H. HARSH

Engineer Maintenance of Way, Baltimore & Ohio Railroad, Pittsburgh 19, Pa.

B. HERMAN

Retired Chief Engineer, Southern Railway System, 2737 Devonshire Place, N. W., Washington 8, D. C.

T. J. JAYNES

Designing Engineer, New York Central System, New York 17, N. Y.

W. S. JOHNS, JR.

Retired Assistant to Chief Engineer, Pennsylvania Railroad, 6050 Overbrook Ave., Philadelphia 31, Pa.

R. E. JONES

Chief Draftsman, Bessemer & Lake Erie Railroad, Greenville, Pa.

W. F. KIRK

Railroad Operations Consultant, 4811 Jarboe St., Kansas City 2, Mo.

J. A. MCGREW

Retired Consulting Engineer, Delaware & Hudson Railroad, 706 Madison Ave., Albany 3, N. Y.

R. H. Mitchell

Division Engineer, Boston & Maine Railroad, Boston 14, Mass.

C. M. Nye

Retired Chief Engineer, Great Northern Railway, Old Harbor Road, Chatham, Mass.

R. E. Oberdorf

Assistant to Chief Engineer, New York, Chicago & St. Louis Railroad, Cleveland 1, Ohio

Ramon Pasquel

Assistant Chief Engineer, Ferrocarril Sud-Pacifico de Mexico, Miguel Blanco Num 544, Guadalajara, Jalisco, Mexico

W. L. Peoples

District Engineer, New York, Chicago & St. Louis Railroad, Brewster, Ohio

Philip Petri

Retired Chief Engineer Maintenance, Baltimore & Ohio Railroad, 4507 Wentworth Road, Baltimore 7, Md.

G. S. Plumley

Consulting Engineer, First Federal Building, 231 Hale St., Charleston, W. Va.

C. C. Rausch

Manager, Industrial Department, Dearborn Chemical Company, Merchandise Mart Plaza, Chicago, Ill.

J. W. Reed

Assistant Engineer, Pennsylvania Railroad, Chicago 6, Ill.

E. S. Schimmel

Retired Bridge Engineer, Lehigh & New England Railroad, South Sterling, Wayne County, Pa.

A. D. Schindler

President and General Manager, Kings County Development Company, 351 California St., San Francisco 4, Calif.

T. F. Scholes

President, T. F. Scholes, Inc., P. O. Box 112, Reading, Pa.

B. J. Simmons

Retired Assistant to General Manager, Western Pacific Railroad, Box 2525, Carmel, Calif.

G. L. Sitton

Assistant to Chief Engineer, Southern Railway System, Washington 13, D. C.

C. U. Smith

Consulting Engineer, Box 955, Lindsay, Calif.

L. Spalding

Principal Assistant Engineer, Bessemer & Lake Erie Railroad, Greenville, Pa.

C. V. Talley

Division Engineer, New York Central System, Springfield, Ohio

E. A. Truran

Retired Structural Engineer, Massachusetts Department of Public Works, Box 28, East Wareham, Mass.

J. H. Twitmyer

Assistant Engineer, Pittsburgh & Lake Erie Railroad, Pittsburgh 19, Pa.

E. F. Wendt

Consulting Engineer, 970 Union Trust Building, Pittsburgh 19, Pa.

G. R. Westcott

Retired Assistant Engineer, Missouri Pacific Railroad, Hutsonville, Ill.

FINANCIAL STATEMENT FOR CALENDAR YEAR ENDING DECEMBER 31, 1952

Balance on hand January 1, 1952			$125,845.69

RECEIPTS

Membership Account			
Entrance Fees	$ 1,770.00		
Dues	41,608.33	$43,378.33	
Sales of Publications			
Proceedings	$ 1,225.47		
Bulletins	1,730.35		
Manuals	4,682.20		
Specifications	2,475.85		
Track plans	3,216.85		
Concrete mix	31.65		
Research reports—refund	9,540.68	$22,903.05	
Advertising			
Publications		$ 5,234.83	
Interest Account			
Interest on investments	$ 3,199.54		
Less interest paid on bonds purchased	50.55	$ 3,148.99	
Miscellaneous		2,849.24	
Total		$77,514.44	

DISBURSEMENTS

Salaries	$21,895.08		
Proceedings	15,498.20		
Bulletins	14,095.19		
Stationery and printing	3,001.21		
Rent, light, etc.	1,140.00		
Supplies	247.32		
Postage	1,152.74		
Refund of dues	143.15		
Audit	400.00		
Pension	1,500.00		
Social security and unemployment taxes	285.43		
Manual	4,189.17		
Track plans	4,401.24		
Committee and officers expense	640.95		
Annual meeting expenses	1,558.49		
News letter	3,274.76		
Miscellaneous	3,541.14		
Total		$76,964.07	
Excess of Receipts over Disbursements		550.37	
Less—loss on sale of bonds		9.37	$ 541.00
Balance on hand December 31, 1952			$126,386.69

REPORT OF THE TREASURER

To the Members:

Balance on hand January 1, 1952		$125,845.69
Receipts during 1952	$ 77,514.44	
Paid out on audited vouchers	76,964.07	
Excess of Receipts over Disbursements	550.37	
Loss from sale of bonds	9.37	541.00
Balance on hand December 31, 1952		$126,386.69
Consisting of		
Bonds at cost	$122,703.38	
Cash in Northern Trust Company Bank	3,658.31	
Petty cash	25.00	
		$126,386.69

We have made an examination of the accounts of the American Railway Engineering Association for the year ending December 31, 1952, and find them to be in accordance with the foregoing statement.

C. A. Bick,
P. D. Mitchell,
Auditors.

GENERAL BALANCE SHEET

Assets	*1952*	*1951*
Due from members	$ 61.50	$ 53.50
Due from sale of publications	247.40	64.10
Due from sale of advertising	686.00	517.00
Furniture and fixtures	1,318.00	1,400.00
Inventory of publications (estimated)	500.00	500.00
Inventory of Manuals	3,382.00	5,881.00
Inventory of track plans	1,837.40	565.75
Inventory of paper stock	3,455.76	2,113.27
Investments (cost)	122,703.38	123,015.88
Interest accrued on investments	408.39	456.58
Cash in Northern Trust Company Bank	3,658.31	2,804.81
Petty cash	25.00	25.00
Total	$139,283.14	$137,396.89
Liabilities		
Member dues paid in advance	282.30	316.80
Surplus	139,000.84	137,080.09
Total	$139,283.14	$137,396.89

American Railway Engineering Association

CONSTITUTION

Revised to October 30, 1950

Article I

NAME, OBJECT AND LOCATION

1. Name

The name of this Association shall be the AMERICAN RAILWAY ENGINEERING ASSOCIATION.

2. Object

The object of the Association shall be the advancement of knowledge pertaining to the scientific and economic location, construction, operation and maintenance of railways.

3. Means to be Used

The means to be used for this purpose shall be:

(a) The investigation of matters pertaining to the object of the Association through Standing and Special Committees.

(b) Meeting for the presentation and discussion of papers, and for action on the recommendations of committees.

(c) The publication of papers, reports and discussions.

4. Conclusions

The conclusions adopted by the Association shall be recommendatory.

5. Location

The office of the Association shall be located in Chicago, Ill.

Article II

MEMBERSHIP

1. Classes

The membership of this Association shall be divided into five classes: Members, Life Members, Honorary Members, Associates and Junior Members.

2. Qualifications

A. GENERAL

(a) An applicant to be eligible for membership in any class other than that of Junior Member shall be not less than 25 years of age.

(b) To be eligible for membership in any class, or for retention of membership as a Member, an Associate or a Junior Member, a person shall not be engaged directly or primarily in the sale to the railways of appliances, supplies, patents or patented services

(c) The right to membership shall not be terminated by retirement from active service.

(d) In determining the eligibility for membership in any class, graduation in engineering from a school of recognized standing shall be considered as equivalent to three years of active practice, and satisfactory completion of each year of work in such school, without graduation, shall be considered as equivalent to one-half year of active practice.

(e) In determining the eligibility for Member under Section B (a) of this Article, each year of practical experience in engineering, or in science related thereto, prior to employment on a railway, if such experience were of the same specialized character as the current work of the applicant, shall be considered as equivalent to one year of railway service.

B. Member

A Member shall be:

(a) An engineer or officer in the service of a railway corporation that is a common carrier, who has had not less than five years' experience in the location, construction, operation or maintenance of railways.

(b) A dean, professor, assistant professor, or equivalent in engineering in a university or college of recognized standing, or an instructor or equivalent in such university or college, who, with an engineering degree, has had at least two years' experience in teaching engineering.

(c) An engineer or member of a public board, commission or other official agency who, in the discharge of his regular duties, deals with railway problems.

(d) An editor of a trade or technical magazine who, in the discharge of his regular duties, deals with railway problems, and who has had the equivalent of five years' engineering or railway experience.

(e) A consulting engineer, engaged in private practice, or an engineer in his employ or in the employ of a consulting engineering organization, who has had the equivalent of five years' engineering experience.

C. Life Member

A Life Member shall be a Member or an Associate who has paid dues for 35 years, or who has been retired under a recognized retirement plan and has paid dues for not less than 25 years.

D. Honorary Member

(a) An Honorary Member shall be a person of acknowledged eminence in railway engineering or management.

(b) The number of Honorary Members shall be limited to ten.

E. Associate

An Associate shall be:

(a) An engineer of a railway which is essentially an adjunct of an industry, or which is used primarily to transport the products and materials of an industry to and from a railway which is a common carrier.

(b) A person qualified by training and experience to cooperate with Members in the object of this Association, but who is not qualified to become a Member.

F. Junior Member

(a) A Junior Member shall be not less than 21 years of age and shall be an engineering employee of a railway corporation who has had not less than three years of experience in the location, construction, operation or maintenance of railways.

(b) His membership in this classification in the Association shall terminate at the end of the calendar year in which he becomes 30 years of age.

(c) He may make application for membership other than as a Junior Member at any time when he becomes eligible to do so.

3. Transfers

The Board of Direction shall transfer from one class of membership to another, or may remove from membership, any person whose qualifications so change as to warrant such action.

4. Rights

(a) Members, and Life Members who were formerly Members, shall have all the rights and privileges of the Association. Life Members who were formerly Associates shall continue to have all the rights and privileges of Associates.

(b) Honorary Members shall have all the rights and privileges of the Association except those of holding elective office, provided, however, that Members or Life Members who are elected Honorary Members shall retain all the rights and privileges of the Association.

(c) Associates and Junior Members shall have all the rights and privileges of the Association except those of voting and holding elective office.

Article III

ADMISSION, RESIGNATION, EXPULSION AND REINSTATEMENT

1. Charter Membership

The Charter Membership of this Association consists of all persons elected to membership before March 15, 1900.

2. Application for Membership

(a) A person desirous of membership in this Association shall make application upon the form provided by the Board of Direction. In the event that Junior Membership is desired, the applicant shall so state.

(b) The applicant shall give the names of at least three Members of this Association to whom personally known. Each of these Members shall be requested by the Secretary of the Association to certify to a personal knowledge of the applicant with an opinion of the applicant's qualifications for membership.

(c) If an applicant is not personally known to as many as three Members of this Association, the names of well-known persons engaged in railway or allied professional work to whom he is personally known shall be substituted, as necessary, to provide a total of at least three references. Each of these persons shall be requested by the Secretary of the Association to certify to a personal knowledge of the applicant, with an opinion of the applicant's qualifications for membership.

(d) No further action shall be taken upon the application until replies have been received from at least three of the persons named by the applicant as references.

3. Election to Membership

(a) Upon completion of the application in accordance with Section 2 of this Article the Board of Direction through its Membership Committee shall consider the application and make such investigation as it may consider desirable or necessary.

(b) Upon completion of such consideration and investigation, each member of the Board of Direction shall be supplied with the required information, together with the recommendation of the Membership Committee as to the class of membership, if any, to which the applicant is eligible, and the admission of the applicant shall be canvassed by ballot among the members of the Board of Direction.

(c) In the event that an application has been made under the provisions of Section 2, Paragraphs (a) and (b) of this Article, a two-thirds affirmative vote of the entire Board of Direction shall be required for election.

(d) In the event that an application has been made under the provisions of Section 2, Paragraphs (a) and (c) of this Article, a unanimous affirmative vote of the entire Board of Direction shall be required for election.

4. Subscription to the Constitution

An applicant for any class of membership in this Association shall declare his willingness to abide by the Constitution of the Association in his application for membership.

5. Honorary Member

A proposal for Honorary Membership shall be endorsed by ten or more Members of the Association and a copy furnished each member of the Board of Direction. The nominee shall be declared an Honorary Member upon receiving a unanimous vote of the entire Board of Direction.

6. Resignation

The Board of Direction shall accept the resignation, tendered in writing, of any person holding membership in the Association whose obligations to the Association have been fulfilled.

7. Expulsion

Charges of misconduct on the part of anyone holding membership in this Association, if in writing and signed by ten or more Members, may be submitted to the Board of Direction for examination and action. If, in the opinion of the Board action is warranted, the person complained of shall be served with a copy of such charges and shall be given an opportunity to answer them to the Board of Direction. After such opportunity has been given, the Board of Direction shall take final action. A two-thirds affirmative vote of the entire Board of Direction shall be required for expulsion.

8. Reinstatement

(a) A person having been a Member, an Associate or a Junior Member of this Association and having resigned such membership while in good standing may be reinstated by a two-thirds affirmative vote of the entire Board of Direction.

(b) A person having been a Member, an Associate or a Junior Member of this Association and having forfeited membership under the provisions of Article IV, Section 3, may, upon such conditions as may be fixed by the Board, be reinstated by a two-thirds affirmative vote of the entire Board of Direction.

Article IV

Dues

1. Entrance Fee

(a) An entrance fee of $10 shall be payable to the Association with each application for membership other than Junior Membership. This sum shall be returned to an applicant not elected.

(b) No entrance fee shall be required for Junior Membership, except that a Junior Member, in transferring to another class of membership, shall pay the entrance fee prescribed for other classes of Membership.

2. Annual Dues

(a) The annual dues for each Member and each Associate shall be $15.

(b) The annual dues for each Junior Member shall be $7.50.

(c) Life Members and Honorary Members shall be exempt from the payment of dues. Life Members desiring to continue to receive the Bulletins and Proceedings of the Association may do so by paying a subscription fee prescribed by the Board of Direction.

3. Arrears

A person whose dues are not paid before April 1 of the current year shall be notified by the Secretary. If the dues are still unpaid on July 1, further notice shall be given, informing the person that he is not in good standing in the Association. If the dues remain unpaid by October 1, the person shall be notified that he will no longer receive the publications of the Association. If the dues are not paid by December 31, the person shall forfeit membership without further action or notice, except as provided for in Section 4 of this Article.

4. Remission of Dues

The Board of Direction may extend the time of payment of dues, and may remit the dues of any Member, Associate or Junior Member who, for good reason, is unable to pay them.

Article V

Officers

1. Officers

(a) The officers of the Association shall be a President, two Vice Presidents, twelve Directors, a Secretary and a Treasurer.

(b) The President, the Vice Presidents and the Directors, together with the two latest living Past Presidents continuing to be Members, shall constitute the Board of Direction, in which the government of the Association shall be vested; they shall act as the trustees and have the custody of all property belonging to the Association. The President, the Vice Presidents and the Directors shall be Members.

(c) The Secretary and the Treasurer shall be appointed by the Board of Direction.

2. Term of Office

The term of office of the President shall be one year, of the Vice Presidents two years and of the Directors three years. The term of each shall begin at the close of the annual convention at which elected and continue until a successor is qualified. All other officers and employees shall hold office or position at the pleasure of the Board of Direction.

3. Officers Elected Annully

(a) There shall be elected at each annual convention a President, one Vice President and four Directors.

(b) The candidates for President and for Vice President shall be selected from the members or past members of the Board of Direction.

4. Conditions of Re-election of Officers

A President shall be ineligible for re-election, except as provided for in Section 5 (e) of this Article. Vice Presidents and Directors shall be ineligible for re-election to the same office, except as provided for in Section 5 (e) of this Article, until, at least one full term has elapsed after the end of their respective terms.

5. Vacancies in Offices

(a) If a vacancy should occur in the office of President, as set forth in Section 6 of this Article, the senior Vice President shall immediately and automatically become President for the unexpired term.

(b) If a vacancy should occur in the office of the senior Vice President, due to advancement under Section 5 (a) of this Article, or for reasons set forth in Section 6 of this Article, the junior Vice President shall automatically become senior Vice President for the unexpired term.

(c) If a vacancy should occur in the office of the junior Vice President, due to advancement under Section 5 (b) of this Article, or for reasons set forth in Section 6 of this Article, the Board of Direction shall by the affirmative vote of two-thirds of its entire membership, select a junior Vice President from the members or past members of the Board of Direction.

(d) A vacancy in the office of Director, due to advancement of a Director to junior Vice President under Section 5 (c) of this Article, or for reasons set forth in Section 6 of this Article, shall be filled by the Board of Direction by the affirmative vote of two-thirds of its entire membership.

(e) An incumbent in any office for an unexpired term shall be eligible for re-election to the office held; provided, however, that anyone selected to fill a vacancy as Director shall be eligible for election to that office, excepting that such appointee filling out an unexpired term of two years or more shall be considered as coming within the provisions of Section 4 of this Article.

6. Vacation of Office

(a) In the event of the death of an elected officer, or his resignation from office, or if he should cease to be a Member of the Association as provided in Section 2 (B), Article II; Section 6 or 7, Article III; or Section 3, Article IV, the office shall be considered as vacated.

(b) In the event of the disability of an officer or neglect in the performance of duty by an officer, the Board of Direction, by the affirmative vote of two-thirds of its entire membership shall have the power to declare the office vacant.

Article VI

Nomination and Election of Officers

1. Nominating Committee

(a) There shall be a Nominating Committee composed of the five latest living Past Presidents of the Association, who are Members, and five Members who are not officers.

(b) The five Members who are not Past Presidents shall be elected annually for a term of one year, when the officers of the Association are elected.

(c) The senior Past President who is a member of the committee shall be the chairman of the committee. In the absence of the senior Past President from a meeting of the committee the Past President next in seniority present shall act as chairman.

2. Method of Nominating

(a) Prior to December 1 of each year the chairman shall call a meeting of the committee at a convenient place, at which nominees for the several elective offices shall be selected as follows:

Office to be Filled	Number of Candidates to be named by the Nominating Committee	Number of Candidates to be elected at the Annual Election of Officers
President	1	1
Vice President	1	1
Directors	8	4
Nominating Committee	10	5

(b) The chairman of the Nominating Committee shall send the names of the nominees to the President and Secretary not later than December 15 of the same year, and the Secretary shall report the names of these nominees to the members of the Association not later than January 1 following.

(c) At any time between January 1 and February 1 any ten or more Members may send to the Secretary additional nominations for any elective office for the ensuing year signed by such Members.

(d) If any person nominated shall be found by the Board of Direction to be ineligible for the office for which nominated, or should a nominee decline such nomination, his name shall be withdrawn. The Board of Direction may fill any vacancies that may occur in the list of nominees up to the time the ballots are sent out.

3. Ballots Issued

Not less than thirty days prior to each annual convention, the Secretary shall issue a ballot to each voting Member of record who has paid his dues to or beyond December 31 of the previous year, listing the several candidates to be voted upon. When there is more than one candidate for any office, the names shall be arranged on the ballot in the order that shall be determined by lot by the Nominating Committee. The ballot shall be accompanied by a statement giving for each candidate his record of membership and activities in this Association.

4. Substitution of Names

Members may remove names from the printed ballot list and may substitute the name or names of any other person or persons eligible for any office, but the number of names voted for each office on the ballot must not exceed the number to be elected at that time to such office.

5. Ballots

(a) Ballots shall be placed in an envelope, sealed and endorsed with the name of the voter, and mailed to or deposited with the Secretary at any time previous to the closure of the polls.

(b) A voter may withdraw his ballot, and cast another, at any time before the polls close.

(c) Ballots received in unendorsed envelopes, or from persons not qualified to vote, shall not be counted.

(d) The ballots and envelopes shall be preserved for not less than ten days after the vote is canvassed.

6. Closure of Polls

The polls shall be closed at 12 o'clock noon on the second day of the annual convention, and the ballots shall be counted by tellers appointed by the presiding officer.

7. Election

(a) The persons who shall receive the highest number of votes for the offices for which they are candidates shall be declared elected.

(b) In case of a tie between two or more candidates for the same office, the Members present at the annual convention shall elect the officer by ballot from the candidates so tied.

(c) The presiding officer shall announce at the convention the names of the officers elected in accordance with this Article.

Article VII

Management

1. President

The President shall have general supervision of the affairs of the Association, shall preside at meetings of the Association and of the Board of Direction, and, by virtue of his office, shall be a member of all committees, except the Nominating Committee.

2. Vice Presidents

The Vice Presidents, in order of seniority, shall preside at meetings in the absence of the President.

3. Treasurer

The Treasurer shall pay all bills of the Association when properly certified by the Secretary and approved by the Finance Committee. He shall make an annual report as to the financial condition of the Association and such other reports as may be called for by the Board of Direction.

4. Secretary

The Secretary, under the direction of the President and Board of Direction, shall be the Executive Officer of the Association and shall attend the meetings of the Association and of the Board of Direction, prepare the business therefor, and record the proceedings thereof. The Secretary shall see that all money due the Association is collected, is credited to the proper accounts, and is deposited in the designated depository of the Association, with receipt to the Treasurer therefor. He shall personally certify to the accuracy of all bills and vouchers on which money is to be paid. He shall invest all funds of the Association not needed for current disbursements, as shall be recommended by the Finance Committee and approved by the Board of Direction, with notification to the Treasurer of such investments. The Secretary shall conduct the correspondence of the Association, make an annual report to the Association, and perform such other duties as the Board of Direction may prescribe.

5. Auditing of Accounts

The financial accounts of the Association shall be audited annually by an accountant or accountants approved by and under the direction of the Finance Committee.

6. Board of Direction

(a) The Board of Direction shall manage the affairs of the Association, and shall have full power to control and regulate all matters not otherwise provided for in the Constitution.

(b) The Board of Direction shall meet within thirty days after each annual convention, and at such other times as the President may direct. Special meetings shall be called on request, in writing, of five members of the Board of Direction.

(c) Seven members of the Board of Direction shall constitute a quorum.

(d) At the first meeting of the Board of Direction after the annual convention, the following committees, each consisting of not less than three members, shall be appointed by the President from the Board of Direction, and they shall report to and perform their duties under the supervision of the Board of Direction.

Finance
Publications
Outline of Work of Committees
Personnel of Committees
Membership
Manual

Other special committees may be appointed by the President at his discretion.

7. Duties of the Committees of the Board of Direction

(a) Finance Committee

The Finance Committee shall have immediate supervision of the accounts and financial affairs of the Association; shall approve all bills before payment, and shall make recommendations to the Board of Direction as to the investment of funds and other financial matters. The Finance Committee shall not have the power to incur debts or other obligations binding the Association, nor authorize the payment of money other than the amounts necessary to meet ordinary current expenses of the Association, except by authority of the Board of Direction.

(b) Publication Committee

The Publication Committee shall have general supervision over the publications of the Association. The Publication Committee shall not have the power to incur debts or other obligations binding the Association, nor authorize the payment of money except by authority of the Board of Direction.

(c) Committee on Outline of Work of Committees

The Committee on Outline of Work of Committees shall review and pass upon the recommendations of standing and special committees for subjects to be investigated, considered and reported on by these committees during the ensuing year, and shall report thereon to the Board of Direction for its approval.

(d) Committee on Personnel of Committees

The Committee on Personnel of Committees shall review and pass upon applications of members for appointment to standing and special committees. It also shall appoint the chairman and vice chairman of such committees and make a report thereon to the Board of Direction for its approval.

(e) Membership Committee

The Membership Committee shall make investigation of applicants for membership and shall make recommendations to the Board of Direction with reference thereto.

(f) Manual Committee

The Manual Committee, with the assistance of the Publications Committee, shall have general supervision over the Manual.

8. Standing Committees

The Board of Direction may appoint standing committees to investigate, consider and report upon questions pertaining to railway location, construction, operation and maintenance.

9. Special Committees

The Board of Direction may appoint special committees to examine into and report upon any subject connected with the objects of this Association.

10. Discussion by Non-Members

The Board of Direction may invite discussions of reports from persons not members of the Association.

11. Sanction of Act of Board of Direction

An act of the Board of Direction which shall have received the expressed or implied sanction of the membership at the next annual convention of the Association shall be deemed to be the act of the Association.

Article VIII

Meetings

1. Annual Convention

(a) The Annual Convention of the Association shall be held in the City of Chicago, Ill., or in such other city as may be determined by the affirmative vote of two-thirds of the entire membership of the Board of Direction. The convention shall open on the second Tuesday in the month of March, or on the third Tuesday if the month of March has five Tuesdays, excepting that some other opening day in March may be designated by the affirmative vote of two-thirds of the entire membership of the Board of Direction.

(b) The Secretary shall notify all members of the Association of the time and place of the annual convention at least 30 days in advance thereof.

(c) The order of business at the annual convention of the Association shall be:

Reading of the minutes of the last meeting
Address of the President
Reports of the Secretary and the Treasurer
Reports of committees
Unfinished business
New business
Installation of officers
Adjournment

(d) This order of business may be changed by a majority vote of Members present.

(e) The proceedings shall be governed by "Robert's Rules of Order" except as otherwise herein provided.

(f) Discussions shall be limited to Members and to those others invited by the presiding officer to speak.

2. Special Meetings

Special meetings of the Associations may be called by the Board of Directions on its own initiative, and may be so called by the Board of Direction upon written request of 100 Members. The request shall state the purpose of such meeting.

The call for such special meeting shall be issued not less than ten days in advance of the proposed date of such meeting and shall state the purpose and place of the meeting. No other business shall be taken up at such meeting.

3. Quorum

Twenty-five Members shall constitute a quorum at all meetings of the Association.

Article IX

Amendment

1. Amendment

Proposed amendment of this Constitution shall be made in writing, shall be signed by not less than ten Members, and shall be acted upon in the following manner:

The amendment shall be presented to the Secretary, who shall send a copy to each member of the Board of Direction as soon as received. If a majority of the entire Board of Direction so votes, the matter shall be submitted to the Association by letter ballot.

Sixty days after the date of issue of the letter ballot, the Board of Direction shall canvass the ballots which have been received, and if two-thirds of such ballots are in the affirmative the amendment shall be declared adopted and shall become effective immediately. The result of the letter ballot shall be announced to members of the Association.

Information and Rules for the Guidance of Committees

The following information and rules for the guidance of committees are designed to obtain the maximum benefits from the efforts of the members who make up the personnel of such committees. They are designed to effect a continuity of effort in committee work throughout the entire year, under a plan whereby the personnel of the committees and their respective outlines of work are set up and made public on or before the beginning of the calendar year, thus enabling the work to be continued without interruption, although the new personnel and subject assignments do not become officially effective until the beginning of the "Association Year," which starts with the close of the annual meeting.

The rules also take into account the fact that the publication of the committee reports must be spread out over a period of four months (November through February), to facilitate printing and to give members of the Association a reasonable length of time in which to study such reports in advance of the annual meeting.

Subjects Re-assigned Annually

The outline of work of each committee shall be reviewed annually. To this end, each committee shall review suggestions for new subjects submitted by the members thereof, or by others, and such suggestions as receive the approval of the committee shall be submitted by the committee chairman to the secretary of the Association not later than October 1, together with the committee's recommendations covering the withdrawal or continuation of current assignments.

The recommendations received from the various committees shall be assembled and forwarded to the Board Committee on Outline of Work, which shall have the responsibility of authorizing the subject assignments to the various committees. Deviation from assignments thus authorized may be made during the course of the year only upon the authority of the Board Committee on Outline of Work.

Committee Personnel Reorganized Annually

The personnel of each committee shall be reorganized annually. It is desirable that 10 percent of the membership be changed each year. Members who do not attend meetings of the committee, who do not render service by correspondence, or who do not return letter ballots will be dropped. To this end the chairman of the committee shall submit to the secretary of the Association not later than October 1 the names of members whom he recommends be dropped because of delinquence in service to the committee, as well as a list of the names of members of the Association who have been recommended for appointment to the committee.

The recommendations received from the various committees shall be assembled and forwarded to the Board Committee on Personnel, which has the duty of appointing the committee personnel.

No additions to the personnel of committees will be made during the year following the publication of the roster, except as provided for in the rules applying to "Guests."

Members who desire appointment to a committee should make application through the chairman or the secretary on the prescribed form.

Chairmen, Vice Chairmen and Subcommittee Chairmen

Chairmen, vice chairmen and subcommittee chairmen must hold the grade of Member in the Association, except that any Associates currently acting as subcommittee chairmen may continue to hold such office until succeeded by a Member.

(Revised November 7, 1952)

The terms of chairmen and vice chairmen shall be three years in each position. Chairmen completing their three-year term shall recommend to the Board Committee on Personnel nominees for the chairmanship and vice chairmanship, with assurance of acceptance from such nominees if appointed by the Board Committee. The term of office of subcommittee chairmen may be more than three years.

Committee Secretary

Any chairman may appoint a secretary with duties usually encompassed by such office.

Size of Committees

The total membership of any committee shall be limited to 60. In determining the membership of a committee, railroads having no more than 50 Association members may have not more than 2 members on any committee; railroads having 51 to 100 members may have not more than 3 members on any committee; railroads having more than 100 members may have not more than 4 members on any committee.

No college, university or other institution of learning shall have more than 2 members on any committee, and no company or other organization shall have more than one Associate member on any committee.

Retired Members

No member who has retired from active service, regardless of whether he undertakes other employment, shall serve on a committee more than 3 years following retirement. However, such member may continue to attend meetings as a "visitor," subject to the approval of the committee chairman.

Associate Members

No company will be permitted to have more than one Associate member of any committee, and company representation shall not necessarily be continuing. However, in the event that a railroad member on a committee becomes associated with a manufacturer or supply company after retirement from railroad service on pension, and thus automatically becomes an Associate member, he shall not be deprived of membership on the committee during the period of three years following his retirement from railroad service.

The membership of Associates on a committee shall be limited to 10 percent of the total membership of the committee. Committees with Associates in excess of 10 percent of their total membership are not required to reduce the number of Associates immediately for the purpose of complying with this rule, but no Associates may be added as long as the proportion of Associates exceeds 10 percent, except as may be occasioned by the exception provided in the preceding paragraph.

"Guests" and "Visitors"

The previously stated rule under Committee Personnel Reorganized Annually, that "no additions to the personnel of committees will be made during the year following the publication of the roster, except as provided for under the rules applying to "Guests," does not preclude the attendance at committee meetings of other members of the Association, as "visitors," with the approval of committee chairmen.

If there are vacancies on a committee roster (i.e., less than 60), or if vacancies occur during the year, or are definitely in prospect at the end of the year, Association members (including Junior members), with the approval of committee chairmen and the

Board Committee on Personnel, can be appointed as "guests" of that committee. As such, they may attend committee meetings and participate in the committee's activities, unofficially, looking to becoming regularly assigned members at the beginning of the next Association year.

"Guests" must always be designated as such on the rosters maintained by the committees and the secretary's office, but their names will not appear in published committee or subcommittee reports. Creation of this class of committee affiliation is not intended to increase the size of any committee beyond the 60 maximum set by the Board, but rather to make it possible to add to "short" rosters between official roster changes.

Furthermore, one need not be either a "regular member" or a "guest" of a committee to attend its meetings from time to time. With the approval of the committee chairman, who must be consulted as regards any specific meeting, any AREA member (including Junior members) may sit in on the meeting as a "visitor," listen to all deliberations and participate in discussions.

Service on More Than One Committee

No member of the Association shall serve on more than one committee, except that a member may serve on two committees if one or both of the committees are among the following: Committee 3—Ties; Committee 7—Wood Bridges and Trestles; Committee 17—Wood Preservation; Committee 20—Contract Forms; Committee 24—Cooperative Relations with Universities; Committee 25—Waterways and Harbors; Committee 28—Clearances; Committee 29—Waterproofing; Committee 30—Impact and Bridge Stresses; and the Special Committee on Continuous Welded Rail.

Organizing the Committees

The new outline of work and personnel of committees shall become effective with the close of the annual meeting in March. However, the pamphlet containing this information is issued not later than January 1 in order that committees may be reorganized immediately after January 1, for the new year's work, if reorganization has not already been effected. Usually this information will be available to the chairmen in tentative form at least 30 days in advance of publication.

It is the duty of the committee chairman to notify new members promptly of their appointment and to notify old members of their reappointment or release. It is also his duty to reorganize the subcommittees without delay. However, in the Association year in which his term as chairman expires, he should call on his successor for advice and assistance in this regard.

Organization Charts

The chairman shall furnish the secretary of the Association two copies of the organization chart (schedule of subcommittee assignments and personnel) of his committee, and shall advise him currently of any subsequent revisions thereof. This chart may be in the form regularly used by committees, but should not be in the form of a blueprint, on which it is difficult to make corrections. White prints are acceptable. These charts should be in the hands of the secretary by February 1, and should be prepared with the greatest care to insure the accuracy of initials and names.

The names of "guest" members on committees, if any, (not "visitors") should appear on the charts, but should be clearly designated as such. These names may be arranged either alphabetically among the members or grouped at the bottom of the chart as desired by the various committees. Names of "visitors" should not appear on or be subsequently added to these charts.

Notices and Minutes of Meetings

The committee chairman shall send copies of all notices of committee meetings to the secretary of the Association as early as possible for publication in the AREA News. Copies of all minutes of meetings must also be filed with the secretary.

Subcommittees

In general, the committees are organized to conduct their work by the appointment of one subcommittee for each subject assignment. If deemed advisable, any subject may be subdivided into several parts and a separate subcommittee assigned to each part. Committees may find it of advantage to create a subcommittee on personnel as well as a subcommittee on new subjects.

Collaboration

Subjects, the nature of which clearly indicates the possibility of overlapping interest of two or more committees, carry an appended clause reading: "collaborating with Committee ...." It is the duty of the chairmen of the committees having an assignment carrying this instruction to take the initiative in effecting such collaboration;—first, by requesting the appointment of representatives of the other interested committee or committees, and second, by submitting copies of the report to them for comment. Regardless of whether the assignment specifically mentions collaboration, committees shall be on the alert to obtain the advice and assistance of other committees in dealing with any subject that imposes any questions of possible overlapping interest or responsibility.

A committee undertaking revision of its Manual chapter should request collaboration of any committee that participated in the original development and adoption of the material under revision. The secretary of the Association will provide information concerning such previous collaboration.

Voting in Committees

Voting in committees and subcommittees on all Association matters, except as may be of a social nature, shall be the prerogative of Members only.

Work of the Committees

Objectives

The objectives of the Association are advanced through the work of the committees in two ways—(1) the development of useful information pertinent to their assignments to be presented to the Association "as information," and (2) the formulation of recommended practices to be submitted for adoption and publication in the Manual.

Planning the Work

In pursuing the work on any assignment, the first step is necessarily one of fact finding, including (a) a study of available literature on the subject, particularly reports of previous investigations, (b) a compilation of current practice, especially recent changes in practice, and (c) resort to original tests or experimentation, after a canvass of all other sources of information indicates that research work is necessary.

Collection of Data

Committees are privileged to obtain data or information in any proper way. If desired, the secretary will issue circulars of inquiry, or questionnaires, prepared by committees, which should be brief and concise. The questions contained in such circulars should be specific and pertinent, and not of such general or involved character as to preclude the possibility of obtaining satisfactory and prompt responses. The circulars should specify to whom answers are to be sent, and should be furnished in duplicate so that a copy can be retained by persons replying.

Research

Requests for appropriations for the conduct of research work should be sent to the secretary of the Association with a supporting statement setting forth: (a) the nature of the information sought; (b) how the railroads are adversely affected by the lack of this information; (c) the estimated cost of the investigation; (d) the estimated time to complete the work; (e) the basis for assuming that the investigation will produce the data desired; and, (f) an estimate of the savings to be realized or other advantages to accrue from the successful completion of the investigation. A request for funds to continue or complete an investigation shall include also a statement of the results obtained to date. All requests for research appropriations, with supporting data, must be in the secretary's office by July 1.

Maintaining Manual Up to Date

Each committee shall critically review the material in its chapter of the Manual at such intervals as to insure that it is kept up to date. It shall resubmit all Manual material for revision or reapproval at intervals of not more than 10 years. This rule, however, is not intended to encourage the reapproval of documents only at 10-year intervals. On the contrary, and especially since each document in the newly reprinted Manual will carry a reapproval line under its heading, committees are urged to recommend the reapproval of documents each time that revisions (major or minor) are proposed, using some such wording as "Reapproved with the following revisions". If such reapproval is not requested specifically when revisions are recommended, the document will continue to carry its previous adoption or reapproval line.

Group Revisions in Specific Years

While it is a healthy situation for committees to be constantly on the alert to improve their respective documents in the Manual, and while some revisions in Manual material will be of a character that will require that they be made at the earliest possible date, many changes will be of an editorial or less-important character and will not demand that they be made immediately.

Accordingly, in the interest of economy, committees should, insofar as possible, group their revisions in any specific document, looking to submitting them as a whole at intervals of two or three years or more, rather than separately year after year—thus avoiding the necessity for reissuing the same Manual pages in successive years, to the greatest extent possible.

Nature and Preparation of Reports

Form of Report

It is important that committee reports be prepared in accordance with the Style Standards for committee reports, as detailed on following pages in this pamphlet.

Nature of Report

Whether the report on any particular assignment should take the form of "information" or a "recommended practice," depends largely on the nature of the assignment.

Some assignments will be fulfilled completely by the presentation of information; others call for information in support of appended recommendations that are submitted for adoption. In still other cases, the primary objective is a comprehensive statement of recommended practices, but the development of these recommended practices may entail investigation or research work, the results of which are of such importance as to warrant their presentation as information prior to the submission of the recommendations. In some cases, it may be advisable to submit as information material in the form of recommended practice with a view to inviting suggestions and criticisms that may serve as the basis for revisions prior to the resubmission of the material for adoption at a later date.

Reports on All Assignments Not Necessary

Committees should pursue their investigations on all assignments but are expected to present progress or final reports for publication only on assignments with respect to which pertinent information has been developed.

Presentation of Material in Reports

Many progress or final reports, whether based on research or other investigation, best lend themselves to written presentation in orderly sequence or chronological arrangement, ending with any conclusions or recommendations which may have been arrived at. However, in most cases, and especially in the case of long reports, to conserve the time of members who may or may not be interested in the details of the study involved, it is recommended that reports be introduced with a brief highlight summary statement of the background, purpose and extent of the study, as may be desirable, and including a synopsis of any conclusions, recommendations or other results—this latter material to supplement a more detailed presentation elsewhere in the reports.

Reports of information, supplementing previous reports of progress, may include a brief review of material previously presented, but should avoid extended repetition of such material.

Use of Trade Names

Committee reports which are based upon physical research or field tests carried out by or through the research staff of the Engineering Division, AAR, may use trade names or manufacturers' names in referring to products, machines, devices or processes under test. No other committee reports, however, shall contain the trade names of products, machines, devices or processes, nor the names of manufacturers, unless in each instance approval is secured from the Board Committee on Outline of Work prior to the publication of the reports. To seek such approval, a committee must submit five copies of the report in question to the secretary's office, for transmission to the members of the Board Committee, six weeks prior to the scheduled filing date of the report. If time does not permit a ruling upon the request of the committee prior to the publication date of the report in question, the report of the committee must either be altered to eliminate the trade names or terms involved, or be withdrawn, at the discretion of the committee which prepared it.

Nature of Manual Material

The material adopted by the Association for publication in the Manual shall be considered Recommended Practice, but shall not be binding on the members. Recommended Practice, as defined by the Board of Direction (May 20, 1936) is a material, device, plan, specification or practice recommended to the railways for use as required, either exactly as presented or with such modifications as may be necessary or desirable to meet the needs of individual railways, but in either event, with a view to promoting efficiency or economy, or both, in the location, construction, operation or maintenance of railways.

For reasons of economy and practicability, Manual material should not repeat in full plans, specifications or other documents of other organizations accepted as AREA recommended practice; reference thereto should be by title, and serial designation, if any, e.g., current ASTM Specifications, designation D 17.

Printing of Manual Material

Material offered for adoption and publication in the Manual, except as noted herein, should be submitted in full, regardless of its publication in previous years, unless the material in question appeared in substantially identical form not more than one year before being submitted for adoption. Such material shall appear in the report of the committee that is published not less than 30 days before the annual meeting at which it is to be presented. Recommended revisions of Manual material, if extensive, shall include only the proposed material, which shall be printed in full in the report of the committee. Manual material recommended for reapproval, or for deletion, shall be presented by title and page reference only. Likewise, plans, specifications or other documents of other organizations recommended for adoption by the AREA shall be presented by title and serial designation only.

Letter Ballot Required of Committee

Any action recommended by a committee with respect to the adoption, revision, reaffirmation or withdrawal of Manual material must have received prior endorsement by the committee in the form of an affirmative vote of two-thirds of the entire Member membership of the committee, such vote to be taken by letter ballot. Associate and Junior members on a committee are not entitled to vote. Thus, it is imperative that committee members promptly consider and vote on all letter ballots, seeking the advice of other committee members or specially qualified officers on their own roads if in doubt as to whether to vote for or against a proposal.

Publication of Reports

Dates for Filing Reports

To insure the orderly publication of the reports in accordance with a predetermined schedule, it is necessary that chairmen file complete reports with the secretary of the Association on or before the dates specified in the Outline of Work pamphlet. The manuscript of the report must be furnished in duplicate, preferably double spaced. Piecemeal filing of reports by subcommittee chairmen is permissible only under special arrangement (in writing) with the secretary of the Association.

Presentation of Reports at Annual Meetings

Presentation of Reports

Since both the degree of effectiveness with which a report is received by those assembled in annual convention, and the accuracy with which it can be reported in the Proceedings, depend upon the clarity with which the oral presentation is made to the meeting, it is desirable that committee members write out and read their presentations, and that they speak directly and distinctly into the microphone at the rostrum, raising or lowering the microphone as may be necessary to that end. In the event that written presentations are read, a copy of such presentations should be given to the secretary or to the convention reporter before the speaker leaves the rostrum.

Reports offered as information should be presented by title or by a brief highlight outline of the contents. Material submitted for adoption and publication in the Manual shall be presented by reading the title and subtitles, but the presiding officer may, upon request, authorize the reading of specific portions of the material being offered.

Oral Discussions

Comments on or criticisms of any report may be offered from the floor. When necessary to insure accuracy, the speaker's remarks will be submitted to him in writing before publication in the Proceedings, for the correction of diction and errors of reporting, but not for the elimination of remarks.

Written Discussions

Written discussions of published reports will be transmitted to the chairman of the interested committee who will read or present them by title or in abstract at the convention. Written discussions will be published in the Proceedings as a part of the discussion of the committee reports.

Action on Reports

No formal action is to be taken by the convention on material submitted as information, whether in the form of a progress or final report.

Action on material submitted for adoption and publication in the Manual will be one of the following:

(a) Adoption as a whole as presented.

(b) Affirmative action on the amendment of a part or parts of the material presented, followed by adoption as a whole as amended.

(c) Adoption of a part, complete in itself, and referring the remainder back to the committee for further consideration.

(d) Recommittal with or without instructions.

Note.—An amendment which affects underlying principles, if adopted, shall of itself constitute a recommittal of such part of the report as the committee considers affected.

The Chair will decline to entertain amendments which in his opinion are primarily a matter of editing.

Letter Ballot of Membership

When and as required between annual meetings, recommendations for the adoption, deletion or revision of Manual material shall be submitted to letter ballot of the Members of the Association under the following limitations:

(a) That the letter ballot shall be taken only after the Board of Direction has recognized the necessity for such emergency action, and

(b) That the propositions submitted by the committee shall have the approval of a special committee of the Board of Direction appointed by the President for that purpose, both as to the substance of the material offered and also as to the circumstances attending the consideration of the material by the committee.

The Board of Direction, acting under the provisions of paragraphs 6 (a) and 11 of Article VII of the AREA constitution, has the authority to amend, delete or revise Manual material at any time, subject to later confirmation or rejection by the membership, submission to the membership to be effected either by means of a letter ballot immediately following such Board action, or by a motion presented at the annual meeting.

Review by Association of American Railroads

All material adopted for publication in the Manual and all recommendations for the revision or withdrawal of Manual material shall be reviewed by the Association of American Railroads before distribution is made thereof to holders or purchasers of the Manual, or parts thereof.

Publication of Annual Supplement

Revisions of or additions to the Manual authorized by action at each convention will be published annually in the form of loose-leaf sheets which will be made available to all holders of the Manual. These supplemental sheets will be accompanied by instructions for insertion of the new sheets and the withdrawal of sheets that have been superseded, as well as those sheets that have been withdrawn by action of the Association.

However, no Supplement will be issued in 1953, since all action at the 1953 annual convention with respect to the Manual will be incorporated directly in the newly reprinted Manual, complete pages of which will be made available to all present member holders of the Manual, without cost.

Publication of Abstracts by Technical Journals

The following rules will govern the releasing of material for publication in technical journals:

Committee reports to be presented at an annual meeting will not be released for publication until after presentation to the annual meeting. Special articles, contributed by members and others, on which no action by the Association is necessary, will be released for publication in technical journals only after issuance in a Bulletin; provided, application therefor is made in writing and proper credit is given the Association, authors or committees presenting such material.

INDEX

C

L

M

N

O

P

V

W

Y

Z