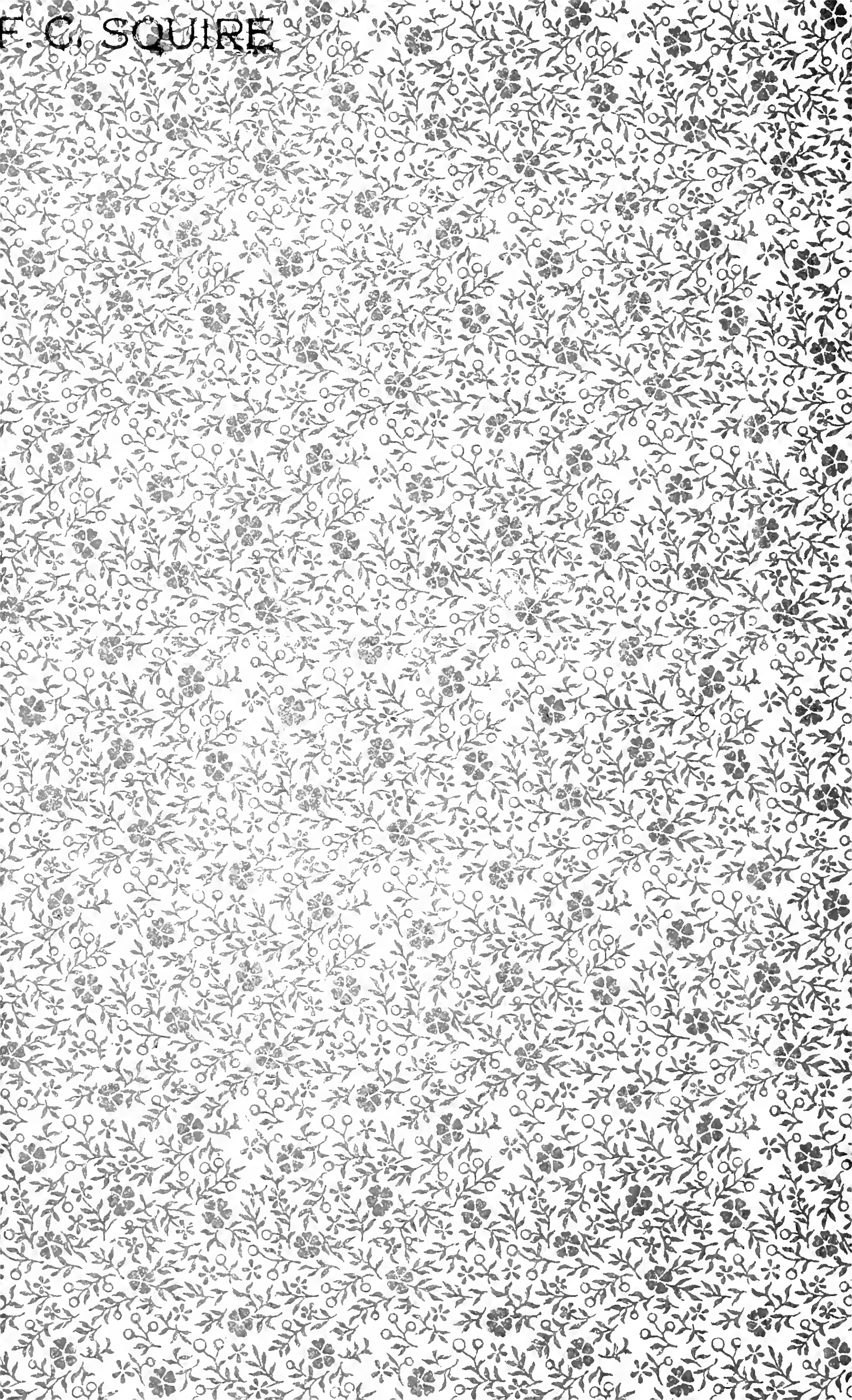
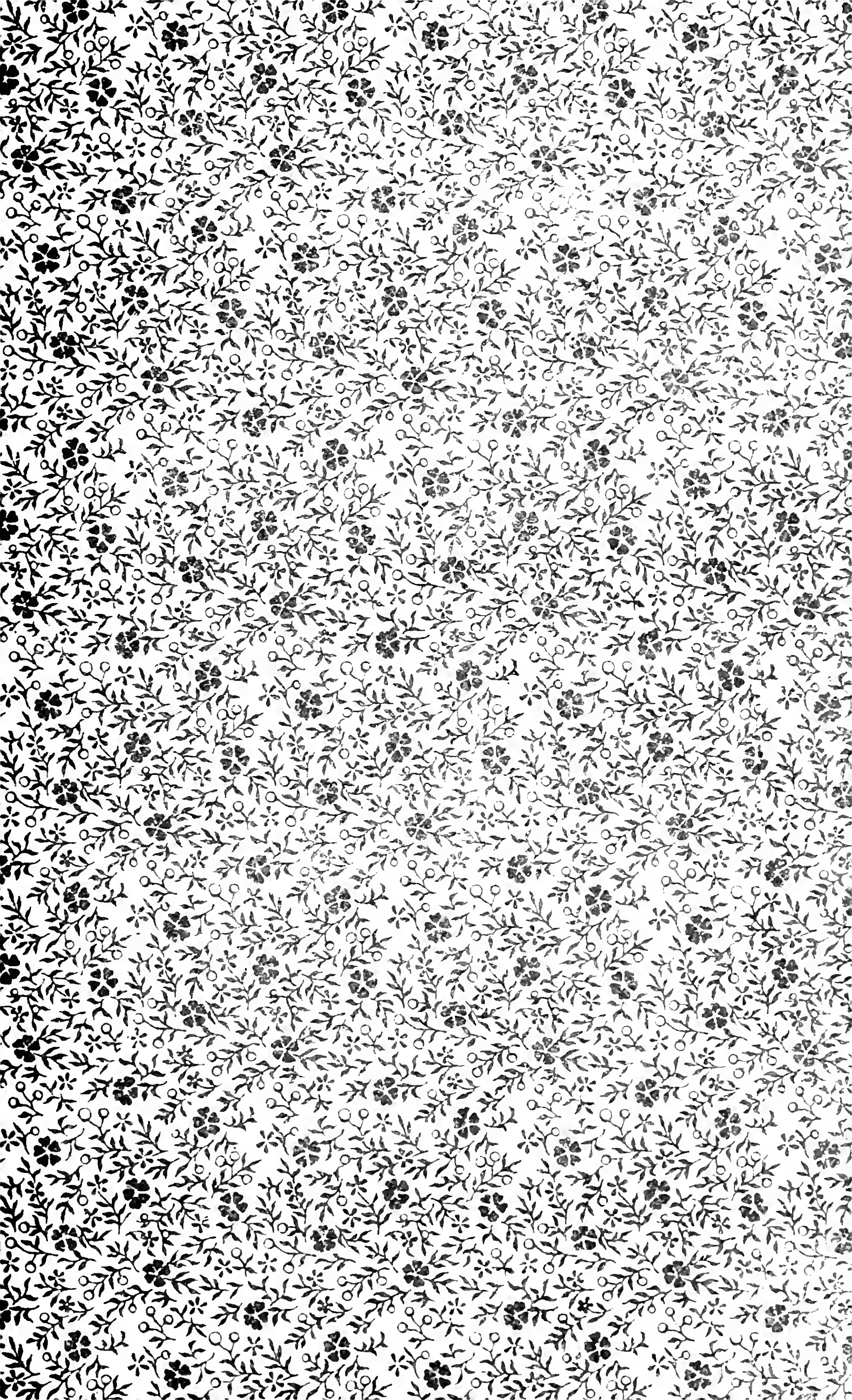
F. C. SQUIRE





PROCEEDINGS

OF THE

TWENTY-SEVENTH ANNUAL CONVENTION

OF THE

American Railway Engineering Association

HELD AT THE

CONGRESS HOTEL, CHICAGO, ILLINOIS

March 9, 10 and 11, 1926

VOLUME 27

PUBLISHED BY
AMERICAN RAILWAY ENGINEERING ASSOCIATION
CHICAGO
1926

TABLE OF CONTENTS

BUSINESS SESSION

COMMITTEE REPORTS

ELECTRICITY—Continued

TIES—Continued

MONOGRAPHS

DISCUSSIONS

CONSTITUTION

CONSTITUTION

REVISED AT THE FIFTH, EIGHTH, TWELFTH, TWENTY-THIRD, TWENTY-FOURTH AND TWENTY-SEVENTH ANNUAL CONVENTIONS

ARTICLE I

NAME, OBJECT AND LOCATION

Name

1. The name of this Association is the AMERICAN RAILWAY ENGINEERING ASSOCIATION.

Object

2. Its object is the advancement of knowledge pertaining to the scientific and economic location, construction, operation and maintenance of railways.

Means to Be Used

3. The means to be used for this purpose shall be as follows:
   - (a) Meetings for the reading and discussion of reports and papers, and for social intercourse.
   - (b) Investigation of matters pertaining to the objects of the Association through Standing and Special Committees.
   - (c) The publication of papers, reports and discussions.
   - (d) The maintenance of a library.

Responsibility

4. Its action shall be recommendatory, and not binding upon its members.

Location of Office

5. Its permanent office shall be located in Chicago, Ill., and the annual convention shall be held in that city.

ARTICLE II

MEMBERSHIP

Membership Classes

1. The membership of this Association shall be divided into three classes, viz.: Members, Honorary Members, and Associates.

Membership Qualifications

(2) A Member shall be:

(a) Either a Civil Engineer, a Mechanical Engineer, an Electrical Engineer, or an official of a railway corporation, who has had not less than five (5) years' experience in the location, construction, maintenance or operation of railways, and who, at the time of application for membership, is engaged in railway service in a responsible position in charge of work connected with the Location, Construction, Operation or Maintenance of a Railway; provided, that all persons who were Active Members prior to March 20, 1907, shall remain Members except as modified by Article II, Clause 9.

(b) A Professor of Engineering in a college of recognized standing.

Honorary Membership Qualifications

3. An Honorary Member shall be a person of acknowledged eminence in railway engineering or management. The number of Honorary Members shall be limited to ten.

Associate Membership Qualifications

4. An Associate shall be a person not eligible as a Member, but whose pursuits, scientific acquirements or practical experience qualify him to co-operate with Members in the advancement of professional knowledge, such as Consulting, Inspecting, Contracting, Government or other Engineers, Instructors of Engineering in Colleges of recognized standing, and Engineers of Industrial Corporations when their duties are purely technical.

Membership Rights

5. (a) Members shall have all the rights and privileges of the Association.

(b) Honorary Members shall have all the rights of Members, except that of holding office, and shall be exempt from the payment of dues.

(c) Associates shall have all the rights of Members, except those of voting and holding office.

Age Requirements

6. An applicant to be eligible for membership in any class shall not be less than twenty-five (25) years of age.

"Railway" Defined

7. The word "railway" in this Constitution means one operated by steam or electricity as a common carrier, dependent upon transportation for its revenue. Engineers of street railway systems and of railways which are used primarily to transport the material or product of an industry or industries to and from a point on a railway which is a common carrier or those which are merely adjuncts to such industries, are eligible only as Associates.

Changes in Classes

8. A Member, elected after March 20, 1907, who shall leave the railway service, shall cease to be a Member, but may retain membership in the Association as an Associate, subject to the provisions of Article II, Clause 9; provided, however, if he re-enters the railway service, he shall be restored to the class of Members.

Supply Men

9. Persons whose principal duties require them to be engaged in the sale or promotion of railway patents, appliances or supplies, shall not be eligible for, nor retain membership in any class in this Association, except that those who were Active Members prior to March 20, 1907, may retain membership as Associates; provided, however, that anyone having held membership in the Association and subsequently having become subject to the operation of this clause, shall, if he again becomes eligible, be permitted to re-enter the Association, without the payment of a second entrance fee.

Transfers

10. The Board of Direction shall transfer members from one class to another, or remove a member from the membership list, under the provisions of this Article.

ARTICLE III

Admissions and Expulsions

Charter Membership

1. The Charter Membership consists of all persons who were elected before March 15, 1900.

Application for Membership

2. The Charter Membership having been completed, any person desirous of becoming a member shall make application upon the form prescribed by the Board of Direction, setting forth in a concise statement his name, age, residence, technical education and practical experience. He shall refer to at least three members to whom he is personally known, each of whom shall be requested by the Secretary to certify to a personal knowledge of the candidate and his fitness for membership.

Election to Membership

3. Upon receipt of an application properly endorsed, the Board of Directors, through its Secretary, or a Membership Committee selected from its own members, shall make such investigation of the candidate's fitness as may be deemed necessary. The Secretary will furnish copies of the information obtained and of the application to each member of the Board of Direction. At any time, not less than thirty days after the filing of the application, the admission of the applicant shall be canvassed by letter-ballot among the members of the Board, and affirmative votes by two-thirds of its members shall elect the candidate; provided, however, that should an applicant for membership be personally unknown to three members of the Association, due to residence in a foreign country, or in such a portion of the United States as precludes him from a sufficient acquaintance with its members, he may refer to well-known men engaged in railway or allied professional work, upon the form above described, and such application shall be considered by the Board of Direction in the manner above set forth, and the applicant may be elected to membership by a unanimous vote of the Board.

Subscription to Constitution

4. All persons, after due notice from the Secretary of their election, shall subscribe to the Constitution on the form prescribed by the Board of Direction. If this provision be not compiled with within six months of said notice, the election shall be considered null and void.

Reinstatement

5. Any person having been a member of this Association, and having, while in good standing, resigned such membership, may be reinstated without the payment of a second entrance fee; provided his application for reinstate-

ment is signed by five members certifying to his fitness for same, and such application is passed by a two-thirds majority of the Board of Direction.

Honorary Membership

6. Proposals for Honorary Membership shall be submitted by ten or more Members. Each member of the Board of Direction shall be furnished with a copy of the proposal, and if, after thirty days, the nominee shall receive the unanimous vote of said Board, he shall be declared an Honorary Member.

Expulsions

7. When charges are preferred against a Member in writing by ten or more Members, the Member complained of shall be served with a copy of such charges, and he shall be called upon to show cause to the Board of Direction why he should not be expelled from the Association. Not less than thirty days thereafter a vote shall be taken on his expulsion, and he shall be expelled upon a two-thirds vote of the Board of Direction.

Resignations

8. The Board of Direction shall accept the resignation, tendered in writing, of any Member whose dues are fully paid up.

ARTICLE IV

Dues

Entrance Fee

1. An entrance fee of $10.00 shall be payable to the Association through its Secretary with each application for membership; and this sum shall be returned to the applicant if not elected.

Annual Dues

2. *The annual dues are $10.00, payable during the first three months of the calendar year.

Arrears

3. Any person whose dues are not paid before April 1st of the current year shall be notified of same by the Secretary. Should the dues not be paid prior to July 1st, the delinquent Member shall lose his right to vote. Should the dues remain unpaid October 1st, he shall be notified on the form prescribed by the Board of Direction, and he shall no longer receive the publications of the Association. If the dues are not paid by December 31st, he shall forfeit his membership without further action or notice, except as provided for in Clause 4 of this Article.

Remission of Dues

4. The Board of Direction may extend the time of payment of dues, and may remit the dues of any Member who, from ill-health, advanced age or other good reasons, is unable to pay them.

***The annual payment of $10.00 made by each member is to be subdivided and credited on the books of the Association, as follows: To member's subscription to the Bulletin, $5.00; annual dues, $5.00.**

ARTICLE V

Board of Direction

Officers

1. The officers of the Association shall be Members and shall consist of:

A President,
A First Vice-President,
A Second Vice-President,
A Treasurer,
A Secretary,
Nine Directors,

who, together with the five latest living Past-Presidents who are Members, shall constitute the Board of Direction in which the government of the Association shall be vested, and who shall act as Trustees, and have the custody of all property belonging to the Association.

Vice-Presidents' Priority

2. The offices of First and Second Vice-Presidents shall be determined by the priority of their respective dates of election.

Terms of Office

3. The terms of office of the several officers shall be as follows:

President, one year.
Vice-Presidents, two years.
Treasurer, one year.
Secretary, one year.
Directors, three years.

Officers Elected Annually

4. (a) There shall be elected at each Annual Convention:

A President,
One Vice-President,
A Treasurer,
A Secretary,
Three Directors.

(b) The candidates for President and for Vice-President shall be selected from the members of the Board of Direction.

Conditions of Re-election of Officers

5. The office of President shall not be held twice by the same person. A person who shall have held the office of Vice-President or Director shall not be eligible for re-election to the same office until at least one full term shall have elapsed after the expiration of his previous term of office.

Term of Officers

6. The term of each officer shall begin with his election and continue until his successor is elected.

Vacancies in Offices

7. (a) A vacancy in the office of President shall be filled by the First Vice-President.

(b) A vacancy in the office of either of the Vice-Presidents shall be filled by the Board of Direction by election from the Directors. A Vice-Presidency shall not be considered vacant when one of the Vice-Presidents is filling a vacancy in the Presidency.

(c) Any other vacancies for the unexpired term in the membership of the Board of Direction shall be filled by the Board.

(d) An incumbent in any office for an unexpired term shall be eligible for re-election to the office he is holding; provided, however, that anyone appointed to fill a vacancy as Director within six months after the term commences shall be considered as coming within the provision of Article V, Clause 5.

Vacation of Office

8. When an officer ceases to be a Member of the Association, as provided in Article II, his office shall be vacated, and be filled as provided in Article V, Clause 7.

Disability or Neglect

9. In case of the disability or neglect in the performance of his duty of an officer, the Board of Direction, by a two-thirds majority vote of the entire Board, shall have power to declare the office vacant, and fill it as provided in Article V, Clause 7.

ARTICLE VI

NOMINATION AND ELECTION OF OFFICERS

Nominating Committee

1. (a) There shall be a Nominating Committee composed of the five latest living Past-Presidents of the Association, who are Members, and five Members not officers.

(b) The five Members shall be elected annually when the officers of the Association are elected.

Number of Candidates

2. It shall be the duty of this Committee to nominate candidates to fill the offices named in Article V, and vacancies in the Nominating Committee caused by expiration of term of service, for the ensuing year, as follows:

Office to be Filled	*Number of Candidates to be named by Nominating Committee*	*Number of Candidates to be Elected at Annual Election of Officers*
President	1	1
Vice-President	2	1
Treasurer	1	1
Secretary	1	1
Directors	9	3
Nominating Committee	10	5

Chairman

3. The Senior Past-President shall act as permanent chairman of the Committee, and will issue the call for meetings. In his absence from meetings, the Past-President next in age of service shall act as Chairman pro tem. at the meeting.

Meeting of Committee

4. Prior to December 1st each year, the Chairman shall call a meeting of the Committee at a convenient place and, at this meeting, nominees for office shall be agreed upon.

Announcement of Names of Nominees

5. The names of the nominees shall be announced by the permanent Chairman to the President and Secretary not later than December 15th of the same year, and the Secretary shall report them to the members of the Association on a printed slip not later than January 1st following.

Additional Nominations by Members

6. At any time between January 1st and February 1st, any ten or more Members may send to the Secretary additional nominations for the ensuing year signed by such Members.

Vacancies in List of Nominees

7. If any person so nominated shall be found by the Board of Direction to be ineligible for the office for which he is nominated, or should a nominee decline such nomination, his name shall be removed and the Board may substitute another one therefor; and may also fill any vacancies that may occur in this list of nominees up to the time the ballots are sent out.

Ballots Issued

8. Not less than thirty days prior to each Annual Convention, the Secretary shall issue ballots to each voting member of record in good standing, with a list of the several candidates to be voted upon, with the names arranged in alphabetical order when there is more than one name for any office.

Substitution of Names

9. Members may erase 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.

Ballots

10. (a) Ballots shall be placed in an envelope, sealed and endorsed with the name of the voter, and mailed or deposited with the Secretary at any time previous to the closure of the polls.

(b) A voter may withdraw his ballot, and may substitute another, at any time before the polls close.

Invalid Ballots

11. Ballots not endorsed or from persons not qualified to vote shall not be opened; and any others not complying with the above provisions shall not be counted.

Closure of Polls

12. The polls shall be closed at twelve o'clock noon on the second day of the Annual Convention, and the ballots shall be counted by three tellers appointed by the Presiding Officer. The ballots and envelopes shall be preserved for not less than ten days after the vote is canvassed.

Requirements for Election

13. The persons who shall receive the highest number of votes for the offices for which they are candidates shall be declared elected.

Tie Vote

14. 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.

Announcement

15. The Presiding Officer shall announce at the convention the names of the officers elected in accordance with this Article.

First Nominating Committee

16. Except as to the Past-Presidents, the first Nominating Committee and the three additional Directors provided for shall be appointed by the Board of Direction, one of the Directors for one year, one for two years and one for three years.

ARTICLE VII

Management

Duties of President

1. (a) 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 shall be ex-officio member of all Committees, except the Nominating Committee.

(b) The Vice-Presidents, in order of seniority, shall preside at meetings in the absence of the President and discharge his duties in case of a vacancy in his office.

Duties of Treasurer

2. The Treasurer shall receive all moneys and deposit same in the name of the Association, and shall receipt to the Secretary therefor. He shall invest all funds not needed for current disbursements as shall be ordered by the Board of Direction. He shall pay all bills, when properly certified and audited by the Finance Committee, and make such reports as may be called for by the Board of Direction.

Duties of Secretary

3. The Secretary shall be, under the direction of the President and Board of Direction, the Executive Officer of the Association. He shall attend the meetings of the Association and of the Board of Direction, prepare the business therefor, and duly record the proceedings thereof. He shall see that the moneys due the Association are collected and without loss transferred to the custody of the Treasurer. He shall personally

certify to the accuracy of all bills or vouchers on which money is to be paid. He is to conduct the correspondence of the Association and keep proper record thereof, and perform such other duties as the Board of Direction may prescribe.

Auditing of Accounts

4. The accounts of the Treasurer and Secretary shall be audited annually by a public accountant, under the direction of the Finance Committee of the Board.

Duties of Board

5. 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 in the Constitution.

Board Meetings

6. 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.

Board Quorum

7. Seven members of the Board shall constitute a quorum.

Board Committees

8. At the first meeting of the Board after the Annual Convention, the following committees from its members shall be appointed by the President, and shall report to and perform their duties under the supervision of the Board of Direction:

(a) Finance Committee.
(b) Publication Committee.
(c) Library Committee.
(d) Outline of Work of Standing Committees.
(e) Personnel of Committees.
(f) Membership.
(g) Manual.

Duties of Finance Committee

9. 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 moneys and as to 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 previous action and authority of the Board of Direction.

Duties of Publication Committee

10. The Publication Committee shall have general supervision of the publications of the Association.

Duties of Library Committee

11. The Library Committee shall have general supervision of the Library, the property therein, and the quarters occupied by the Secretary; shall make recommendations to the Board with reference thereto, and shall direct the expenditure for books and other articles of permanent value, from such sums as may be appropriated for these purposes.

Duties of Committee on Outline of Work of Standing Committees

12. The Committee on Outline of Work of Standing Committees shall present a list of subjects for committee work during the ensuing year at the first meeting of the Board of Direction after the Annual Convention.

Standing Committees

13. The Board of Direction may appoint such Standing Committees as it may deem best, to investigate, consider and report upon questions pertaining to railway location, construction or maintenance.

Special Committees

14. Special Committees to examine into and report upon any subject connected with the objects of this Association may be appointed from time to time by the Board of Direction.

Discussion by Non-Members

15. The Board of Direction may invite discussions of reports from persons not members of the Association.

Sanction of Acts of Board

16. 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, and shall not afterwards be impeached by any Member.

ARTICLE VIII

MEETINGS

Annual Convention

1. The Annual Convention shall be held in the City of Chicago. The meetings shall begin on a Tuesday in the month of March, as may be determined by the President.

Special Meetings

2. Special meetings of the Association may be called by the Board of Direction, and special meetings shall be so called by the Board upon request of thirty Members, which request shall state the purpose of such meeting. The call for such meeting shall be issued not less than ten days in advance, and shall state the purpose and place thereof, and no other business shall be taken up at such meeting.

Notification of Annual Convention

3. The Secretary shall notify all members of the time and place of the Annual Convention of the Association at least thirty days in advance thereof.

Association Quorum

4. Twenty-five Members shall constitute a quorum at all meetings of the Association.

Order of Business

5. (a) The order of business at annual conventions of the Association shall be as follows:

Reading of Minutes of last meeting.
Address of President.
Reports of the Secretary and Treasurer.
Reports of Standing Committees.
Reports of Special Committees.
Unfinished business.
New business.
Election of officers.
Adjournment.

(b) This order of business, however, may be changed by a majority vote of members present.

Rules of Order

6. The proceedings shall be governed by "Robert's Rules of Order," except as otherwise herein provided.

Discussion

7. Discussion shall be limited to members and to those invited by the presiding officer to speak.

ARTICLE IX

Amendments

Amendments

1. Proposed amendments to this Constitution shall be made in writing and signed by not less than ten Members, and shall be acted upon in the following manner:

The amendments shall be presented to the Secretary, who shall send a copy of same to each member of the Board of Direction as soon as received. If at the next meeting of the Board of Direction a majority of the entire Board are in favor of considering the proposed amendments, the matter shall then be submitted to the Association for letter-ballot, and the result announced by the Secretary at the next Annual Convention. In case two-thirds of the votes received are affirmative, the amendments shall be declared adopted and become immediately effective.

GENERAL INFORMATION

(Subject to change from time to time by Board of Direction.)

GENERAL RULES FOR THE PREPARATION, PUBLICATION AND CONSIDERATION OF COMMITTEE REPORTS

(A) Appointment of Committees and Outline of Work

Standing Committees

1. The following are Standing Committees:

I. Roadway.
II. Ballast.
III. Ties.
IV. Rail.
V. Track.
VI. Buildings.
VII. Wooden Bridges and Trestles.
VIII. Masonry.
IX. Grade Crossing Design, Protection and Elimination.
X. Signals and Interlocking.
XI. Records and Accounts.
XII. Rules and Organization.
XIII. Water Service.
XIV. Yards and Terminals.
XV. Iron and Steel Structures.
XVI. Economics of Railway Location.
XVII. Wood Preservation.
XVIII. Electricity.
XIX. Conservation of Natural Resources (Abolished.)
XX. Uniform General Contract Forms.
XXI. Economics of Railway Operation.
XXII. Economics of Railway Labor.
XXIII. Shops and Locomotive Terminals.
XXIV. Cooperative Relations with Universities.

Special Committees

2. Special Committees will be appointed from time to time, as may be deemed expedient, in the manner prescribed by Article VII, Clause 14, of the Constitution.

The following are Special Committees:

Stresses in Railroad Track.
Standardization.
Clearances.

Personnel of Committees

3. The personnel of all Committees will continue from year to year, except when changes are announced by the Board of Direction. Ten per cent. of the membership of each Committee shall be changed each year.

Members of committees who do not attend meetings of committees during the year or render service by correspondence will be relieved and the vacancies filled by the Board at the succeeding Annual Convention.

Outline of Work

4. As soon as practicable after each Annual Convention the Board of Direction will assign to each Committee the important questions which, in its judgment, should preferably be considered during the current year. Committees are privileged to present the results of any special study or investigation they may be engaged upon or that may be considered of sufficient importance to warrant presentation.

(B) Preparation of Committee Reports

General

5. The collection and compilation of data and subsequent analysis in the form of arguments and criticism is a necessary and valuable preliminary element of committee-work.

Collection of Data

6. Committees are privileged to obtain data or information in any proper way. The Secretary will issue circulars of inquiry, which should be brief and concise. The questions asked should be specific and pertinent, and not of such general or involved character as to preclude the possibility of obtaining satisfactory and prompt responses. They should specify to whom answers are to be sent, and should be in such form that copies can be retained by persons replying either by typewriter or blueprint.

Plan of Reports

7. Committee reports should be prepared as far as practicable to conform to the following general plan:

(a) It is extremely important that every Committee should examine its own subject-matter in the "Manual" prior to each Annual Convention, and revise and supplement it, if deemed desirable, giving the necessary notice of any recommended changes in accordance with Clause 6 (a) of the General Rules for the Publication of the "Manual." If no changes are recommended, statement should be made accordingly.

(b) When deemed necessary, the previous report should be reviewed.

(c) Subjects presented in previous reports on which no action was taken should be resubmitted, stating concisely the action desired. It may not be necessary to repeat the original text in the report, reference to former publication being sufficient, unless changes in the previously published version are extensive. Minor changes can be explained in the text of the report.

Definitions

(d) Technical terms used in the report, the meaning of which is not clearly established, should be defined, but defined only from the standpoint of railway engineering.

History

(e) If necessary, a brief history of the subject-matter under discussion, with an outline of its origin and development, should be given.

Analysis

(f) An analysis of the most important elements of the subject-matter should be given.

Argument

(g) The advantages and disadvantages of the present and recommended practices should be set forth.

Illustrations

(h) Illustrations accompanying reports should be prepared so that they can be reproduced on one page. The use of folders should be avoided as much as possible, on account of the increased expense and inconvenience in referring to them. Plans showing current practice, or necessary for illustration, are admissible, but those showing proposed definite design or practice should be excluded. Recommendations should be confined to governing principles.

Illustrations should be made on tracing cloth with heavy black lines and figures, so as to stand a two-thirds reduction; for example: To come within a type page (4 inches by 7 inches), the illustration should be made three times the above size.

To insure uniformity, the one-stroke, inclined Gothic lettering is recommended.

Photographs should be clear and distinct silver prints.

Conclusions

(i) The conclusions of the Committee which are recommended for publication in the Manual should be stated in concise language, logical sequence, and grouped together, setting forth the principles, specifications, definitions, forms, tables and formulas included in the recommendation. Portions of the text of the report which are essential to a clear interpretation and understanding of the conclusions, should be included as an integral part thereof.

(c) PUBLICATION OF COMMITTEE REPORTS

Reports Required

8. (a) Reports will be required from each of the Standing and Special Committees each year.

(b) Although several subjects may be assigned to each Committee by the Board of Direction, a full report on only one subject is expected at each Annual Convention, but the preliminary work on some of the remaining subjects should be in progress, and, when deemed advisable, partial reports of progress should also be presented. This method allows time for their proper preparation and consideration.

Date of Filing Reports

9. Committee reports to come before the succeeding convention for discussion should be filed with the Secretary not later than November 30th of each year.

10. Committees engaged upon subjects involving an extended investigation and study are privileged to present progress reports, giving a brief statement of the work accomplished, and, if deemed expedient, a forecast of the final report to be presented.

Publication of Reports

11. Committee reports will be published in the Bulletin in such sequence as the Board of Direction may determine, for consideration at

the succeeding convention. Reports will be published in the form presented by the respective Committees. Alterations ordered by the convention will be printed as an appendix to the report.

Written Discussions

12. Committees should endeavor to secure written discussions of published reports. Written discussions will be transmitted to the respective Committees, and if deemed desirable by the Committee, the discussions will be published prior to the convention and be considered in connection with the report.

Verbal Discussions

13. Each 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.

(D) Consideration of Committee Reports

Sequence

14. The sequence in which Committee reports will be considered by the convention will be determined by the Board of Direction.

Method

15. The method of consideration of Committee reports will be one of the following:

(a) Reading by title.
(b) Reading, discussing and acting upon each conclusion separately.
(c) By majority vote, discussion will be had on each item. Clauses not objected to when read will be considered as voted upon and adopted.

Final Action

16. Action by the convention on Committee reports will be one of the following, after discussion is closed:

(a) Receiving as information.
(b) Receiving as a progress report.
(c) Adoption of a part complete in itself and referring remainder back to Committee.
(d) Adoption as a whole.
(e) Recommittal with or without instructions.
(f) Adoption as a whole.
(g) Recommendation to publish in the Manual.

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 lie entirely within the duties of the Editor.

(E) Publication by Technical Journals

The following rules will govern the releasing of matter for publication in technical journals:

Committee reports, requiring action by the Association at the annual convention, will not be released until after presentation to the convention; special articles, contributed by members and others, on which no action by the Association is necessary, are to be released for publication by the technical journals after issuance in the Bulletin; provided, application therefor is made in writing and proper credit be given the Association, authors or Committees presenting such material.

GENERAL RULES FOR THE PUBLICATION OF THE "MANUAL"

Title

1. The title of the volume will be "Manual of the American Railway Engineering Association."

2. The Board of Direction shall edit the Manual and shall have authority to withhold from publication any matter which it shall consider as not desirable to publish, or as not being in proper shape, or as not having received proper study and consideration.

Adoption of Reports Not Binding

3. Matters adopted by the Association and subsequently published in the Manual shall be considered in the direction of good practice, but shall not be binding on the members.

Contents

4. The Manual will only include conclusions relating to definitions, specifications and principles of practice as have been made the subject of a special study by a Standing or Special Committee and embodied in a Committee report, published not less than thirty days prior to the Annual Convention, and submitted by the Committee to the Annual Convention, and which, after due consideration and discussion, shall have been voted on and formally adopted by the Association. Subjects which, in the opinion of the Board of Direction, should be reviewed by the American Railway Association, may be referred to that Association before being published in the Manual.

5. All conclusions included in the Manual must be in concise and proper shape for publication, as the Manual will consist only of a summary record of the definitions, specifications and principles of practice adopted by the Association, with a brief reference to the published Proceedings of the Association for the context of the Committee report and subsequent discussion and the final action of the Association.

Revision

6. Any matter published in the Manual may be amended or withdrawn by vote at any subsequent Annual Convention, provided such changes are proposed in time for publication not less than thirty days prior to the Annual Convention, and in the following manner: (a) Upon recommendation of the Committee in charge of the subject; (b) upon recommendation of the Board of Direction; (c) upon request of five members, made to the Board of Direction.

7. The Manual will be revised either by publishing a new edition or a supplemental pamphlet as promptly as possible after each Annual Convention.

BUSINESS SESSION

PROCEEDINGS

The object of this Association is the advancement of knowledge pertaining to the scientific and economic location, construction, operation and maintenance of railways. Its action is not binding upon its Members.

TUESDAY, MARCH 9, 1926

MORNING SESSION

The Twenty-Seventh Annual Convention of the American Railway Engineering Association was called to order in the Florentine Room of the Congress Hotel, Chicago, Illinois, by President J. M. R. Fairbairn, Chief Engineer, Canadian Pacific Railway.

The President:—The convention will please come to order.

This meeting is the Twenty-Seventh Annual Convention of the American Railway Engineering Association, and is also the annual session of the Construction and Maintenance Section and of the Electrical Section of the American Railway Association. These meetings being concurrent, they are both now open for the transaction of business.

The privileges of the floor are extended to visiting officers of railroads who are not members of the Association, and also to members of college or university faculties who may be present.

The first order of business is the reading of the Minutes of the last annual meeting. These Minutes have been published and furnished to all concerned, so that if there are no objections the Minutes will be considered approved.

The next order of business is the reading of the President's Address.

ADDRESS OF PRESIDENT J. M. R. FAIRBAIRN

Our Association has, during the past year, continued the good work for which it was originally organized and progress is being made in every field of our labor.

Our Committees, as you will see from the reports already published, have done excellent work and, generally, the Association has reason to be pleased with its year's progress.

The Treasurer's report will show that our financial position is both sound and gratifying.

I regret to say that during the year we have lost, by death, twenty-one of our members. Among these, prominent in the work of the Association, were:

Julius Kruttschnitt
A. M. Burt
W. M. Camp

The officers of the Association and the members of the Board of Direction have, as usual, shown throughout the year's work an unfailing zeal and spirit of willing co-operation, for which I wish to express to them my most heartfelt appreciation and grateful thanks.

The report of the Secretary will show that our membership has increased during the year by 3½ per cent, this being just our average for the past seven years.

From time to time this Association has conducted, through various mediums, spasmodic campaigns for additional membership, the results having been usually more or less gratifying, but when one looks over the list of members with their railway affiliations and geographical distribution and the annual increases in total membership, which vary in recent years all the way from less than 1 per cent to 16 per cent, one is at once struck by the desirability of a continuous campaign for new members in order that we may have year by year a more consistent increase in our numbers, which will, if possible, equalize in some degree the corporate and geographical distribution of the membership.

With this in view, the following outline of the work of the American Railway Engineering Association, its benefit to the railways, and to its own members, is given, in the hope that a clearer understanding of this work may increase the number of those connected with railway work who will interest themselves in this most valuable activity.

Our Association is now commencing its Twenty-Seventh Annual Convention, the principal business of which is the reception, consideration and approval, or otherwise, of the reports of the twenty-three Standing Committees and those Special Committees dealing with special assignments. To those of our members accustomed to attending the Annual Convention and those engaged in committee-work the full meaning of this announcement is well-known, but to those members not privileged to attend the convention or so situated that they cannot participate in committee-work, as well as to the railway public outside our membership, this meaning is not, by any means, so clear. There is in the work of the Association, in its committees throughout the year, and at its Annual Convention, a very valuable asset, both to the railways, from whom our members are drawn, and to the members themselves, particularly those active in the work of our committees.

The membership of the Standing Committees of the Association, varying in numerical strength from a minimum of 12 to a maximum of 34 members, is selected in each case by the Personnel Committee of the Board of Direction, with special reference to the qualifications of each individual for the particular work assigned to his Committee. Again, the various subjects assigned to each Committee are, of course, pertinent to the particular field which that Committee covers and are selected carefully by the Outline of Work Committee of the Board of Direction after the fullest co-operation with the Committee Chairmen in each case, with a view to covering, in any one year, only those subjects which are most urgently in need of analysis and solution by the railways.

A study of the committee reports during the life of the Association is a liberal education in the field of railway location, construction and maintenance, as well as giving much enlightenment on many features of operation.

To follow the work of the Association through its Annual Proceedings gives one a most comprehensive idea of the improvement in the art of manufacturing transportation, and at the same time shows clearly what has been done to simplify practice and to standardize materials and structures, all of which tends to the maximum of efficiency in the personnel and economy to the companies.

The twenty-six volumes, of which the Annual Proceedings consist, and the Manual, giving the recommended practice of the Association, constitute a reference library which no railway officer can well afford to be without. The recommended practice of the Association on any particular subject is clearly set forth in the Manual, and the considerations leading up to such recommended practice may be found in the committee reports, while the discussion by the membership at large on the same subject, as called forth at the Annual Meeting, is readily available in the Proceedings.

With this information at hand, any railway officer, even though not a member of the Association, can get a very fair idea of the best American practice and the reasons therefor, but to get the greatest value from the work of the Association it is necessary that one should be a member, busy working on one or more committees, or sub-committees, attending the meetings of these and participating in the committee discussions, where all the details of any subject are thoroughly thrashed out.

To the committee member the opportunity is afforded of intensive study of interesting problems which arise in his daily work, but instead of struggling alone with these problems he has the great advantage of conferring with a group of others, equally interested with himself in the same problem, having varied experience on other railways affected by different conditions of organization, traffic, physical formations and climate.

This study, coupled with the opportunity to meet and get to know personally a large number of others in the same line of effort, is a distinct advantage to any man, broadening tremendously his point of view and, consequently, enhancing his value to the company which he serves. Many committees, by so locating their meetings that their members can see and study various structures, layouts or methods, have given their members opportunities for such study seldom obtained by the individual officer.

The work already done has assisted materially in the simplification of much of the work of railway officers, but there is still a tremendous field to cover. New conditions arising annually bring new assignments from the Outline of Work Committee to the various standing committees. Many subjects run for years before adequate collection of data, investigation and study enable a Committee to reach a definite conclusion, and even then the convention sometimes overturns such definite conclusion and it becomes necessary that the whole subject be considered again.

It is to be earnestly hoped that as the work of this Association becomes more intimately known to railway executives, they will take a keener interest in it and will give more widespread encouragement to junior officers to join the Association, grow up with it, and take part in its committee activities.

This service, is, of course, a voluntary one, similar to the service given by a number of sister associations of like aims and kindred activities, but such a service has a most beneficial reaction on each individual concerned and may well engender in him the satisfaction born of a consciousness that these associations have in no small degree contributed to the building up of that fabric of railway knowledge upon which all great land transportation systems are based.

I am informed that our Association's specifications and recommendations in the field of railway practice are studied throughout the English-speaking nations and by many others interested in the science of transportation, not only in the old continent of Europe but in the newly awakened Orient. This calls forth the hope that more of our co-workers in the railway field in these foreign countries will be induced to become members of this Association, and thus join in carrying on this international work of broadcasting the principles of good practice in railway matters. It is only necessary to peruse the technical press of the world on railway construction, trackwork, terminal, locomotive and bridge design in order to appreciate the extent to which our practice has influenced that of foreign countries.

Gentlemen, the great Calling in which we are all engaged is, I submit, a noble one, affecting the welfare of the whole world, and I am confident that time will show that not only are we assisting to annihilate distance and bring the Nations closer together, but we are also directly helping to create similarity of National ideals and a better understanding of one another among the Nations of the earth. (Applause.)

The President:—The next order of business is the reports of the Secretary and of the Treasurer.

Secretary E. H. Fritch:—The reports of the Secretary and of the Treasurer, giving a summary of the activities of the Association during the past year, have been printed and distributed prior to this meeting. It is hardly necessary to read these reports, and they are therefore respectfully submitted for your approval.

REPORT OF THE SECRETARY

March 1, 1926.

To the Members:

The customary annual report, showing the operations and condition of the American Railway Engineering Association during the year, is submitted herewith under six general headings:

(I) Resumé of Year's Activities

- Committee Reports
- Classification of Subjects
- Joint Activities
- Research Work
- Monographs
- Subjects Covered in Reports
- Personnel of Committees by Railways

(II) Membership

- Additions During the Year
- Classification of Membership
- Deceased Members
- Geographical Distribution

(III) Publications

- Bulletin, Proceedings, Manual
- General Index

(IV) Finances

- Receipts and Disbursements
- Report of Treasurer
- General Balance Sheet

(V) Miscellaneous

- Proposed Amendment to Constitution
- Representative on A. R. A. Board of Directors

(VI) Conclusion

Respectfully submitted,

E. H. Fritch

Secretary.

(1) RESUMÉ OF YEAR'S ACTIVITIES

Committee Reports

The outstanding feature of the fiscal year's operations is the series of excellent committee reports presented to the twenty-seventh annual meeting for consideration and action.

The founders of the organization wisely concluded that the best results would be achieved through the medium of practically permanent committees. That this expectation was well-founded is borne out by the admirable reports which have been submitted year after year.

The vast amount of practical and useful information which the respective committees have made available has been of inestimable value to the interests we serve as well as to the individual members.

Credit for this commendable record is primarily due to the committeemen. These men, often at great personal sacrifice, have given freely of their time and talents, as an unselfish contribution to the common good.

A review of the subjects covered in the current year's reports, listed on following pages, will indicate the wide range of the information presented.

Classification of Committee Activities

The activities of the respective committees in the past year have been directed in the following proportions:

On Roadway and Track problems	28 per cent
On Structure problems	22 per cent
On Railway Economics	10 per cent
On Operating problems	15 per cent
On Railway Labor problems	6 per cent
On Miscellaneous Engineering problems	19 per cent
	100 per cent

Joint Activities

Contact has been maintained with other organizations on matters of mutual concern, among them the following:

"Culvert Load Determination"

This investigation has been under way for the past two years by the Committee on Roadway, in co-operation with the Armco Culvert and Flume Manufacturers' Association, the latter organization financing the tests. A report on the experiments thus far made is given in the current report of the Committee on Roadway, Bulletin 284.

"Effect of Various Bolt Tensions on Mechanical Strength of Joints; Cause and Prevention of Rail Battering"

Report of an investigation made by Past-President Hunter McDonald, Chief Engineer of the Nashville, Chattanooga & St. Louis Railway. This comprehensive study covered a period of two years, and is reported on fully in the report of the Rail Committee in Bulletin 283.

"Specifications and Designs for Girder Rails"

The Committees on Rail and Track have collaborated in formulating specifications and designs for girder rails. The matter is covered in the reports of the two committees in Bulletin 283.

"SPECIFICATIONS FOR STEEL FOR RAILWAY BUILDINGS"

The Committees on Buildings and Iron and Steel Structures have co-operated in preparing a specification for steel for use in railway buildings. This specification will appear in a future Bulletin.

"SIMPLIFICATION OF GRADING RULES AND CLASSIFICATION OF TIMBER AND LUMBER FOR RAILWAY USES"

The Committee on Wooden Bridges and Trestles has continued co-operation with the Central Committee on Lumber Standards; the United States Departments of Commerce and Agriculture, and the American Society for Testing Materials, in the standardization program of the lumber industry, inaugurated under the auspices of the Secretary of the Department of Commerce. A comprehensive report is made on this subject in Bulletin 284, under Wooden Bridges and Trestles.

"STANDARD SPECIFICATIONS FOR CONCRETE AND REINFORCED CONCRETE"

The Committee on Masonry, in its current report, discusses the "Report of the Joint Committee on Concrete and Reinforced Concrete," and offers suggestions for certain changes. The discussion is given in Bulletin 282.

"IMPROVED METHODS OF PREVENTING CORROSION OF FENCE WIRE"

The Committee on Signs, Fences and Crossings is co-operating with the American Society for Testing Materials in tests of fence wire and fencing. Reference to this study is embodied in the report of the Committee on Signs, Fences and Crossings, Bulletin 282.

"BEARING PRESSURES ON LARGE ROLLERS"; "PUNCHED AND REAMED WORK"

The Committee on Iron and Steel Structures has made tests on bearing pressures on large rollers at the University of Illinois under the direction of Prof. W. M. Wilson.

Tests of punched and reamed work has been continued by the Committee at Lafayette College under the direction of Prof. F. O. Dufour.

Bulletin 280 gives reference to these two studies.

"SERVICE TESTS RECORDS"

The Committee on Wood Preservation has continued its co-operation with the Forest Products Laboratory in the compilation of service tests records.

The Marine Piling Investigation, heretofore conducted under the auspices of the National Research Council, has been turned over to this Committee. Report on the tests under way is given in Bulletin 283.

"NATIONAL ELECTRICAL SAFETY CODE"

The Committee on Electricity has continued co-operation with the Bureau of Standards in the revision of the National Electrical Safety Code and other codes of similar character. The details of such co-operation are given in Bulletin 280.

"STANDARDIZATION"

The Association is represented on a number of sectional committees of American Engineering Standards Committee involving projects of concern to railway interests.

Research Work

"Stresses in Railroad Track"

The Special Committee on Stresses in Railroad Track, under the direction of Prof. A. N. Talbot, Chairman, reports progress in Bulletin 282. The efforts during the past year were directed on the rail joint in an effort to determine the intensity and distribution of the stresses in the splice bar and in the rail at the joint, the characteristics of the flexural action for different forms of the splice bar, and the effect of varying conditions in the joint, such as the tension of the bolts and the fit of the splice bar to the rail. An effort was also made to learn to what extent the stresses and moments varied from joint to joint in the track and whether the joints in service behaved in accordance with assumptions quite commonly made.

"Iron and Steel Structures"

This Committee contemplates undertaking column tests in co-operation with the American Society of Civil Engineers, and has applied to the Board of Direction for the necessary funds.

For the past three years, under this Committee's direction, a series of tests on bearing values of large rollers were carried on at the University of Illinois, the expense thereof being absorbed by that university. The work has reached a stage where new equipment is required to make certain tests for which equipment is lacking. Requests for the requisite funds to provide this equipment has been made to the Board of Direction.

Another series of tests under the direction of this Committee has been carried on at Lafayette College, supervised by Prof. F. O. Dufour. These experiments will be continued during the ensuing year.

"Permanent Research Bureau"

The Committee on Economics of Railway Operation, in a resolution transmitted to the Board of Direction, recommended that a permanent bureau be created which shall undertake to carry on investigations, whether in the mechanics or economics of railway transportation, that will contribute to the more scientific and efficient operation of railways.

The Committee calls attention to the results attained in many industries, as well as that of the Government, in promoting research work. The Board of Direction has the matter under active consideration.

Monographs

From time to time, special articles contributed by members have appeared in the Bulletin. These monographs are an extremely valuable contribution to railway engineering literature. A list of the papers is given below:

"Shrinkage of Earth, Swell of Rock, and Shrinkage of Ballast"—by H. E. Hale.

"Water Softening Developments—Rock Island Lines"—by Paul M. LaBach.

"The Relation Between the Swaying of Hopper Cars and the Stagger of Rail Joints in Track"—by B. R. Leffler.

"The Effect of Minor Sags and Humps on the Operation of Trains"—by Walter Loring Webb.

"The Design of Treads for the Supporting and Segmental Girders of Rolling Lift Bridges"—by Otis E. Hovey.

"The American Railway Engineering Association"—by J. E. Armstrong.

"Translating the Physical Characteristics of a Railway Line Into Equivalent Straight and Level Miles and Ton-Mile Cost in the Economics of Railway Location and Operation"—by J. L. Campbell.

Personnel of Committees by Railways

The table on following pages gives a list of committees, and number of members from each railway represented on the respective committees.

CONTENTS OF COMMITTEE REPORTS

Report of Committee on Track........................Bulletin 283

Proposed Revised Specifications for Steel Tie Plates
Proposed Revised Specifications for Soft Steel Cut Track Spikes
Detail Plans of Switches, Frogs and Crossings, including Plans of Self-Guarded Frogs
Specifications for Frog Filler Sections
Specifications and Design of Wooden Handles for Track Tools
Specifications for Hickory Handles for Track Tools
Effect of Brine Drippings on Track Appliances and Tests of Tie Plates Subject to Brine Drippings
Canting of Rail Inward
Methods of Determining Recommendations for Rail Renewals
Design of Tie Plates
Cause and Prevention of Rail Battering and Principles of Joint Design
Track Construction in Paved Streets
The Value of Nutlocks for Rail Joints with Special Reference to Heat-Treated Bolts of Large Diameter

Report of Committee on Buildings......................Bulletin 285

Specifications for Railway Buildings
Ice Houses and Icing Stations
Floors for Railway Buildings
Paints for Railway Buildings
Location and Design for Signs for Passenger Stations
Built-up Roofing

Report of Committee on Wooden Bridges and Trestles....Bulletin 284

Simplification of Grading Rules and Classification of Timber and Lumber for Railway Uses
Commercial Names for Lumber and Timber Cut from the Principal Species of Softwoods
Standard Grades of Red Cedar Shingles
Softwood Factory and Shop Lumber
Structural Grades of Lumber and Timber and the Method of their Derivation
Specifications for Structural Joist, Plank, Beams, Stringers, and Posts
Coded Specifications for Structural Grades
Notes on Tables of Working Stresses
Designing Stresses
Safe Loads for Wooden Columns
The Value of Treated Timber in Wooden Bridges and Trestles
Classification of the Uses of Timber and Lumber under American Railway Engineering Association Specifications

Report of Committee on Masonry.......................Bulletin 282

Discussion of Report of Joint Committee on Standard Specifications for Concrete and Reinforced Concrete.

Report of Committee on Signs, Fences and Crossings.....Bulletin 282

Methods of Apportioning the Cost of Highway Improvements Adjacent and Parallel to Railroad Rights-of-Way
Elimination of Highway Grade Crossings
Improved Methods of Preventing Corrosion of Fence Wire
The Use of Natural Rock Asphalt as a Substitute for Plank in Road Crossings

Report of Committee on Signals and Interlocking.........Bulletin 281

Automatic Train Control
Signals for Highway Crossing Protection
Requisites for Automatic Signals for Highway Crossing Protection

Report of Committee on Records and Accounts...........Bulletin 281

Methods and Forms for Gathering and Recording Data for Keeping Up to Date the Physical and Valuation Records of the Property of Railways
The Feasibility of Reducing the Number of Forms in Maintenance of Way and Engineering Departments, Combining Forms and Simplifying those Retained
Comparison of Daily and Monthly Time and Material Reports

Report of Committee on Rules and Organization..........Bulletin 280

Water Service Repairmen
Handling Explosives, Scrap and Refuse Material
Procedure in Case of Accident
First Aid to the Injured
General Supervisor of Work Equipment
Inspectors of Work Equipment
Supervisors of Work Equipment

Report of Committee on Water Service..................Bulletin 281

Revision of Manual—Definitions of Terms
Regulations of Federal and State Authorities Pertaining to Drinking Water Supplies and Sanitary Examination of Drinking Water Supplies
Pitting and Corrosion of Boiler Tubes and Sheets
Cost of Impurities in Locomotive Feedwater Treatment
Relative Merits of the Different Methods of Deep-Well Pumping
Design, Construction and Maintenance of Pipe Lines
Flow of Water in Pipes
Design and Construction of Water Station Buildings
Boiler Washing Plants as Affecting Water Supply

Report of Committee on Yards and Terminals............Bulletin 282

Joint Use of Passenger Terminals
Joint Operation of Passenger Terminals
Scales
Freight Yard Design, Suggesting Economies in Operation
Mechanical Means for Controlling or Retarding Movement of Cars in Hump Yards

Report of Committee on Iron and Steel Structures....Bulletin 282, 285

Specifications for Steel Highway Bridges
Instructions for Maintenance Inspection of Superstructures of Steel Railway Bridges
Column Tests
Specifications for the Waterproofing and Drainage of Solid-Floor Railway Bridges
Copper-Bearing Steel for Structural Purposes
Rules for Lighting Bridges
Uniform Code of Regulations and Signals for Operating Draw Bridges

Report of Committee on Economics of Railway Location..Bulletin 280

The Economics of Railway Location as Affected by the Introduction of Electric Locomotives
MINORITY REPORT
The Relative Merits of a 0.4 Per Cent Ruling Grade as Compared with a 0.3 Per Cent Grade

Report of Committee on Wood Preservation..............Bulletin 284

Revision of Manual
Treatment of Douglas Fir
Service Test Records
Marine Piling Investigations
Preservative Treatment of Trunking and Capping
Treatment with Creosote and Petroleum
Treatment with Zinc-Chloride and Petroleum

Report of Committee on Electricity....................Bulletin 280

- Water Power
- Overhead Transmission Line Construction
  - Specifications for the Maintenance of Overhead Electric Supply Lines
  - Specifications for the Joint Use of Poles for Power, Communication and Signal Circuits
- Standardization of Adhesive and Rubber Tapes
  - Specifications for Friction Tape
- Specifications for Porcelain Insulators for Railroad Supply Lines
  - Some Causes of Insulator Failures
- Clearances for Third Rail and Overhead Working Conductors
- Specifications for Track and Third Rail Bonds
- Data Regarding Rail Bonding Practice
- Tungsten Lamp Standards

Report of Committee on Uniform General Contract Forms Bulletin 282

- Form of Agreement for Furnishing Water from Railway Water Systems to Employees and Others
- Form of Agreement for Purchase of Water
- Form of Agreement for Joint Use of Freight Station Facilities
- Form of Agreement for Purchase of Electrical Energy
- Form of Agreement for Joint Use of Poles on Railway Rights-of-Way

Report of Committee on Economics of Railway Operation. Bulletin 284

- Methods of Increasing the Traffic Capacity of a Railway
- Methods of Analyzing Costs for the Solution of Special Problems, including Costs of Starting and Stopping Trains
- Methods of Operation by Which the Intensive Use of Facilities may be Secured
- Units for Comparing Costs of Operation and Equipment Maintenance

Report of Committee on Economics of Railway Labor.....Bulletin 285

- Standard Methods for Performing Maintenance of Way Work and Establishment of Units of Measure of Work Performed
- Extent to which it is Practicable to Stabilize Employment in the Maintenance of Way Department in the Interest of Efficiency, and the Necessary Measures
- Methods of Maintaining Motor Cars
- Economy in Use of Labor-Saving Devices
- Educating and Training Maintenance of Way Employees

Report of Committee on Shops and Locomotive Terminals. Bulletin 281

- Engine Terminal Layout
- General Layout and Design of Passenger Car Shops
- Ventilation of Engine Houses
- Storehouses for Shops and Locomotive Terminals

Report of Committee on Stresses in Railroad Track.......Bulletin 282

- Progress Report

Report of Committee on Clearances....................Bulletin 284

- Progress Report

Report of Committee on Co-operative Relations with Universities ....Bulletin 285

- Progress Report

(II) MEMBERSHIP

The following table shows the changes in the membership during the fiscal year:

Membership as of March 1, 1925			2227
Additions during the year		183	
Losses by death	21		
Resignations	43		
Dropped from rolls	42	106	
Net gain		77	77
Total membership as of March 1, 1926			2304

We are indebted to Mr. A. A. Miller, Engineer Maintenance of Way, Missouri Pacific Railroad, for securing the largest number of new members from any one railroad, namely, thirty-two additional members, during the last six months.

The Executives of the thirty-six railways enumerated below hold membership in the Association:

Akron, Canton & Youngstown
Atchison, Topeka & Santa Fe
Atlanta, Birmingham & Atlantic
Augusta & Summerville
Canadian National
Canadian Pacific
Central of Georgia
Central Railroad of New Jersey
Chesapeake & Ohio
Chicago, Burlington & Quincy
Chicago Great Western
Chicago, Rock Island & Pacific
Duluth & Iron Range
Duluth, Missabe & Northern
Elgin, Joliet & Eastern
Great Northern
Illinois Central
Jacksonville Terminal
Lehigh Valley
Missouri Pacific
Missouri-Kansas-Texas
Montana, Wyoming & Southern
New York Central Lines
New York, New Haven & Hartford
Northern Pacific
Norfolk & Western
Pere Marquette
Richmond, Fredericksburg & Potomac
St. Louis-San Francisco
Southern Pacific
Terminal R. R. Association of St. Louis
Toledo Terminals
Union Pacific System
Virginian
Wabash
Western Maryland

Representing 160,290 miles of railroad.

Classification of Membership

The following table is a departmental classification of the membership:

General Officers	138
Includes Chairmen of Boards, Presidents, Directors, Vice-Presidents, Assistants to Presidents, General Managers, Assistant General Managers	
Conducting Transportation	95
Includes General and Assistant General Superintendents, Division Superintendents, Trainmasters	
Maintenance of Way and Structures	1574
Includes Chief Engineers, Chief Engineers of Maintenance of Way, Engineers Maintenance of Way, Bridge Engineers, Division Engineers, Signal Engineers, Assistant Engineers, etc.	
Maintenance of Equipment	19
Includes General Superintendents of Motive Power, and other Mechanical Department Officers	
Traffic Officers	4
Accounting Officers	8
Purchasing and Stores Department	2
Professors in Colleges	54
Miscellaneous	410
Includes Consulting and Civil Engineers, Engineers of Industrial Corporations, Government and Municipal Engineers, etc.	
Total	2304

Personnel of Committees by Railways—1925

Railways	Roadway	Ballast	Ties	Rail	Track	Buildings	Wooden Bridges and Trestles	Masonry	Signs	Signals and Interlocking	Records and Accounts	Rules and Organization	Water Service	Yards and Terminals	Iron and Steel Structures	Economics of Railway Location	Wood Preservation	Electricity	Contract Forms	Economics of Railway Operation	Economics of Railway Labor	Shops and Locomotive Terminals	Cooperative Relations	Stresses in Track	Standardization	Clearances	TOTAL
Alabama & Vicksburg																1											1
Atchison, Topeka & Santa Fe	2	1	1	1	1	1	1		1	1	1	1	1	1	1		2			1	1	1	1		1		22
Gulf, Colorado & Santa Fe																						1					1
Atlantic City					1																						1
Atlanta & West Point							1																				1
Atlantic Coast Line						1													1	2	1			1			6
Baltimore & Ohio	1	2		1	1	2		1	3	1	1	2	2		2		1	1	1	2	2	1		2	1		30
B. & O. C. T.			1						1		1																3
Bessemer & Lake Erie																1				2							3
Boston & Maine	1							1				1					1	1				1					6
Canadian National		2	2	1	1			3			1	1	1	1	1	1		1	3	4		2			1		26
Canadian Pacific	1			1	2	1	1		1			1	1	1	1	1					1		1		1		15
Carolina, Clin. & Ohio																			1								1
Central of New Jersey								1										1				1					3
Central of Georgia		1	1			1	1				1		1						1		1						8
Chesapeake & Ohio	1			1	1					1	1		1		1					3	1		1		1		13
Chicago & Alton	1													1		1											3
Chicago & Eastern Illinois															1							1					2
Chicago & Northwestern									2	1	2	2	1		1		1					1			1	1	13
Chicago & Western Indiana											1											2			1	1	5
Belt Railway of Chicago					1																						1
Chicago, Burlington & Quincy		1		1	3	1	1	1	2		1	1		1	1		1			2	1	1	1	2			23
Chicago Great Western						1																					1
Chicago, Ind. & Louisville									1	1																	2
Chicago Junction														1													1
Chicago, Milwaukee & St. Paul		1	1	1				1	1		1	1	2		1		1	1		2	1	3					18
Chicago, Rock Island & Pacific	1	1	1	1	2	1		1			2	1	2	1	1		2			1	1	1	2	1			23
Chicago Union Station														1													1
Copper Range																1											1
Delaware & Hudson		1										1															2
Delaware, Lackawanna & Western			1	1				1	1		1			1			1	1					1	1			10
Detroit Terminal					1																						1
Denver & Rio Grande Western							1												1						1	1	4
Duluth & Iron Range	1		1																			1			1		5
Duluth, Missabe & Northern							2							1													3
Elgin, Joliet & Eastern					1									1													2
Erie					1				1			1						1	1					1			6
Florida East Coast					1	1		1							1												4
Great Northern													1				1										2
Hocking Valley						1	1																				2

Illinois Central	1	1	2	1	1	2	2	1	3	2	2	2	3	2			1	3	1	1	2	1			2	1	37
International-Great Northern																					1						1
Jacksonville Terminal Company														1													1
Kansas City Southern							1								1						2						4
Kansas City Terminal										1				1													2
Lake Superior & Ishpeming			1																								1
Lehigh Valley				1				1			1	1													2	1	7
Long Island																		2									2
Louisville & Nashville				1	1				1					1													4
Missouri-Kansas-Texas		1	1			1					1	1	2	1		1	1				1	1					12
Missouri Pacific			1	1	1		1	1	1		1	1	1	1		1	1		1		1			1			15
Mobile & Ohio							1	1													1						3
Montana, Wyoming & Northern																1											1
Nashville, Chatta. & St. Louis				1									1								1						3
New York, Chicago & St. Louis			1									1															2
New York Central Lines	1			1							1			1				1				1					6
Boston & Albany																			1								1
Big Four	1	1												2	2												6
Cincinnati Northern						1																					1
Michigan Central		1	1		1		1		2	1											1						8
New York Central Railroad		1	1		1			1	1	3		2			3			2			1	1	1	2	3	3	26
Peoria & Eastern	1																			1							2
New York, New Haven & Hart			1	1		2			1		1			1	1			1	1		1				1	1	13
Norfolk & Western	1				1	1								1	1	1	1	1						1	1	1	11
Norfolk Southern	1																		1								2
Northern Pacific			1	1			1		1	1	2		1		1	1	1			2					1		14
Pennsylvania Railroad System	2	1	2	2	2		1		1	2	2	2	1	2	1		1	2		1		1	1	1	1		29
Peoria & Pekin		1																									1
Pere Marquette	1		1					1									1				1						5
Public Service Co. of N. J.																		1									1
Portland Terminal							1																				1
Pittsburg & Shawmut					1																						1
Richmond, Fred. & Potomac		1												1													2
Reading	1			1											1				1								4
Rutland						1																					1
St. Louis-San Francisco	1							1													3						5
St. Louis Southwestern		1											1														2
Seaboard Air Line		1					1	1											1				1		2		7
Southern	2	1	1					1		1			1	1	2			1	1			1					13
Southern Pacific	1		1	2	1		1			1			1				1					2					11
Terminal R. R. of St. Louis					1							1		1													2
Toronto Terminals														1											1	1	3
United Ry. & Electric Co.			1																								1
Union Pacific System		1	1	1						1			1	1	1					1	1						9
Wabash		1			1		1				1		1				1				1						7
Waterloo, Cedar Falls & Nor.									1																1	1	3
Western Maryland														1													1
Western Pacific			1														1										2
Wheeling & Lake Erie		1																			1						1
Non-Railroad Members	2	3			5	3	5	4	1	1	2	2	2	6	8	10	5		4	8	1	2	6	7	1		87
TOTAL	25	27	27	23	34	22	26	24	27	19	28	26	30	37	34	21	26	21	21	33	30	27	16	20	25	12	661

Deceased Members

It is with sincere regret that we record the loss by death of twenty-one valued members during the year. These departed members very materially aided in the upbuilding of the Association during their lifetime.

Memoirs of members who have died during the year appeared currently in the Bulletin.

Edmund H. Bowser, Superintendent Tie and Timber Department, Illinois Central Railroad.

L. R. Brine, First Assistant Engineer, Atlanta, Birmingham & Atlantic Railway.

Hardy Bryan, Assistant Engineer, Northern Pacific Railway.

Aaron Moulton Burt (*Director*), Vice-President—Operation, Northern Pacific Railway.

Walter Mason Camp, Editor, *Railway Review.*

J. K. Conner, Chief Engineer, New York, Chicago & St. Louis Railway.

Arthur Crable, Engineer Maintenance of Way, Hocking Valley Railway.

⚔C. R. Fickes, Resident Engineer, Florida East Coast Railway.

T. H. Gatlin, Chief Engineer Construction, Southern Railway.

John S. Goodell, Civil Engineer.

C. E. Gosline, Track Engineer, Delaware, Lackawanna & Western Railroad.

John W. Harshaw, Division Engineer, Southern Pacific Company.

Julius Kruttschnitt, Chairman Executive Committee, Southern Pacific Company.

H. A. Lloyd, Maintenance Inspector, Erie Railroad.

W. L. Mapother, President, Louisville & Nashville Railroad.

Bertram Clifford Martin, Resident Engineer, Hudson River Connecting Railroad (New York Central Lines).

⚔Charles Henry Miller, President, Miller-Butterworth Company.

John R. Onderdonk, Engineer of Tests, Baltimore & Ohio Railroad.

G. E. Potter, Division Engineer, New York, Chicago & St. Louis Railway.

J. W. Sammons, Assistant Engineer, International-Great Northern Railway.

Miles Cary Selden, Superintendent, Chesapeake & Ohio Railway.

⚔In Military Service during World War.

GEOGRAPHICAL DISTRIBUTION OF MEMBERSHIP

United States and Possessions

Alabama	7
Alaska	1
Arizona	4
Arkansas	19
California	70
Colorado	11
Connecticut	27
District of Columbia	30
Florida	31
Georgia	47
Hawaiian Islands	1
Idaho	6
Illinois	323
Indiana	44
Iowa	24
Kansas	51
Kentucky	30
Louisiana	16
Maine	9
Massachusetts	42
Missouri	159
Maryland	60
Michigan	58
Mississippi	11
Minnesota	72
Montana	8
Nebraska	26
New Jersey	38
New Hampshire	1
New Mexico	2
New York	205
North Carolina	18
North Dakota	5
Ohio	122
Oklahoma	17
Oregon	10
Pennsylvania	167
Philippine Islands	2
Porto Rico	1
Rhode Island	7
South Carolina	2
Texas	97
Tennessee	22
Utah	8
Vermont	7
Virginia	79
Washington	21
West Virginia	26
Wisconsin	13
Wyoming	4
	2069

Other Countries

Canada	148
Japan	22
China	11
South America	9
Mexico	7
Cuba	5
India	5
Australia	4
Manchuria	3
Costa Rica	2
Egypt	2
Korea	2
Africa	1
Central America	1
Czecho-Slovakia	1
England	1
Ireland	1
Scotland	1
France	1
New Zealand	1
Poland	1
Serbia	1
Siam	1
Spanish Honduras	1
Sudan	1
Sweden	1
Turkey	1
	235

(III) PUBLICATIONS

The Bulletin

The monthly Bulletin is the medium through which the committee reports, monographs, and Association affairs are promulgated. The usual ten numbers have been issued during the year.

The Proceedings

The annual volume of Proceedings is the permanent record of the Association's activities, consisting of committee reports, discussions thereon, monographs, and the business session at the annual meetings. Volume 26, for 1925, aggregated 1500 pages.

The Manual

The additions to and changes in the last edition of the Manual (1921) make it desirable to reissue the volume in the near future. Several committees have made extensive revisions in their current reports; other committees are contemplating similar revisions in their respective sections. The Board of Direction has therefore decided upon a complete reissue of the Manual following the annual meeting of 1927, to include all matter adopted since the 1921 issue, the changes made since that time, and also the action of the 1926 and 1927 annual meetings.

The next edition of the Manual will consist of approximately two thousand pages. In addition, there will be a portfolio of plans for track work, etc.

General Index of the Proceedings

The Board of Direction has decided upon a reissue of the General Index of the Proceedings, bringing the volume up to date, including the current number. The first issue appeared in 1915, and included references to the contents of Volumes 1 to 16, inclusive. The work of compiling the additions is under way and it is expected to issue the revision during the current year.

The General Index will be of material assistance in readily referring to the great amount of valuable data included in the twenty-seven volumes of Proceedings.

(IV) FINANCES

The following is a condensed summary of the Financial Statement given in Exhibit A.

Receipts during the year	$50,927.97
Disbursements	49,744.31
Excess of Receipts over Disbursements	$ 1,183.66

The General Balance Sheet is shown in Exhibit B.

(V) MISCELLANEOUS

Amendment to Constitution

An amendment to the Constitution was submitted to vote by letter-ballot on November 1, 1925. The change involves Section 1, Article VIII, to read as follows:

> "The Annual Convention shall be held in the City of Chicago. The meetings shall begin on a Tuesday in the month of March, as may be determined by the President."

The reason for the proposed change is that it is considered desirable to hold the annual meetings of the A.R.E.A. coincident with the annual exhibit of railway appliances held at the Coliseum. The time for holding the annual meetings of the Association will hereafter be determined following adjournment, and announced by the President within thirty days.

The result of the letter-ballot on the proposed amendment to the Constitution is as follows:

For the Amendment	630
Against the Amendment	164

The amendment having received the required two-thirds majority, it will become effective with the close of the twenty-seventh annual convention.

Representative of Engineering Division on A.R.A. Board of Directors

The American Railway Engineering Association functions also as the "Engineering Division" of the American Railway Association, the meetings being concurrent.

Mr. L. W. Baldwin, President of the Missouri Pacific Railroad, a veteran member of the A.R.E.A., has been elected as the Representative of the Division on the Board of Directors of the A.R.A.

(VI) CONCLUSION

(1) The American Railway Engineering Association is the realization of an ideal, carefully worked out and persistently followed for more than a quarter century.

(2) The Association has been of practical benefit to the transportation industry by progress made in uniformity of practice and standardization—in terminology, methods and structures.

(3) It has advanced and extended railway engineering knowledge, and fostered a spirit of co-operation and fellowship among engineers.

(4) The elements which have contributed to its successful working are briefly:

(a) A definite program;
(b) Continuity of purpose;
(c) Co-operation and loyalty of the members;
(d) Thorough and conscientious committee-work;
(e) Encouragement from railway managements.

(5) Railway operations are becoming constantly more complex, and the problems involved call for analytical ability of the highest order. The members of the American Railway Engineering Association are especially well-qualified to aid in their proper solution, and it is safe to assume that the same spirit of enthusiasm and unselfish devotion will characterize its future activities as it has in the past.

Exhibit A

FINANCIAL STATEMENT FOR CALENDAR YEAR ENDING DECEMBER 31, 1925

Balance on hand January 1, 1925		$54,431.06

RECEIPTS

Membership Account	
Entrance Fees	$ 1,740.00
Dues	22,913.25
Binding Proceedings and Manual	1,678.93
Badges	14.00
Sale of Publications	
Proceedings	3,771.72
Bulletins	1,489.35
Manual	1,287.40
Specifications	490.65
Leaflets	178.75
Advertising	
Publications	2,357.10
Interest Account	
Investments	2,704.65
Bank Balance	226.91
Annual Meeting	
Sale of Dinner Tickets	3,695.00
Miscellaneous	289.96
American Railway Association	
Rail Investigations	8,090.32
Total	$50,927.97

DISBURSEMENTS

Salaries	$10,369.88
Proceedings	5,098.77
Bulletins	11,462.78
Manual	56.25
General Index	1,250.00
Stationery and Printing	1,654.49
Rents, Light, etc	845.00
Supplies	732.61
Expressage	608.58
Postage	1,271.54
Exchange	72.20
Committee Expenses	25.95
Officers' Expenses	111.35
Annual Meeting	6,772.81
Refund Dues, etc.	14.00
Audit	150.00
Miscellaneous	901.30
American Railway Assn.—Rail Investigations	8,346.80
Total	$49,744.51

Excess of Receipts over Disbursements		$ 1,183.66
Balance on hand December 31, 1925		55,614.72
Consisting of:		
Bonds at Cost	$45,785.89	
Cash in S. T. & S. Bank	9,803.83	
Petty Cash Fund	25.00	
	$55,614.72	

STRESSES IN TRACK FUND

Balance on hand January 1, 1925	$ 3,057.06
Received from interest during 1925	85.81
Total	$ 3,142.87
Paid out on Audited Vouchers during 1925	1,033.21
Balance of fund on hand December 31, 1925	$ 2,109.66

Respectfully submitted,
BOARD OF DIRECTION.

REPORT OF THE TREASURER

Balance on hand January 1, 1925		$54,431.06
Receipts during 1925	$50,927.97	
Paid out on audited vouchers	49,744.31	
Excess of Receipts over Disbursements		1,183.66
Balance on hand, December 31, 1925		$55,614.72
Consisting of:		
Bonds at Cost	$45,765.89	
Cash in S. T. & S. Bank	9,803.83	
Petty Cash Fund	25.00	
	$55,614.72	

STRESSES IN TRACK FUND

Balance on hand January 1, 1925	$ 3,057.06
Received from interest during 1925	85.81
Total	$ 3,142.87
Paid out on Audited Vouchers during 1925	1,033.21
Balance of fund on hand December 31, 1925	$ 2,109.66

The Securities listed above are in a safety deposit box of the Standard Trust & Savings Bank, Chicago, Illinois.

Respectfully submitted,
GEO. H. BREMNER,
Treasurer.

I have made an audit of the accounts of the American Railway Engineering Association for the year ending December 31, 1925, and find them to be in accordance with the foregoing financial statements

CHARLES CAMPBELL,
Auditor.

Exhibit B

GENERAL BALANCE SHEET

December 31, 1925

	1925	1924
ASSETS		
Due from Members	$ 2,691.28	$ 3,075.50
Due from Sale of Publications	1,069.00	830.35
Due from Advertising	5,360.00	4,165.00
Due from A.R.A.—Rail Investigations	992.73	726.25
Furniture and Fixtures (Cost)	997.40	997.40
Gold Badges	57.50	68.80
Publications on hand (Estimated)	6,000.00	6,000.00
Manual	1,800.00	3,000.00
General Index	1,250.00	
Extensometers	500.00	500.00
Investments (Cost)	45,785.89	40,941.64
Interest on Investments (Accrued)	301.47	924.53
Cash in Standard Trust & Savings Bank	9,803.83	13,464.42
Petty Cash Fund	25.00	25.00
Total	$76,634.10	$74,738.89
LIABILITIES		
Members' Dues paid in advance	$ 7,264.75	$ 6,398.72
Impact Test Fund on Electrified Railways	285.46	285.46
Advertising paid in advance	5.00	60.00
Due for printing Bulletins	1,375.77	1,081.34
Surplus	67,703.12	66,913.37
Total	$76,634.10	$74,738.89

Mr. Chas. S. Churchill (Norfolk & Western):—I move their approval.

The President:—If there is no objection, we will consider the reports approved.

The President:—The next order of business is the reports of Standing and Special Committees, the first being the Committee on Rules and Organization.

The report will be presented by Mr. W. C. Barrett, Chairman.

(For Report, see pp. 65-79.)

The President:—The next order of business is the report of the Committee on Ballast.

The report of the Committee will be presented by Mr. F. J. Stimson, Chairman.

(For Report, see pp. 81-88.)

The President:—The next report is that of the Committee on Iron and Steel Structures.

Mr. O. F. Dalstrom, the Chairman of the Committee on Iron and Steel Structures, is unfortunately unable to be present and the report will therefore be presented by Mr. B. R. Leffler, Vice-Chairman.

(For Report, see pp. 89-112.)

The President:—The next report is that of the Committee on Electricity. Will the Committee on Electricity please come forward?

The report of the Committee will be presented by Mr. E. B. Katte, Chairman.

(For Report, see pp. 113-170.)

AFTERNOON SESSION

(First Vice-President C. F. W. Felt in the Chair.)

Vice-President C. F. W. Felt:—The Committee on Economics of Railway Location will please come to the platform.

Prof. E. E. King, Chairman of the Committee, will present the report.

(For Report, see pp. 171-176.)

Vice-President Felt:—Chairman C. R. Knowles, the Chairman of the Committee on Water Service, will please come to the platform with his Committee and present the report.

(For Report, see pp. 177-243.)

(Second Vice-President D. J. Brumley in the Chair.)

Vice-President D. J. Brumley:—The report of the Committee on Records and Accounts will be presented by Mr. H. M. Stout, Chairman.

(For Report, see pp. 245-284.)

Vice-President Brumley:—While the next Committee is getting ready to come to the platform, the Chair will annonuce the Tellers to canvass the vote for officers of the Association:

E. H. Barnhart, Chairman; R. D. Garner, T. H. Strate, C. M. Bardwell, H. T. Livingston, J. R. Caswell, T. B. Ballantyne, J. P. Hanley, E. E. King, D. P. Beach, H. W. VanHovenberg, C. S. Heritage, W. J. Burton, S. F. Grear, J. M. Metcalf.

They are requested to report in Room 1502 at seven o'clock tonight to canvass the vote.

The next Committee to report is that on Shops and Locomotive Terminals. The report will be presented by Mr. F. E. Morrow, Chairman.

(For Report, see pp. 285-313.)

WEDNESDAY, MARCH 10, 1926

MORNING SESSION

The President:—The first order of business this morning is the report of the Committee on Signals and Interlocking. The report of the Committee will be presented by Mr. F. B. Wiegand, Chairman.

(For Report, see pp. 315-351.)

The President:—The next order of business is the report of the Committee on Signs, Fences and Crossings. The report will be presented by the Chairman, Mr. T. E. Rust.

(For Report, see pp. 389-434.)

The President:—The report of the Committee on Yards and Terminals will be presented by the Chairman, Mr. J. R. W. Ambrose.

(For Report, see pp. 353-388.)

The President:—The next order of business is the report of the Committee on Uniform General Contract Forms. In the absence of the Chairman and Vice-Chairman of this Committee, Mr. Clark Dillenbeck will present the report.

(For Report, see pp. 435-455.)

The President:—The next report is that of the Committee on Masonry. The report will be presented by Mr. C. C. Westfall, its Chairman.

(For Report, see pp. 457-470.)

The President:—The reception of the report of the Special Committee on Stresses on Railroad Track is next in order. This report will be presented by Prof. A. N. Talbot, Chairman.

(For Report, see pp. 471-472.)

AFTERNOON SESSION

(Past-President J. L. Campbell in the Chair.)

Past-President J. L. Campbell:—The first order of business is the report of the Committee on Rail.

The Rail Committee is one of the Committees of the Association whose work is rivaling that of the Committee on Stresses in Track, and they are also setting a standard to which all of the other Committees will have to come sooner or later.

The report of the Committee will now be presented by Mr. G. L. Moore, the Chairman.

(For Report, see pp. 473-629.)

Past-President Campbell:—The Committee on Track will now come forward. The report of the Committee will be presented by Mr. J. V. Neubert, the Chairman.

(For Report, see pp. 631-686.)

Past-President Campbell:—The Committee on Co-operative Relations with Universities will please come forward. The report of the Committee will be presented by Mr. Robert H. Ford, Chairman.

(For Report, see pp. 1205-1208.)

Past-President Campbell:—This problem is one that is going to grow, but I feel the Association is going to find a solution for it. It is the great human element in our business.

Before we adjourn we will hear the election returns. The Secretary will read the returns.

Secretary Fritch:—The report of the Tellers is as follows:

REPORT OF THE TELLERS

March 9, 1926.

To the American Railway Engineering Association:

We, the Committee of Tellers, report the following as the result of the count of ballots:

For President:	
C. F. W. Felt	1210
For Vice-President (one to be elected):	
W. D. Faucette	714
Edwin B. Katte	525
For Treasurer:	
Geo. H. Bremner	1209
For Secretary:	
E. H. Fritch	1209

For Directors (three to be elected):

L. W. Baldwin	980
R. H. Ford	503
Frank Lee	409
J. V. Hanna	387
W. K. Hatt	330
B. R. Leffler	298
C. H. Stein	289
W. T. Dorrance	262
F. W. Green	223

For Members of the Nominating Committee (five to be elected):

L. B. Allen	811
A. F. Robinson	745
E. R. Lewis	667
C. W. Baldridge	647
W. H. Hoyt	580
J. W. Orrock	537
H. J. Pfeifer	532
F. E. Morrow	518
B. H. Mann	483
F. R. Layng	442
R. B. Robinson	1
W. J. H. Manning	1
E. K. Post	1
W. H. Penfield	1
W. G. Arn	1
C. T. Dike	1
S. A. Jordan	1
Maurice Coburn	1
A. F. Dorley	1
E. H. Pfafflin	1
W. J. Eck	1
Frank Ringer	1
H. M. Bassett	1

Respectfully submitted,

E. H. Barnhart, Chairman;
R. D. Garner,
T. H. Strate,
C. M. Bardwell,
H. T. Livingston,
J. R. Caswell,
T. B. Ballantyne,
J. P. Hanley,
E. E. King,
D. P. Beach,
H. W. VanHovenberg,
C. S. Heritage,
W. J. Burton,
S. F. Grear,
J. M. Metcalf,
Tellers.

Past-President Campbell:—The convention is now adjourned until nine o'clock tomorrow morning.

THURSDAY, MARCH 11, 1926

MORNING SESSION

The President:—The first business this morning will be the report of the Committee on Ties. The report of the Tie Committee will be presented by Mr. W. J. Burton, Chairman.

(For Report, see pp. 687-732.)

The President:—The next order of business is the report of the Committee on Economics of Railway Operation. The report of the Committee will be presented by Mr. G. D. Brooke, the Chairman.

(For Report, see pp. 733-757.)

The President:—We will now interrupt the consideration of this report for a few moments. We are exceedingly fortunate this morning in having a visit from one of our earliest (I will not say oldest, but I would have said oldest if I had not seen him) and most distinguished members. He has come here today as one of our Directors, and has most kindly consented to act as sponsor for the Engineering Division on the Board of Directors of the American Railway Association. I hope he will say a few words to us and give us all a chance to know who he is. I have great pleasure in introducing the President of the Missouri Pacific Railroad, Mr. L. W. Baldwin. (Applause.)

Mr. L. W. Baldwin:—Mr. President and Gentlemen of the American Railway Engineering Association: I came today to be with you and to renew acquaintance with most of you and have the pleasure of seeing and being with the remainder, but primarily to thank you for the confidence that you have shown in me by electing me one of your Directors, because I really believe that this Association has done more in the direction of proper construction, maintenance and largely the operation of railroads than any other such association that has been dealing with these matters.

I am, therefore, very proud and happy to take the position as a Director in the Association, and I only hope that I can be to a reasonable degree helpful to you, because I know that help in this work both for me and the property I represent will be very great.

I particularly appreciate, Mr. President, the opportunity of being here and making these few remarks. (Applause.)

The President:—I am sure we are all delighted to have heard Mr. Baldwin. The Chair thanks him on behalf of the Association for coming here this morning and giving us a word of kindest encouragement.

Before he leaves, I wish to announce that Secretary Fritch has a ceremonial rite which he wishes to perform at the moment, and I will ask him to do so now.

Secretary Fritch:—Mr. President, we are about to lose from the Board of Direction a member who has been of great service to the Association during the past eleven years. He has been a tower of strength in the councils of the Board, and has served with distinction in the various positions he has held while a member of the Board.

Mr. H. R. Safford will retire from the Board due to expiration of term of office at the close of this Convention. I therefore desire to offer the following resolution:

"Resolved, By the American Railway Engineering Association, in convention assembled, that we record our appreciation of the distinguished services rendered by Mr. H. R. Safford in the interests of the Association during his long connection with the Board of Direction.

"Resolved, That as a mark of the esteem and regard in which he is held, a medallion be presented to Mr. Safford."

Mr. Safford, I take pleasure in presenting this medallion to you.

(The audience arose and applauded.)

Mr. H. R. Safford (Gulf Coast Lines):—Mr. Fritch, Mr. Chairman and Gentlemen:—It is somewhat difficult for me to make a suitable response to this act of kindness and appreciation.

If I have at any time rendered any service that has any element of value in it, it is an exceedingly small return for what I think this Association has done for me and for the extremely pleasant contact and experience that this membership has meant to me.

The eleven years that it has been my pleasure and my honor to be an officer and the some fourteen years before that of my services within the ranks have been a period of time in which no other influence, I feel, has been of as great value as the work in this body.

This Association has done more, as I have said previously, to make railroading better; it has done more to create that degree of fraternity in railroad service, which is one of the outstanding features of the business, than any other influence of which I know. I retire as a member of the Board, but I am not retiring as a member of the Association, and while my activities will have to be along more restricted lines, I pledge my continuing interest and support and in any little way that I can further the interests of this body, it shall be an ambition of primary importance. I thank you. (Applause.)

The President:—The next order of business is the reception of the report of the Committee on Roadway. This report will be presented by the Chairman, Mr. C. M. McVay.

(For Report, see pp. 759-828.)

The President:—The next order of business is the report of the Committee on Wooden Bridges and Trestles. The report will be presented by Mr. Arthur Ridgway, Chairman.

(For Report, see pp. 829-912.)

The President:—The report of the Committee on Wood Preservation will be presented to you by the Chairman, Mr. S. D. Cooper.

(For Report, see pp. 913-1001.)

The President:—The Chairman of the Committee on Clearances informs the Chair that his report is purely one of progress, and for that reason it has been decided that the Committee will not be called on, so that at two o'clock we will take up the report of the Committee on Economics of Railway Labor. I hope that you will all be here promptly at two o'clock so we can get the work of this Committee under way quickly.

(For Report, see pp. 1003-1004.)

AFTERNOON SESSION

(Past-President Hunter McDonald in the Chair.)

Past-President Hunter McDonald:—The Chair will ask the Chairman of the Committee on Economics of Railway Labor, Mr. C. C. Cook, to make the opening statement in presenting this report.

(For Report, see pp. 1005-1060.)

Past-President McDonald:—The Committee on Buildings will kindly come forward. Mr. W. T. Dorrance, the Chairman of the Committee, will present his report.

(For Report, see pp. 1061-1204.)

(President J. M. R. Fairbairn resumed the Chair.)

The President:—As a matter of interest to the Convention, the Chair would like to announce that the registration up to the moment for this year was 824 members and 196 guests, a total of 1020. This is the first time in the history of the Association that we have reached the one-thousand mark. (Applause.)

The President:—The result of the ballot on the amendment to the Constitution is 630 in favor, and 164 against, leaving a majority in favor of the amendment of 466. It, therefore, carries.

Mr. C. F. W. Felt (Santa Fe):—I have a resolution to offer:

"Resolved, By the American Railway Engineering Association, in convention assembled, that its thanks are hereby extended to

"E. W. Beatty, Esq., Chairman and President, Canadian Pacific Railway
Dudley F. Holtman, Esq., U. S. Department of Commerce
Rev. Allan P. Shatford, Canon of the Church of St. James, Montreal, Canada

for their excellent addresses at the Annual Dinner on the evening of March tenth."

I move its adoption.

(The motion was carried unanimously.)

Mr. H. M. Stout (Northern Pacific):—Mr. Chairman, we are bringing to a close three days of very intensive work. Casting back over these three days, many pleasant occasions are called to mind, which like ornaments have been thoughtfully provided and are much appreciated. This applies particularly to the unique decorations of the banquet hall last evening, adding to the enjoyment of the annual dinner, and the excursions in prospect tomorrow. I have, therefore, the following resolution to offer:

"Resolved, By the American Railway Engineering Association, in convention assembled, that its thanks are hereby extended to the Canadian Pacific Railway Company for its courtesy in arranging for exhibits at the annual dinner on the evening of March 10; to the Illinois Central Railroad Company, Illinois Steel Company, the Universal Portland Cement Company and the Portland Cement Association, the Pettibone-Mulliken Company, and the Chicago Plan Commission, for their courtesy in planning and arranging trips of interest for the benefit of the members and guests of this Association."

Mr. Chairman, I have the pleasure of moving the adoption of the resolution.

The President:—You have heard the resolution, gentlemen. All in favor please say "aye." It is carried.

Mr. A. F. Blaess (Illinois Central Railroad):—I have a resolution to offer:

"Resolved, By the American Railway Engineering Association, in convention assembled, that its thanks are hereby extended to the Chairmen, Vice-Chairmen and members of the several committees, for their labors during the past year and for the valuable reports presented to this meeting;

"To the technical press for the many courtesies extended during the year and during the convention;

"To the National Railway Appliances Association for the courtesies extended to the officers and members of the Association."

I move its adoption.

The President:—You have heard the resolution, gentlemen. All in favor please say "aye."

Mr. John G. Sullivan (Past-President):—To we old people who have been in this Association twenty-five years or more, it is a great source of pleasure and gratification to see how the Association is growing and how the work is improving and especially so when the younger members responsible for the improvement are those who have been associated with you for some time. I have, therefore, great pleasure in this case to moving the following resolution:

"Resolved, That the members of the American Railway Engineering Association, in convention assembled, desire to place on record their hearty appreciation of the capable manner in which this convention has been presided over by Mr. J. M. R. Fairbairn, and for the efficient administration of the affairs of the Association during his occupancy of the Presidential chair.

"Resolved, That this resolution be spread upon the Minutes of the meeting, and a suitably engrossed copy presented to Mr. Fairbairn."

First Vice-President Felt:—All in favor of this resolution please say "aye." The "ayes" have it. (Applause.)

Mr. J. L. Campbell (Past-President):—My dear Mr. Fairbairn: On behalf of the American Railway Engineering Association, the pleasant assignment which has fallen to me reminds me of the parable of the talents. When the Lord of the kingdom returned after an absence and found that the faithful steward to whom he had entrusted ten talents, accounted to him for twenty, he said to him, as the American Railway Engineering Association now says to you, "Well done, thou good and faithful servant; thou has been faithful over a few things, I will make thee ruler over many things."

When you began your career you were made ruler over a few things. As the result of faithful and productive stewardship, you have been made ruler over many things within and without the American Railway Engineering Association. You stand today more than merely a member and representative of the American Railway Engineering Association; coming from Canada, you also represent that great country on the north which the United States delights to honor through its representatives.

Now, in appreciation of your service to this Association and as a visible token of its regard for you and as a reminder as the years go by of the service that you have rendered to the Association and its thanks to you, the Association is happy in presenting to you this loving cup. We know that you will take it and cherish it with a great deal of pleasure. (Applause.)

The President:—Mr. Campbell and Fellow-Members of the Association: How you can expect me to express my thanks in proper form after an operation of this kind, I do not quite know. I am really at a loss to say anything. I can only say that I appreciate your kindness more than I can tell you, and that I feel that working for the American Railway Engineering Association may be best described as Shakespeare described the quality of mercy—it blesseth him that gives and him that takes. Certainly, working for the American Railway Engineering Association has a twofold effect: If a man is useful to the Association, he is also useful not only to the railway he serves, but to all other railways, and in turn he receives a tremendous amount of benefit from that work. I believe he gets more benefit out of it than anyone else.

In regard to my own share in what we have tried to do in the last year, I can only say that if this is a true expression of your appreciation, your appreciation very much outruns anything that I have done.

I wish at this moment to thank particularly those who have been associated with me in the Association's work—the Board of Direction and the officers generally, for nothing could have exceeded the kindly and sympathetic assistance and co-operation that they have given their President during the past year. I thank you most sincerely for this tribute. (Applause.)

Mr. Fritch will now present the report of the Tellers.

Secretary Fritch:—The result of the vote for officers for the current year is as follows:

President: C. F. W. Felt.
Vice-President: W. D. Faucette.
Treasurer: Geo. H. Bremner.
Secretary: E. H. Fritch.
Directors:
    L. W. Baldwin.
    Robert H. Ford.
    Frank Lee.

Five Members of the Nominating Committee:
    L. B. Allen.
    A. F. Robinson.
    E. R. Lewis.
    C. W. Baldridge.
    W. H. Hoyt.

The President:—Is there any other new business? If not, I will appoint Past-Presidents McDonald and Sullivan as sponsors to the new President and ask them to escort him to the President's chair.

Mr. Felt, in handing you this symbol of office, I can only say that I hope you will receive the same willing co-operation from all the officers of this Association during the coming year that I have received from them during the past year. I wish you every success in this office. (Applause.)

President C. F. W. Felt:—Mr. Fairbairn and Gentlemen of the Association: I thank you very much for this high honor, in fact, the highest honor that anyone can obtain, I believe, in the railroad associations, that you conferred upon me. I deeply appreciate it, and especially when I look back a little at the history of the Association and see who have preceded me.

As far as the future is concerned, I think that we can look to it with great hope, because we have the membership, the thoroughly organized committees and Board of Direction, and above all, plenty of work. I feel sure that we will continue to make progress as long as we realize that there is yet work to do. A great deal has been accomplished but if we will look back, we will see that each year has added something.

Now during this coming year, to use a current expression, it is up to us to "carry on." As I am quite sure that each of you will do your part, I shall endeavor to do mine. I thank you all, gentlemen, very much. (Applause.)

If there is no further business, this convention will stand adjourned *sine die.*

(The meeting adjourned at 3:20 o'clock.)

(The twenty-eighth annual convention of the American Railway Engineering Association will be held at the Congress Hotel, Chicago, March 8, 9 and 10, 1927.)

E. H. Fritch

Secretary.

COMMITTEE REPORTS

REPORT OF COMMITTEE XII—RULES AND ORGANIZATION

W. C. BARRETT, *Chairman;*
M. M. BACKUS,
D. P. BEACH,
H. L. BROWNE,
E. N. BURROWS,
P. D. COONS,
J. H. DAVIDSON,
ARTHUR DANIELS,
J. L. DOWNS,
J. M. FAIR,
P. O. FERRIS,
W. J. FOSTER,
B. HERMAN,
H. H. HARSH,
E. H. BARNHART, *Vice-Chairman;*
J. L. JAMIESON,
B. R. KULP,
E. F. MANSON,
J. A. PEABODY,
R. N. PRIEST,
H. J. PFEIFER,
E. M. SMITH,
J. W. STEPHENS,
C. H. TILLETT,
R. E. WARDEN,
F. B. WIEGAND,
C. R. WRIGHT,
Committee.

To the American Railway Engineering Association:

Your Committee respectfully presents herewith report covering the following subjects:

(1) Revision of the Manual.

(2) Manual of Rules for the Guidance of Employees of the Maintenance of Way Department. (Appendices "A" and "B.")

Action Recommended

(1) No changes recommended.

Your Committee felt that since the Committee's report as a Supplement to the Manual has been in the hands of the members of the Association such a short time, it was preferable to defer any revisions until next year.

(2) That the rules in Appendix "A" be approved for printing in the Manual.

(3) That Appendix "B" be received as information.

Recommendations for Future Work

(1) Revision of the Manual.
   (a) Rules for Inspection of Bridges, Trestles and Culverts.
(2) Continue study and report on "Manual of Rules for the Guidance of Employees of the Maintenance of Way Department."
   (a) Rules for Conduct of Work on Bridges, Trestles and Culverts.

Respectfully submitted,

THE COMMITTEE ON RULES AND ORGANIZATION,
W. C. BARRETT, *Chairman.*

Bulletin 280, October, 1925.

Appendix A

WATER SERVICE REPAIRMEN

E. H. Barnhart, Chairman, Sub-Committee

(Compiled by Committee XIII—Water Service, in Collaboration with Committee XII—Rules and Organization.)

510. Water Service Repairmen report to and receive instructions from the Supervisor of Water Service.

511. They will have immediate charge of helpers, laborers and all other forces under them and will exercise general supervision over pumpers on their districts or assigned territory. They must keep such records as the Supervisor of Water Service may direct and make the required reports of work done and of the receipt, distribution and use of material furnished them.

512. They will have charge of and be responsible for the proper maintenance of water stations, including wells, pipe lines, tanks, water columns, heating plants, windmills and other facilities used in connection therewith. They will be responsible for the maintenance of plumbing, heating and such other facilities as the Supervisor of Water Service may designate. They will be responsible for the proper maintenance of fire pumps, hydrants, hose and other facilities required for protection against fire (exclusive of fire extinguishers, water barrels and buckets) except at locomotive terminals where fire protection facilities are handled by the Mechanical Department.

513. They will have charge of and be responsible for such tools and materials as are necessary for the performance of their work and must know that these are properly used. They must advise the Supervisor of Water Service of the necessity for materials well in advance of the actual need.

514. When necessary to take out of service any water tank, water column or other facilities affecting the water supply or the operation of any other department, either temporarily or permanently, repairmen will notify the Supervisor of Water Service and must not—except in emergency—proceed with the work until the proper authority is obtained. If an emergency exists, they must notify the Supervisor of Water Service and Chief Dispatcher by wire. Proper notice must be given when the facility is restored to service.

515. They must at all times keep the Supervisor of Water Service and Chief Dispatcher advised of their movements so that they may be available in case of an emergency.

BUILDINGS

(Compiled by Committee XII, in Collaboration with Committee VI—Buildings.)

1661. Before depositing new concrete on or against concrete which has set, the surface of the latter must be roughened, thoroughly cleaned of foreign material and saturated with water, and a thick coat of rich grouting spread over the surface *immediately* before placing new concrete.

1662. In patchwork first concrete should be placed with force by throwing from paddle and allowed to harden undisturbed. The first concrete should be kept wet until thoroughly hardened. Patches should be built up by successive application in same way.

1663. Common and face brick work must be laid even and true to line, plumb and level. Brick should be thoroughly wetted either by immersion or sprinkling before laid, except in freezing weather.

1664. All brick courses should be proportioned so that they will work out evenly with heights of windows and doors without split or fractional courses.

1665. The mortar must be thoroughly mixed and used at once. No mortar which has frozen or hardened beyond the point of reworking into plastic mass shall be used.

1666. Centers of approved type must be provided for all openings. They must be well supported and rigidly braced, so as to properly carry the load until the brick work has set.

1667. All openings, anchors, bearing plates, ties and nailing blocks must be properly located.

1668. Brick flues must have approved form of fireproof lining so located as to reduce fire hazard; brick flues not provided with fire brick lining must be provided with terra-cotta flue lining and all joints in this lining must be completely filled with mortar. The fire hazard must be considered in the design and location of all flues. Special precautions must be taken, where new masonry work joins up with old masonry work, to see that the old work is sufficiently bonded, anchors provided and work keyed so that an absolutely tight and neat bond is assured between old and new work.

1669. All mill work and finished lumber must be protected from the sun and rain until used. Framing must be done to give close joints. All corners and angles must be solid and well braced.

1670. Joists must be of the dimensions and spaced as shown on the plans. Joists must not be levelled on wooden blocks or chips. Headers and trimmers must be of sufficient strength to carry the load.

1671. Roof trusses must be framed and built in strict accordance with detail plans, accurately fitted and securely nailed, spiked or bolted. Chords of trusses should preferably be of one piece and must be set level, plumb and securely braced longitudinally and in the planes of the top chord. Trusses must be framed with the proper camber. Rafters and purlins must be accurately set with solid bearing over the wall plates or beams and securely fastened at all points. Sheathing must be of uniform width, securely fastened at every bearing and the joints broken on the rafters.

1672. Siding must be placed horizontal with tight square butt joints closely and accurately fitted against all casings and sills.

1673. Flooring must be laid in even lengths, and must be securely fastened and joints broken on joists.

1674. Window and door frames must be set true and plumb, braced, protected and securely anchored.

1675. Stairs must be strongly and rigidly built to meet local conditions and when exposed to the weather, treads provided with proper pitch.

1676. Flashing must be properly placed to insure roof from leaking.

1677. Guarantee of ready prepared roofing should not be fully relied on to give proper results. Records of service must be kept to see that guarantee is being carried out.

1678. Downspouts and gutters should be placed outside the buildings whenever possible and must be protected against damage, and cleaned regularly.

1679. Green lath must not be used. Lath must be moistened before plaster is applied. Metal lath used in damp or salt air climate must be painted or back plastered.

1680. Lath must be securely fastened at every bearing with broken joints and no lath should extend beyond any corner or angle.

1681. Proper temperature must be maintained to prevent plaster from freezing. Lime and cement must be stored in a dry place until used.

1682. All openings in walls must be made before plastering.

PAINTING

(Compiled by T.&T. Section, A.R.A., in Collaboration with Committee XII—Rules and Organization, A.R.E.A.)

1717. When painting the interior of station buildings and telegraph offices, care must be used not to paint insulated wires and cables, because of the deteriorating effect of ordinary paint on insulation.

HANDLING EXPLOSIVES, SCRAP, AND REFUSE MATERIAL

Scrap and Refuse

3000. Wornout and unserviceable tools must be turned into the stores department, according to instructions.

3001. Salvageable scrap will be picked up and stored at designated points for disposition.

3002. Track ties, head blocks and switch ties removed should be piled adjacent to the track and culled before final disposition.

3003. Material and rubbish from repairs of bridges, buildings, trestles, culverts, telegraph lines, fences, etc., must be cleaned up as soon as the work is completed. Material of a usable nature must be placed in a convenient pile for loading. If rubbish is burned see that the fire is at a safe distance from all structures.

3004. Material piled for inspection or loading must be placed at a safe distance from the track.

3005. Rubbish and waste from station grounds, buildings and freight houses which cannot be burned should be buried or otherwise disposed of as directed.

3006. In burning refuse when incinerators are not available the fire must not be left unattended or started unless sufficient force is at hand for keeping it under control. The fire must be put out before leaving.

Explosives—Dynamite

3025. Danger signs must be conspicuously placed on all buildings and magazines in which explosives are stored. The Supervisor must be familiar with the state and federal laws and local regulations covering the transportation and storage of explosives. He must see that these requirements are understood and obeyed by the employee delegated to handle the explosive to be used.

3026. Dynamite, powder and other explosives shall be stored in fireproof magazines located at a safe distance from the company buildings, or buildings and property of others, in accordance with the law, and where they are not liable to be interfered with.

3027. The supply in storage should be kept at the minimum for the requirements and be removed in small quantities as needed.

3028. Fusees and caps must in no case be stored in the same building with explosives.

3029. No man should be assigned to the handling of these explosives who is not able to satisfy the Supervisor of his qualifications and previous experience in their use.

3030. Employees must not strike or light matches while handling explosives. An employee shall not carry a lighted candle or other fire while handling dynamite or other explosive supplies. No explosives may be brought within five feet of any lantern or enclosed fire.

3031. Under no circumstances may an employee permit dynamite, detonators or other explosives he may be handling to be placed near a fire or within range of flying sparks even though the explosive is packed in a strong tight box.

3032. When frozen, dynamite may fail to explode or explode with little force, and in either case a whole or part of the charge may be left in the "bore" hole or mixed with broken rock or dirt. Such dynamite is liable to explode if struck with a shovel or other tool and cause personal injury or loss of life.

3033. Dynamite is likely to freeze when its temperature falls below 50 degrees Fahr. and dynamite of such temperature must be considered as frozen and thawed before using.

3034. Dynamite may be thawed by using an approved kettle or by placing it in a tight box and burying it in fresh manure.

3035. In thawing dynamite with an approved kettle: First, fill the water compartment with water of such temperature that it will not be higher than 100 degrees Fahr. when the dynamite is put in the compartment provided for it. Second, place the dynamite in the compartment provided for it after ascertaining that the compartment is clean and dry.

3036. Do not place dynamite in the kettle when the temperature of the water is above 100 degrees Fahr.

3037. Do not place the thawing kettle near a lighted lantern or a fire of any kind.

Inflammable Oils

3050. All gasolines evaporate rapidly in hot weather, but even in the coldest weather gasoline gives off inflammable vapors in sufficient amount to ignite readily. This vapor is heavier than air and tends to form a layer along the ground and only mixes slowly with the air.

3051. Gasoline and other similar fuels for use in pumping plants, motor cars, etc., must be kept in tanks buried in the ground and properly ventilated. These tanks must never be filled by open lamp or torch light. Lighted matches, pipes or cigarettes must be kept away from these tanks.

3052. Oil-soaked rags or waste often cause spontaneous combustion. Do not allow these to accumulate.

3053. Fusees, torpedoes or matches must be kept or carried only in containers provided for their protection.

3054. Do not use water on an oil fire. Smother if possible with dry earth, steam or wet blankets.

3055. In case of wrecks involving tank cars of inflammable oils the Section Foreman should be specially careful to:

(a) Police the location.
(b) Cause the removal or prevent the approach of all lights or fires other than closed electric lights.
(c) Keep all unauthorized persons away.

PROCEDURE IN CASE OF ACCIDENT

General

3100. When an accident has occurred the most important point is that someone must take upon himself the direction of affairs. If you are the employee of highest rank on the ground, take command at once.

3101. Immediately send a reliable person to get in touch with the nearest Company's surgeon. Should the need of surgical aid be very urgent, summon any surgeon who can arrive the quickest, at the same time notifying the Company's surgeon.

3102. In the meanwhile, designate those who are to minister to the injured, selecting men you know to be best qualified.

3103. Spectators will crowd around, depriving the injured man of air and hindering you with their advice and comments. Make them stand back at a distance, well out of the way.

3104. Do not permit whisky or other alcoholic liquor to be given the patient while under your direction.

3105. If local fire department is available material assistance can be rendered by them, if called. Do not hesitate to call on them for aid.

Accidents

3125. All telegraphic calls for surgeons will have precedence over all other business, except train orders.

3126. In cases of injuries to passengers or employees requiring surgical aid, the surgeon of the Company who can reach the point the quickest must be immediately called by the officer in charge, and the case put in his exclusive control. If impossible to secure immediate attendance of Company's surgeon, other surgical aid should be promptly secured to attend until the arrival of the Company's surgeon. Upon arrival of Company's surgeon, he shall assume charge of the situation, making proper arrangements with the surgeon already in attendance for continuance, or discontinuance, of services.

3127. When a number of persons are injured, the services of competent surgeons in the vicinity should at once be secured and every attention given the wounded. Company's surgeons must be immediately notified, giving number of persons injured, and what probably will be required for their relief.

3128. The Company will not be responsible for the employment of other surgeons than those above named, and no obligation of any kind, beyond the services required while awaiting the arrival of the Company's surgeon, or subsequently arranged by him, must be assumed for the Company.

3129. The officer in charge will arrange to have the injured persons removed from the scene of the accident as promptly as possible, providing an ambulance or other conveyance, and sending a man or men with the injured persons, when necessary; any expense incurred to be billed direct to the Company, or paid by the person in charge, who will present a statement of same and receive voucher.

3130. No important surgical operation should be performed previous to the arrival of Company's surgeon, except such as may be required for the immediate safety of the patient.

3131. While the Company's surgeons will be assigned to duty within prescribed limits, they will be expected to go out of such limits whenever required.

3132. Employees will be expected, whenever able, to visit the Company surgeon's office for treatment, except where their residence is remote therefrom.

3133. Emergency cases, directions for the use of which are contained therein, will be carried on all trains and at all important shops and stations.

3134. Employees who witness or have any knowledge whatever of an accident, should refrain from giving information to the injured person or anyone else except the Company's officers and claim agents, unless legally required. Persons seeking information should be referred to the Claim Agent or other official of the Company.

3135. It is the desire of the Company that all statements in reference to personal injury accidents should be as full as possible and that all facts should be stated, whether favorable or unfavorable, to the injured person, the Company or its employees.

FIRST AID TO THE INJURED

Shock

3150. After a painful injury, the person will be greatly prostrated, more or less dazed; his face pale and covered with cold sweat, pulse and breathing weak. He is suffering from shock, which will be severe in proportion to the severity of the injury. The best thing to give him is a half or a whole cup of strong black coffee or tea, or even hot water slowly swallowed. Lay him flat on his back with head low. The coldness of his body-surface indicates that all blood is driven to the internal organs. You must return it to the natural channels. Wrap him in warm blankets. Apply bottles filled with hot water, or heated bricks, everywhere about his body and limbs, taking care that you do not burn his skin.

Examination

3155. In order to relieve the suffering of an injured person, you will first have to ascertain the extent of his injury. It may be found necessary to remove some portion of the clothing, which often cannot be done in the usual way, because the slightest movement of the body would greatly increase suffering. With your pocket knife cut off the trousers, coat and shirt by ripping up the seams, but the underclothing must be cut or torn off the easiest way, and likewise the shoes, when a foot is badly crushed. You will generally find a bleeding wound that will call for first attention.

Hemorrhage or Bleeding

3160. Do not forget that exposure of the wound to the air, especially if, at the same time, you elevate the injured part as high as you can get it, is all that is necessary to stop bleeding in a large majority of cases. Pressure of a firm bandage directly upon the bleeding should also be tried.

3161. Should these means fail to stop the bleeding after several minutes' trial, you will have to make pressure upon the blood vessels through which the flow is coming toward the wound. The blood flows from the heart, through the vessels, precisely as water flows from the hydrant through your garden hose. If the water is streaming through a break in the hose, the escape can be stopped by pressure on the hose between the break and the hydrant. In the same way you can stop bleeding from a wound by making pressure on the blood vessels somewhere between the bleeding point and the heart.

3162. In the arm and leg the vessels are buried among the muscles, hence to bring pressure to bear upon them you will have to tie a strong bandage, a handkerchief, rope, strap or similar article tightly around the limb. An article thus employed is called a "constrictor," because it constricts or squeezes close together all the parts within its embrace.

3163. Above the elbow and above the knee there is one bone. The blood vessels lie close to this single bone, and you can compress them with ease between the constrictor and the bone. Below the elbow and below the knee there are two bones, some of the vessels are placed between the two bones. When you wish to stop bleeding in arm or hand injuries, tie the constrictor high on the arm, close to the shoulder, and in leg or foot injuries, tie it high on the thigh close to the groin. In these situations the vessels lie nearer to the surface than in other parts of the limbs, and are therefore more easily compressed.

3164. It will often be sufficient merely to tighten a strong handkerchief around the lightly clothed limb. If this does not succeed, tie the constrictor loosely around the limb, passing a piece of broom handle or stout stick through the loop, and twist it slowly till the bleeding ceases. If this tears or bruises the skin, concentrate the pressure at one point, namely, directly upon the vessels. The course of the vessels in the limbs is easy to remember. In the upper arm they follow a line from the middle of the armpit to the middle of the bend of the elbow; and in the upper leg, from the middle of the groin to the inner side of the knee joint.

3165. First lay bare the limb; then take a small, hard object, a cork, spool, stone; wrap it in cotton or a soft handkerchief to protect the skin, and place it under the constrictor by twisting the stick. The moment bleeding ceases, discontinue the twisting. The stick can be kept in position by looping a bandage around one end of it, and tieing the two ends of the bandage on the opposite side of the limb.

3166. Keep the constrictor just tight enough to stop the bleeding, and no tighter. The pressure should be released every half hour. Should bleeding recommence, quickly replace the constrictor, but it may be laid aside, if bleeding has ceased.

Wounds

3170. To avoid introducing germs, do not wash a wound or allow your hand or the hand of the injured man to touch any part of it. If germs can be kept out, the wound will heal quickly and naturally.

3171. To protect wounds from further injury, apply a dressing, but do not put a cud of tobacco, or waste, or cobwebs, or a soiled handkerchief upon it. Go to your Emergency Box, where you will find, in clean and sterile condition, everything you will need in emergencies. A pad of gauze (called a compress) should always be laid directly upon the wound, taking care not to touch with your hands the surface next to the wound; upon this place a layer of cotton and hold in place by a bandage wound above the limb.

Burns

3175. The suffering caused by a burn is increased by exposure of the burned surface to the air. The white lead used by painters, when brushed over small burns, has been found to give immediate relief. The most convenient remedy for burns is common baking soda, a package of which is in every emergency case. For use on small burns, make the soda into a paste with water, and spread on in a thick coat. When the burn involves a large area of skin it is better to dissolve the entire package (¼ lb.) in half a gallon of water. Take enough triangular bandages from your emergency case, or clean linen from a Pullman car, or from the caboose, soak in the solution and wrap about the burned area. This dressing should be held in position with bandages, and both bandages and dressing be kept wet by frequent liberal sprinkling with the solution.

Broken Bones—Fractures

3180. A simple fracture is one in which the broken bone does not communicate with an open wound in the skin. A compound fracture is one in which the broken bone does communicate with an open wound in the skin.

3181. Ordinarily, a simple fracture need cause no alarm. It may go untended for some hours without serious risk to the patient. If the surgeon is expected to arrive within a reasonable time, make the injured person as comfortable as possible, supporting the broken limb upon pillow, folded coat or other suitable soft pad.

3182. If it should be necessary to take the patient from the scene of the accident, do not attempt to move him until the broken limb has been tightly secured by splints. The reason for this is that the ends of the bone at the break are often sharp and, if roughly handled, they will push their way through the flesh and protrude outside through the skin.

3183. Before applying splints it will greatly add to the comfort of a patient with a simple fracture if you gently draw the injured limb into its natural position, always determining the natural position by comparing the injured limb with the opposite side. But when the injury is a compound fracture, if the injured limb is doubled back under the body or otherwise bent out of line, draw gently into a straight position, but make no effort to restore its natural shape. Dress the flesh wound before putting on splints.

Eye Injuries

3190. When you get something in your eye that has fastened itself to the eyeball, do not pick at it yourself, or allow others to do so. Go to the doctor. The use of a toothpick, lead pencil or pocket knife is objectionable. Such things are usually unclean and almost certain to convey germs into the injured eye and cause inflammation.

3191. By gently turning the lid over a lead pencil you can often see the foreign body; or it may have lodged and not adhered to the eyeball. In these instances you can safely try to remove it. Around the end of a match wrap a bit of clean cotton, or the edge of a soft handkerchief. Brush this lightly over the foreign body several times. If you do not quickly dislodge it you will not be justified in continuing your efforts.

3192. A doctor should be consulted when your eye is inflamed or painful from even a slight injury.

3193. When a severe injury is received, as, for instance, laceration of the eyeball, the injured man must be taken to a surgeon immediately. Cover the eye with absorbent cotton or soft rags soaked in cold water and fasten in place with a bandage around the head. Do not make the bandage too tight, and keep the dressing wet with cold water until the patient reaches the doctor.

Electric Shock

3200. While attempting to rescue a person injured from a powerful electric current, do not touch his body if he is still in contact with the live wire or third rail, because you will receive in your own body the full force of the current.

3201. As rubber is a non-conductor, rubber gloves will give protection; or a rubber coat wrapped about the hands. But these things are not often to be had quickly, and quick action is imperative.

3202. Try to push the wire away, using a dry stick or board. If you can get hold of the coat tails or other loose portion of the clothing pull the injured man by grasping them, provided they are not wet. The current may be broken by cutting a live wire, using a hatchet with a dry wooden handle.

. 3203. Electric shock from powerful currents is very often instantly fatal, but if it is impossible to tell in any case that life is certainly extinct, an attempt should always be made to save the life of the patient by prompt action. A doctor should be summoned with the greatest urgency, but do not waste time waiting for him, as the minutes and seconds are precious.

3204. Electric shock kills by paralyzing the breathing apparatus. The injured person has lost the power of drawing in and expelling air from his lungs. The object of your efforts is to do this for him, by putting his chest through the movements imitating breathing. The best method of practicing artificial respiration, or breathing, is as follows:

Artificial Respiration

3210. The patient is laid on the ground face down. One arm should be bent so that the forehead rests on it. The face must be turned to one side so that the air can pass into the nose and mouth. Kneeling astride the body, place the palms of your hands across the small of the patient's back, with the thumbs nearly together. By bending your body forward and allowing its weight to fall on your wrists, you squeeze his chest into smaller size and expel the air from the lungs. Now release the pressure and the chest will naturally return to its normal size, and air again enters the lungs. Go through this motion about twelve to fourteen times a minute. To carry on artificial respiration is extremely laborious. The services of several persons are required to relieve one another by turns, and efforts should be kept up for at least an hour and a half, as persons apparently lifeless have been revived after long-continued labor.

Drowning—Suffocation

3215. Persons who have been rescued after more or less prolonged submersion in water, and those who have been overcome by gases as in a railroad tunnel, are precisely in the condition resulting from powerful electric shocks. They are suffocated, but the power of breathing may be only temporarily suspended. The only hope of reviving them is by artificial respiration, which should always be attempted and persisted in for two hours.

Sunstroke and Heat Exhaustion

3220. Sunstroke and heat exhaustion are caused by long-continued hard labor in the summer sun or in close, hot shops. It is of importance to be able to know which of the two conditions has been produced, because what would properly do for the aid of one would be harmful for the other.

3221. When a person receives a sunstroke, he falls unconscious. His face is red, breathing noisy, pulse weak, skin burning to the touch.

3222. When overcome by heat exhaustion, the person is simply dazed; the skin pale, cool and moist.

3223. Note the two sets of symptoms are exactly opposite.

3224. In sunstroke the heat of the body must be reduced as quickly as possible. Put the patient in a cool place and apply ice, or cloths wrung out in cold water, to his head and along his spine.

3225. In heat exhaustion keep the patient quiet and give him the assistance advised under "Shock," namely, hot tea, coffee or water, and apply bottles of hot water to his body. In either case, get the person into a doctor's care as quickly as possible.

Emergency Cases

3230. Surgeons speak of dressing material as being clean or as being dirty; there is no middle ground.

3231. The words clean, sterile, antiseptic, in the surgical sense, have the same meaning. A clean dressing is one in which the germs have been destroyed by some means, generally by exposure to intense heat, or to the action of strong chemicals, as bichloride of mercury. After being sterilized the dressing is enclosed in an airtight covering to keep the germs from it, until wanted for use. Sterile dressings are the only kind that should be applied to wounds.

3232. Examine your Emergency Case frequently to satisfy yourself that the supplies are unbroken. If any of the articles are missing, fill the deficiency at once, following the directions pasted inside of the lid.

3233. It is a good practice also to familiarize yourself with every separate article in the case, and the use it may be put to.

Splints

3240. The commonest form of splint consists of two thin, flat boards between which the injured part is securely fastened. But as railroad accidents often happen in out-of-the-way places, where choice of materials cannot be had, it will be necessary to use anything that can be made to answer the purpose of splints. Umbrellas have been used, and canes, barrel staves, fence pickets, pillows, bed clothes, etc. Whatever you select must be long enough to cover the joint above and below the seat of fracture, and if wooden splints are used they must be well padded to protect the skin against chafing and bruising. If the person is lightly clad, put on the splint outside of the clothing.

Stretchers

3245. A stretcher is provided by the Company in every shop, on every baggage car and in the care of many station agents. A list of the latter is printed in the time-table.

3246. When it is necessary to move a person from the place of accident to a hospital or to his home, or elsewhere, and a Company stretcher cannot be produced, one can be constructed for the occasion in the following manner:

3247. The sleeves of two coats are turned wrong side out and the coats are spread on the ground with their lower edges touching. A pole is then passed through the sleeves on each side. The coats are then buttoned up with the buttoned side turned down. A piece of wood should then be placed across the poles as a head rest.

3248. The blanket stretcher is made as follows: Two strong poles should be cut to the proper length; narrow fence rails, limbs of trees, or small saplings will answer. A blanket is then placed on the ground and the poles rolled from each side in the edges of the blanket until the portion remaining unrolled is of sufficient width for a stretcher bed. This stretcher may be made more secure by wrapping cords about the portion of the blanket surrounding the poles, and the cords passed through holes made in the blanket near the poles. Two sticks or pieces of board may be fastened at either end to hold the stretcher ends apart. Many other things, easily procured, may be used for stretchers in case of necessity. Such things as doors, window shutters, boards, mats, etc.

Appendix B

GENERAL SUPERVISOR OF WORK EQUIPMENT

E. H. Barnhart, Chairman, Sub-Committee.

1. The General Supervisor of Work Equipment will report to and receive instructions from the Chief Maintenance of Way Officer.

2. He will be in charge of the maintenance and repairs to the following equipment on the system: Ditching machines, steam shovels, pile-drivers, locomotive cranes, rail-handling machines, tie tamping machines, spreaders, ditcher-spreaders, disking machines, mowing machines, weed burners, motor cars, camp cars, air dump cars and concrete mixers.

3. He will be responsible for all such equipment and will see that it is in condition, at all times, for efficient service.

4. He will handle the distribution and transfer of all such equipment to and from the various divisions.

5. He will keep such records of the performance of each machine, including the labor and material expended in operating, maintaining and repairing, so that he will know the efficiency of each machine.

6. He shall recommend the purchase of new machines and shall pass upon the retiring and dismantling of obsolete equipment.

7. He shall know the location of each machine, and shall arrange for a system of numbering, so as to keep proper records, as hereinbefore provided.

8. In an emergency, requiring the quick dispatch or transfer of any machine, the Division Engineer will make request upon the General Supervisor of Work Equipment.

INSPECTORS OF WORK EQUIPMENT

1. Inspectors of Work Equipment report to and receive instructions from the General Supervisor of Work Equipment.

2. They will perform such duties as may be assigned to them and will act in an advisory capacity to the Supervisors of Work Equipment.

SUPERVISORS OF WORK EQUIPMENT

1. Supervisors of Work Equipment report to and receive instructions from the Division Engineer.

2. They will be in charge, on their respective divisions, of such work equipment as may be under the general supervision of the Division Engineer.

3. They must report their movements daily to the Division Engineer and Chief Dispatcher.

4. They will be responsible for the operation and maintenance of all equipment while under their charge.

5. They must see that the repairmen are properly equipped with tools and supplies, that they perform their work efficiently and make proper reports.

6. They must make a quarterly inspection of all work equipment, reporting on the prescribed form to the Division Engineer, stating the condition and when repairs will be necessary.

7. They must make a monthly report of the performance of work equipment under their jurisdiction, giving amount of work accomplished, cost of fuel, lubricants and other supplies necessary to run the machines and cost of repairs.

8. Division Engineer must be notified when necessary to take any work equipment out of service. Prompt notice must be given when again ready for service.

9. They will keep daily record of location of each machine, together with such records of performance as are necessary to make the required reports.

10. They must see that Work Equipment Repairmen and Operators make the required reports on the costs of repairs and operation of the machines under their charge.

WORK EQUIPMENT REPAIRMEN

1. Work Equipment Repairmen report to and receive instructions from the Supervisor of Work Equipment.

2. They will have immediate charge of helpers, laborers and all other force under them engaged in the maintenance of work equipment.

3. They will keep such records regarding the cost of repairs to work equipment and other roadway machines as the Supervisor may direct and make the required reports of work done and of the receipt, distribution and use of material.

4. They will have charge of and be responsible for the proper maintenance of all work equipment and roadway machines on their assigned territory.

5. They must know the exact condition of work equipment and roadway machines under their jurisdiction, making inspection of them at every available opportunity.

6. They will have charge of and be responsible for such tools and material as are necessary for the performance of their work and must know that these are properly used.

7. Work equipment and roadway machines, including motor cars, must not be shipped to the equipment shop for repairs unless repairs are of such nature that they cannot be performed economically in the field.

8. Equipment in unsafe condition must not be permitted to remain in service.

WORK EQUIPMENT OPERATORS

1. Work Equipment Operators report to and receive instructions from the Supervisor of Work Equipment.

2. They will have charge of any helpers assigned to their machine.

3. They will make the required reports covering the operation of the machine as the Supervisor of Work Equipment may direct and will forward them as instructed.

4. They must know the exact condition of the machine under their charge; that it is in proper condition to do the work efficiently, and if, in their judgment, such machine is not performing efficiently, they must notify the Supervisor, in detail, wherein such machine is not in condition.

5. They will have charge of such tools and equipment as may be assigned to them and if any such tools are not in proper condition, must notify the Supervisor of Work Equipment.

6. They must not ship machine to shop for repairs except upon proper authority from the Supervisor of Work Equipment, but when such machine is forwarded, they must see that it is properly prepared for safe movement and in case an operator does not accompany the machine, all brass and other valuable parts, easily removable, should be taken off, boxed and shipped separately.

REPORT OF COMMITTEE II—BALLAST

F. J. Stimson, *Chairman;*	G. H. Harris, *Vice-Chairman;*
L. L. Adams,	S. A. Jordan,
G. J. Bell,	G. P. MacLaren,
J. G. Bloom,	David McCooe,
C. J. Coon,	M. J. McConough,
C. E. Dare,	M. B. Morgan,
F. T. Darrow,	R. B. Robinson,
J. L. Gonzalez,	W. A. Roderick,
Paul Hamilton,	E. I. Rogers,
K. H. Hanger,	C. B. Stanton,
W. S. Hanley,	Vance Sykes,
A. G. Holt,	C. E. Weaver,
G. D. Hughey,	P. H. Winchester,
H. N. Huntsman,	A. H. Woerner,

Committee.

To the American Railway Engineering Association:

Your Committee respectfully presents herewith report covering the following subjects:

(1) Revision of Manual (Appendix A).
(2) Revised Specifications for Washed Gravel Ballast (Appendix B).
(3) Proper treatment, from the standpoint of ballast, of track in paved streets or at paved street and highway crossings (Appendix C).
(4) Conference with Committee on Rules and Organization (Appendix D).

Action Recommended

1. That the changes in the Manual as outlined in Appendix A be approved, and the revised version substituted for the present recommendations in the Manual.

2. That the Specifications for Washed Gravel Ballast be withdrawn from the Manual and that the revised specifications as shown in Appendix B be accepted as tentative specifications, it being the intention to submit them for final approval one year hence with such modifications as a year's experience with and consideration of them may develop.

3. That, for the reasons given in Appendix C, the Committee be relieved of any further consideration of this subject.

4. That Appendix D be accepted as information. Action in regard thereto being in connection with work of Committee on Rules and Organization.

Recommendations for Future Work

1. Revision of the Manual.

2. Relative value as ballast of stone from various quarries; report on the method of determining. (Carried over.)

3. Relative value from the standpoint of effect upon operating expenses of various kinds of ballast. (Carried over.)

4. Shrinkage of ballast. (Carried over.)

5. Cause of pumping joints. (Carried over.)

6. Outline of work for ensuing year.

Respectfully submitted,
The Committee on Ballast,
F. J. Stimson, *Chairman.*

Bulletin 280, October, 1925.

Appendix A

(1) REVISION OF MANUAL

P. H. Winchester, Chairman, Sub-Committee; L. L. Adams, C. J. Coon, K. H. Hanger, G. D. Hughey.

The plan for a fifteen-tined ballast fork was withdrawn from the Manual by the action of the Association at its 1925 Convention. When the Committee on Ballast recommended that action, it was the intention to prepare a new design which would overcome the features pointed out by the manufacturers which made it impossible to produce the fifteen-tined ballast fork formerly adopted as recommended standard.

It developed in the discussion of this matter that the fifteen-tined fork was intended for use in removing, in connection with cleaning, stone ballast from the crib between the ties. It is apparent that for such use a tool that will remove all material, dirt as well as ballast, is desirable. The ballast shovel, shown in the Manual, is better fitted for such work than a ballast fork, even with the tines as close together as in the discarded plan.

Conclusions

It is recommended that no design for a fifteen-tined ballast fork be provided for inclusion in the Manual.

It is further recommended that the Specifications for Ballast Forks, adopted, Volume 22, of 1921, printed in Manual of 1921, on pages 88-91, and for Ballast Shovel, adopted, Volume 24, of 1923, printed in Supplement to Manual, 1921, pages 3-7, be revised by eliminating plans printed on pages 6 and 7 of Supplement to Manual of 1921 and further by adding to the plans on pages 91 and 5, respectively, a note reading:

> "Dee handles of the built-up type may be substituted if designs, meeting the approval of the .... Engineer, are submitted."

Explanation: The scarcity of good handle timber makes the wood "Dee" handle difficult to secure. There have been developed designs in metal as well as split "Dees" which are not only practical and serviceable, but are economical in the use of timber. The revision proposed provides for their use at the option of the purchaser. The adding of the proposed note to the plan on page 5 makes plans on pages 6 and 7 of Supplement to Manual of 1921 unnecessary.

Appendix B

(2) REVISION OF SPECIFICATIONS FOR WASHED GRAVEL BALLAST

C. E. Dare, Chairman, Sub-Committee; J. G. Bloom, H. N. Huntsman, G. P. MacLaren, A. H. Woerner.

The existing Specifications for Washed Gravel Ballast were adopted at a time when the use of such material was comparatively new. It was recognized by the Committee on Ballast that it was an imperfect specification and with a view to learning the feeling in regard thereto, the Sub-Committee sent out the following questionnaire to the railroads:

> 1. Should the amount of sand which is permitted by the specifications be changed?
> 2. What per cent of gravel should there be between one-half inch and the No. 10 screen?
> 3. Is it desirable to lower the maximum size from 2½ inches to 2 inches?
> 4. Should the per cent of large aggregate between the maximum size and one-inch be limited to some particular per cent of the total volume?

Replies were received from 33 railroads using gravel ballast and these indicated a change desired.

It is recognized by the Committee that gravel may be well washed, well screened and well graded and yet be practically worthless as ballast because of its lack of resistance to disintegration and wear. Some work has been done looking towards the development of a test for "Soundness." As yet nothing has been developed that can be put into practice, but it is hoped that in our next report such a test will be in shape to present for your consideration.

In view of the information developed by the questionnaire referred to above and from other sources, the Committee proposes the following:

Present Specifications	*Revised Specifications*
Gravel for ballast shall be so prepared that dust, loam and dirt are removed, that all aggregates that will not in any position pass through a 2½ in. ring are rejected; and that the sand contained in the ballast shall not, in volume, exceed 20 per cent nor be less than 15 per cent of the material as loaded for use.	Gravel for ballast shall be so prepared that all dust, dirt and loam are removed, that all aggregates that will not in every position pass through a 1½ in. ring are either rejected or crushed and returned to the ballast and that the resultant product conform to the following:
The term "sand" where used in these specifications, refers to any hard granular comminuted rock	Where the percentages of crushed material runs between nothing and 20, the ratios of various sizes of

Present Specifications	*Revised Specifications*
which will pass through a No. 10 screen and be retained on a No. 50 screen.	aggregates to the whole shall be as follows: 1/10 in. to ¼ in..........min. 25% max. 40% ¼ in. to ½ in.............min. 20% max. 30% ½ in. to 1 in..............min. 20% max. 55% 1 in. to 1½ in............min. 0% max. 35% Where the percentage of crushed material runs more than 20 and less than 40, the ratios of various sizes of aggregates to the whole shall be as follows: 1/10 in. to ¼ in..........min. 10% max. 30% ¼ in. to ½ in............min. 20% max. 35% ½ in. to 1 in..............min. 20% max. 60% 1 in. to 1½ in.............min. 0% max. 50% Where the percentage of crushed material is more than 40, the ratios of the various sizes of aggregates to the whole shall be as follows: ¼ in. to ½ in............min. 20% max. 35% ½ in. to 1 in.............min. 25% max. 60% 1 in. to 1½ in............min. 5% max. 55%

Test No. 1. Dust, Dirt or Loam

A sample of the prepared ballast containing one-eighth (⅛) cubic foot shall be placed in a watertight receptacle having a capacity of not less than one (1) cu. ft. Into this receptacle shall then be placed two quarts of clear water, after which the receptacle shall be agitated until the gravel is thoroughly washed. The water shall be drained off immediately and placed in a glass jar and allowed to settle. If the sediment deposited in the bottom of the jar is more than one-half (½) of one (1) per cent of the volume of sample, the output of the plant shall be rejected until the fault has been corrected.	A sample of the prepared ballast containing one-eighth (⅛) cubic foot shall be placed in a watertight receptacle having a capacity of not less than one (1) cu. ft. Into this receptacle shall then be placed two quarts of clear water, after which the receptacle shall be drained off immediately and placed in a glass jar and allowed to settle. If the sediment deposited in the bottom of the jar is more than one-half (½) of one (1) per cent of the sample, as determined by weight, the output of the plant shall be rejected until the fault has been corrected.

Test No. 2. Large Aggregate

A sample weighing not less than 150 lb. shall be placed in or on a screen having round holes 2¾ in.	A sample weighing not less than 150 lb. shall be placed in or on a screen having round holes 1½ in. in

Present Specifications	*Revised Specifications*
in diameter. If a thorough agitation of the screen fails to pass through the screen 98 per cent of the material, as determined by weight, the output of the plant shall be rejected until the fault has been corrected.	diameter. If a thorough agitation of the screen fails to pass through the screen 98 per cent of the material, as determined by weight, the output of the plant shall be rejected until the fault has been corrected.
Test No. 3. Sand One cubic foot of the prepared ballast shall be thoroughly dried, placed in a screen having ten meshes to the inch and the screen agitated till all particles which will pass have passed through the screen. If the material which passes through the screen exceed 20 per cent or is less than 15 per cent in volume of the original sample, the output shall be rejected until the fault has been corrected.	One cubic foot of the prepared ballast shall be thoroughly dried, weighed and placed in a screen having ten meshes to the inch and the screen agitated till all particles which will pass have passed through the screen. If the material which passes through the screen exceed 3 per cent of the original sample, as determined by weight, the output shall be rejected until the fault has been corrected.
Inspection In case inspection develops the fact that the material which has been or is being loaded is not in accordance with these specifications, the inspector shall notify the manufacturer to stop further loading until the fault has been corrected, and to dispose of all defective material that had been loaded in cars, which shall be done at the expense of the contractor.	No change.
Measurements When ballast is being paid for by the ton, and it is impracticable to weigh each car, the weight per yard shall be obtained by weighing at frequent intervals not less than five cars loaded with ballast, the contents of which have been carefully measured. The weight per yard obtained by such a test shall be used in figuring the weight per car until another test is made.	No change.
When ballast is paid for by the yard, the amount shall be determined by weighing each car, where practicable, and applying the weight per yard as determined by frequent tests. When impracticable to weigh each car, the contents of each car will be carefully estimated by comparison with cars, the contents of which have been actually measured.	No change.

Conclusions

It is recommended that the Specifications for Washed Gravel Ballast now appearing in the Manual be withdrawn and that the revised form prescribed herewith be accepted as a tentative specification with a view to its adoption as recommended practice one year hence.

Appendix C

(3) PROPER TREATMENT, FROM THE STANDPOINT OF BALLAST, OF TRACK IN PAVED STREETS OR AT PAVED STREET AND HIGHWAY CROSSINGS

G. H. Harris, Chairman, Sub-Committee; G. J. Bell, David McCooe, W. A. Roderick, E. I. Rogers.

In taking up this question, it was learned that Committee IX—Signs, Fences and Crossings, had this same subject under consideration and as it so intimately concerns the work they are handling, this Committee thought best to leave the subject entirely in their hands.

Conclusions

It is recommended that the Committee on Ballast be relieved from further consideration of this subject, except to collaborate with Committee IX, should there be any question in regard to the subject in regard to which they desire such collaboration.

Appendix D

SPECIAL SUB-COMMITTEE OF COMMITTEE ON BALLAST TO WORK WITH THE COMMITTEE ON RULES AND ORGANIZATION

A. G. Holt, Chairman, Sub-Committee; J. G. Bloom, E. I. Rogers.

Discussion by correspondence in regard to rules pertaining to ballast was carried on with Committee XII and the following changes were agreed to.

Referring to Volume 26 of the Bulletin, dated November, 1924, and page 192 and those immediately following:

	Present Form	*Revised Form*
Rule 785	When unloading ballast care must be exercised to secure proper disposition and avoid waste. If special ballast cars are not available hopper bottom cars should be used.	When unloading ballast care must be exercised to secure proper disposition and avoid waste. Cars available best adapted to the work should be used.

	Present Form	*Revised Form*
Rule 790	It is not possible to maintain good riding track under heavy traffic with insufficient ballast. The purpose of ballast is to provide uniform bearing for the track, distribute the weight of the train load to the roadbed, hold the track in position and assist in drainage.	The object of ballast is to secure a solid and uniform bearing for the ties, distribute the applied load over a large surface, hold the ties firmly in position, give elasticity to the track and allow the water to pass off freely.
Rule 791	Track must be kept in good line and surface while ballasting. The ballast program should be so arranged, and the supply so regulated, as to leave the least possible open track when the season closes. During the progress of the ballasting, open track should be watched carefully and protected with the prescribed slow signals, if necessary.	Before distributing ballast the roadbed should be carefully prepared with embankments and cuts widened to conform to standard plan. Track must be kept in good line and surface while ballasting and stakes should be set for this purpose. The ballast program should be so arranged and the supply so regulated as to leave the least possible open track during the progress of the work, with no open track when the season closes. During the progress of the ballasting open track should be watched carefully and protected with the prescribed slow signals.
Rule 792	Where directed by the Division Engineer, preparatory to the distribution of new ballast, all the old ballast and unsuitable material must be removed to the bottom of the ties, for the full width of the roadbed, the old ballast cleaned and the unsuitable material used for widening enbankments and other purposes. At the same time, all ties requiring renewal should be replaced and the ties properly spaced, if necessary.	Where directed by the Division Engineer, preparatory to the distribution of new ballast, all the old ballast and unsuitable material must be removed to the bottom of the ties for the full width of the roadbed, the old ballast cleaned and the material unsuitable for ballast used for widening embankments or other purposes. At the same time all ties requiring renewal should be replaced and the ties properly spaced.
Rule 793	When the old ballast has been thoroughly cleaned, sufficient new ballast should be unloaded to make the first raise, which is usually made by shovel tamping the ties. When ballasting or surfacing track out of face, both rails should be raised together. It is safer, especially where traffic is heavy and fast, to raise both rails together, than to raise and surface one rail, and then bring the other up to grade.	When the old ballast has been thoroughly cleaned, sufficient new ballast should be unloaded to make the first raise, which is usually made by shovel tamping the ties. Care must be taken in handling ballast to keep it clean and free from earth. Rock or slag ballast must be handled into the track only with ballast forks. When ballasting or surfacing track out of face, both rails must be raised together.

Present Form	*Revised Form*
Rule 795	
In gravel or broken stone ballast, tamp the ties solid from 15 in. inside of the rail to the ends. If possible, the end of the tie outside of the rail should be tamped first and a train allowed to pass over before tamping on the inside of the rail. The space under the rail should be tamped well. The center of the tie should not be tamped.	In gravel or broken stone ballast the ties should be tamped solid from 15 in. inside the rail out to the ends. The space under the rail should be tamped well. The center of the tie should not be tamped.
Rule 796	
Where the track is electrically bonded the ballast must be kept at least one inch below the base of rail. At road crossings, platforms, etc., where this is not practicable, the rails may be insulated by painting them with an asphaltum or tar product, and good clean stone mixed with the same material may be used for at least 1 foot each side of the rails.	Where the track is electrically bonded, the ballast must be kept at least one inch below the base of rail. At road crossings and platforms where this is not practicable, the rails should be insulated by painting them with an asphaltum or tar product, and good clean stone mixed with the same material should be used for at least one foot each side of the rail.

Conclusion

Submitted as information.

REPORT OF COMMITTEE XV—IRON AND STEEL STRUCTURES

O. F. Dalstrom, *Chairman;*
P. S. Baker,
J. E. Bernhardt,
A. W. Carpenter,
M. F. Clements,
R. P. Davis,
F. O. Dufour,
Thos. Earle,
W. R. Edwards,
G. A. Haggander,
Reuben Hayes,
C. S. Heritage,
Otis E. Hovey,
J. B. Hunley,
G. H. Gilbert,
P. G. Lang, Jr.,
Crosby Miller,
P. B. Motley,

B. R. Leffler, *Vice-Chairman;*
Albert Reichmann,
A. F. Robinson,
H. N. Rodenbaugh,
O. E. Selby,
I. L. Simmons,
P. B. Spencer,
R. O. Stewart,
H. B. Stuart,
R. M. Stubbs,
G. H. Trout,
F. E. Turneaure,
F. P. Turner,
H. T. Welty,
A. R. Wilson,
W. L. Wilson,
W. M. Wilson,

Committee.

To the American Railway Engineering Association:

Your Committee respectfully presents herewith report covering the following subjects:

(1) Revision of Manual (Appendix A).
(2) Specifications for Steel Highway Bridges (Appendix B).
(6) Instructions for Maintenance Inspection of Superstructures of Steel Bridges (Appendix C).
(9) Column Tests (Appendix D).
(10) Specifications for the Waterproofing and Drainage of Solid-Floor Railway Bridges (Appendix E).
(11) Investigation of Copper-Bearing Steel for Structural Purposes (Appendix F).

Action Recommended

1. That the report on Revision of Manual (Appendix A) be acted on as follows:

(a) The part covering Bearing Pressures on Large Rollers to be received as information.
(b) The part covering "Punched Work" and "Reamed Work" to be received as information.
(c) The part covering removal of certain portions of the Manual to be approved.

2. That the report on Specifications for Steel Highway Bridges (Appendix B) be received as information.

6. That the report on Instructions for Maintenance Inspection of Superstructures of Steel Bridges (Appendix C) be approved for publication in the Manual.

Bulletin 280, October, 1925.

9. That the report on Column Tests (Appendix D) be received as information.

10. That the Specifications for the Waterproofing and Drainage of Solid-Floor Railway Bridges (Appendix E) be received as information.

11. That the report on Investigation of Copper-Bearing Steel for Structural Purposes (Appendix F) be received as information.

Some progress has been made during the year on Subject No. 4, Rules for Lighting Bridges, and a Uniform Code of Regulations and Signals for Operating Draw Bridges.

No progress has been made during the year on the other four subjects on the Committee's Outline of Work, given below:

3. The electric welding of connections in steel structures.
5. The maintenance of bridges, including equipment for that purpose.
7. Investigations and tests of I-beams connected in groups by diaphragms and bracing.
8. Tests and study of the behavior of bridge pins.

Recommendations for Future Work

The Committee recommends the re-assignment of the following subjects in the form given:

1. Revision of Manual.
2. Specifications for steel highway bridges.
3. The electric welding of connections in steel structures.
4. Rules for lighting bridges, and a uniform code of regulations and signals for operating drawbridges, conferring with the Committee on Signals and Interlocking.
5. The maintenance of bridges, including equipment for that purpose.
6. Investigations and tests of I-beams connected in groups by diaphragms and bracing.
7. Tests and study of the behavior of bridge pins.
8. Column tests.
9. Specifications for the waterproofing and drainage of solid-floor railway bridges.
10. Investigation of copper-bearing steel for structural purposes.
11. Specifications for steel tanks and their supports, for the storage of water and oil, collaborating with the Committee on Water Service.
12. Outline of work for the ensuing year.

The following new subjects are recommended:

1. Information regarding the use of alloy steels for bridges, with special reference to economic features.
2. Investigation of bearing pressures on large rollers.

Respectfully submitted,

The Committee on Iron and Steel Structures,

O. F. Dalstrom, *Chairman.*

Appendix A

(1) REVISION OF MANUAL

B. R. Leffler, Chairman, Sub-Committee; A. W. Carpenter, W. R. Edwards, P. G. Lang, Jr., P. B. Motley, I. L. Simmons.

During the past year the third edition of the General Specifications for Steel Railway Bridges was issued. This edition includes all revisions adopted by the Association to August, 1925. These Specifications should replace the Specifications in the 1921 edition of the Manual.

The matter under the subject Inspection of Bridges and Records of Inspection, page 725 of the 1921 edition of the Manual, should be eliminated as it will be superseded by the matter in Appendix C of this report.

Punched Work and Reamed Work

During the past year, the tests of punched work and reamed work mentioned in the Committee's report at the 1925 convention, were continued under the direction of Prof. F. O. Dufour at Lafayette College, Easton, Pa. The tests have not been studied enough to reach a conclusion, but it is the intention to consider the tests fully the coming year and make a final report.

Bearing Pressures on Large Rollers

The tests on bearing pressures on large rollers mentioned in the Committee's report to the 1925 convention, are being continued under the direction of Prof. W. M. Wilson at the University of Illinois.

The tests thus far made were to determine the influence of:

(a) The diameter of the segment.
(b) The length of the segment measured parallel to its axis.
(c) The relative value of steel castings and steel forgings.
(d) The hardness of steel castings as controlled by their chemical composition.

Another series of tests is planned to determine the influence of hardness upon the load that produces set, when different degrees of hardness are obtained by various heat treatments of steel castings.

Appendix B

(2) SPECIFICATIONS FOR STEEL HIGHWAY BRIDGES

J. B. Hunley, Chairman, Sub-Committee; R. P. Davis, A. F. Robinson, O. E. Selby, H. B. Stuart, F. E. Turneaure, H. T. Welty.

The subject of Specifications for Steel Highway Bridges is under consideration by a Conference Committee, composed of three representatives from the A.R.E.A. (Committee XV) and three from the American Association of State Highway Officials. A representative of the American Institute of Steel Construction and two additional members of Committee XV are participating in an advisory capacity.

The A.R.E.A. representatives are J. B. Hunley, Chairman; Albert Reichmann and O. E. Selby.

The A.A.S.H.O. representatives are:

E. F. Kelley, Chief, Division of Tests and Research, Bureau of Public Roads, Washington, D. C.
L. N. Edwards, Bridge Engineer, State Highway Commission, Augusta, Maine.
Searcy B. Slack, Bridge Engineer, Georgia Highway Commission, East Point, Georgia.

The advisory participants are Lee H. Miller, O. E. Hovey, and H. T. Welty.

The formation of the Conference Committee was described in the Committee's report at the Convention of 1925, Appendix B, Bulletin 271, page 281.

The activities of the Sub-Committee during the past year were devoted to the work of the Conference Committee. Five meetings of two days each have been held by the Conference Committee. Excellent progress has been made in preparing specifications, using as a basis the Specifications for Steel Highway Bridges published by the A.R.E.A. in 1924, Bulletin 262, page 239, and the specifications adopted by the A.A.S.H.O. in 1923 and approved by the Secretary of Agriculture for use in Federal-Aid road work. Other specifications and sources of information have been consulted.

A fine spirit of cooperation has been manifested, the representatives of both associations as well as the advisors working with an earnest desire to agree upon and recommend common specifications. Questions upon which there have been differences of opinion have been considered in an open-minded way and the work has progressed rapidly. The prospects for complete agreement on specifications are favorable. It is expected that the Committee's report in 1927 will include complete specifications for steel highway bridges.

Appendix C

(6) INSTRUCTIONS FOR MAINTENANCE INSPECTION OF SUPERSTRUCTURES OF STEEL RAILWAY BRIDGES

H. B. Stuart, Chairman, Sub-Committee; J. E. Bernhardt, R. P. Davis, G. H. Gilbert, G. A. Haggander, I. L. Simmons, P. B. Spencer.

Responsibility of Inspectors

1. These instructions are for the guidance of inspectors in the maintenance inspection of steel railway bridges. Inspectors will be held responsible for the performance of their duties in accordance with these instructions.

2. The Inspector shall make a complete detailed inspection of every bridge.

Communications

3. Unless there are other instructions, copies of communications sent to other officials shall be sent to the Bridge Engineer.

Drawings and Rules

4. The Inspector shall be familiar with standard bridge drawings, and the rules and instructions applying to the maintenance of bridges.

Bridge List

5. A list of the bridges will be furnished to the Inspector by the Bridge Engineer. This list will give the number (or name) and location of each bridge, type of superstructure, and lengths of spans. In each case the number (or name) and location of the bridge given in the list shall appear on the Inspector's report. The Inspector shall report any errors in the information given in the list, and shall furnish other information to the Bridge Engineer when required.

Emergency Reports

6. If a bridge is found in need of immediate repairs for safety, the Inspector shall notify, by the quickest means available, the proper Division official and the Bridge Engineer, giving the bridge number (or name), description, location, nature of defects, and temporary repairs needed. The Inspector shall send to the above mentioned officials, by the first train, a complete report in writing, with a detailed sketch showing the defects. If necessary, the Inspector shall protect traffic in accordance with the rules of the Operating Department.

Reports

7. The Inspector shall make a record of the inspection of every bridge. This record shall be made at the site, at the time of the inspection, and on a form provided for that purpose. He shall make a written report

as required, giving his recommendations as to the repairs needed and when they should be made.

8. On the report form which accompanies these instructions, are listed the features most frequently found in need of attention, but this form shall not be taken as listing all features requiring inspection. Remarks on features not listed in the form shall appear on the blank part of the form or on a separate sheet. Only one side of a sheet shall be used.

9. On the report form symbols shall be used as follows:

O—Opposite items which do not apply to the bridge inspected.

OK—Opposite items referring to features which do not need attention.

X—Opposite items under which are made special remarks on repairs needed. The identifying numbers of the items so marked shall be entered in the blank ruled part of the sheet, with a concise but complete description of the features needing attention, together with recommendations for repairs.

One of these symbols shall appear opposite every item on the form.

Features to Be Examined

10. The Inspector shall examine the bridge as to the following features and the others listed on the report form:

(a) DECK

Size, spacing, and depth of ties over supports.
Uniformity of bearing of ties.
Condition of timber as to defect and decay.
Number and size of defective ties, guard timbers, and guard rails.
Fastenings of ties.
Fastenings of guard timbers and guard rails.
Size of tie plates.
Condition of walks and railings.
Condition of planking between rails and between tracks.
Condition of refuge bays.
Condition of ballasted deck.
Whether waterproofing is effective or requires repairs.

(b) FIRE PROTECTION

Description and condition of fire protection.

(c) TRACK

Condition of rails, joints, and fastenings.
Alinement of track and its relation to the steel structure.
Surface of track on bridge and on approaches. Where the track is out of line or surface, the report shall show the location, amount, and probable causes.

(d) SHIMS AND BLOCKING

Condition of shims and blocking, giving description and location, making sketch if necessary.

(e) BRIDGE SEATS

Condition as to defects and cleanness.

(f) ANCHORS AND BEARINGS

Whether the superstructure is securely anchored to the masonry.
Whether bed plates, rollers, and pedestals are clean, in correct position, and have full bearing.
Whether rollers are operating properly.
Whether there are any flaws or breaks in bearings.

(g) EXPANSION

Clearance between expansion ends and masonry or adjoining spans.
Whether there is any apparent movement of the masonry.

(h) PAINT

Condition of paint.
Date of last painting, number of coats and kind of paints, as stenciled on the bridge.
Whether spot painting or repainting is necessary.

(i) STRAIGHTNESS AND ALINEMENT OF MEMBERS

Condition of individual members as to bends and kinks.
Camber of trusses.
Alinement of trusses, girders, floor members, and towers.
Adjustment of eye-bars and counters.

(j) DAMAGE FROM BLOWS

Parts damaged by blows from equipment, lading or floating objects.
Location and extent of damage, making sketch to show parts damaged and repairs suggested.

(k) CRACKS AND BREAKS

Cracks and breaks, especially in floor connection angles, hangers, pin plates, fillets of angles of flanges and posts, and in end sections of lower chords or flanges over or near bearings.

(l) PINS, PIN HOLES, AND NUTS

Condition of pins and pin holes, as to movement and wear.
Pins should be observed under traffic, if practicable. The report shall give the location of the pins observed, the amount of movement of the pins, and the wear of pins and pin holes if it can be determined.
Whether pin nuts are tight.

(m) RIVETS AND TURNED BOLTS

Location and number of rivets and turned bolts that are loose and of rivets that have badly corroded heads, giving special attention to floor connections.

(n) CORROSION

Condition of members as to loss of section from corrosion, noting extent of such action, with measurements of remaining section if members are badly corroded.

(o) CLEANNESS

Collection of dirt on horizontal surfaces.

(p) MOVABLE BRIDGES

1. *Lubrication*
   - Whether a lubrication chart is posted and the instructions on it are followed.
   - Whether moving parts have been kept sufficiently lubricated. They should be observed during operation. The report shall show whether lack of lubrication is due to inattention or to inadequate facilities. If facilities are inadequate, complete information shall be given with recommendation for improvement.
2. *Gears*
   - Condition of gears as to:
     - Accurate meshing.
     - Fit on shafts.
     - Fit of keys.
     - Breaks, flaws, and excessive wear.
     - Protection against falling objects.
     - Cleanness.
3. *Bearings*
   - Whether bearings have proper linings and good running fit.
   - Whether shafting is accurately alined and whether collars and thrust bearings are in adjustment.
   - Attachment of caps to bases and of bearings to supports.
   - Alinement, fit, and wear of trunnions and trunnion bearings.
4. *Castings*
   - Condition of wedges, sheaves, locking devices, rollers, treads, etc., as to breaks, or flaws which might cause breaks.
5. *Cables*
   - Adjustment of cables as indicated by slackness, inclination of equalizer bars, or uneven seating of spans.
   - Condition of cables as to rust and excessive accumulations of hardened grease.
   - Broken wires and broken strands.
   - Condition as to lubrication.
   - Working clearances.
   - End connections and clamps.
6. *Clutches and Brakes*
   - Working condition and cleanness.
7. *Power Equipment*
   - Condition for delivering the necessary power.
   - Whether properly maintained.
8. *Mechanical Features*
   - Operating condition.
   - Adjustment of balance wheels.
   - Adjustment of wedges or other lifting devices.
   - Entire turntable of swing bridges.
   - Rail locks and signal interlocking connections.
   - Navigation lights.
   - Clearances through a complete cycle of operation

8. *Mechanical Features*—Continued
    - Balance through a complete cycle of operation.
    - Safety devices—electrical and mechanical.
    - Lightning protection of power plant and superstructure.
    - Condition and adjustment of guides, centering devices, buffers, and bridge locks.
    - Condition and fastenings of racks, tracks, and tread plates.
9. *Counterweights*
    - Condition of counterweights and their supports.
10. *Operating Diagram*
    - Whether an operating diagram is posted.
11. *Record of Openings.*
    - Whether a complete record is being kept of bridge openings, vessel movements, and happenings affecting the interests of the Railway Company.

General

11. The Inspector shall report indications of overload or failure in any part of the bridge. He shall observe the behavior of the bridge during the passing of live load, if practicable, noting excessive vibration, deflection, and side sway.

Attachments of wires, pipes, etc., that may be harmful to the bridge shall be reported.

REPORT FORM (first page)

NAME OF RAILWAY

Inspection Report, Superstructures of Steel Railway Bridges

.......................DIVISION BRIDGE No.......................

Date inspected................ Inspector.........................

Description: Name, number, lengths, and kinds of spans.................

....

1. Number board
2. Waterway
3. Highwater marks
4. Deck
   (a) Ties
   (b) Guard timbers
   (c) Guard rails
   (d) Planking
   (e) Refuge bays
   (f) Hook bolts
   (g) Guard timber bolts
   (h) Guard rail fastenings
   (i) Track alinement
   (j) Track level
   (k) Track fastenings
   (l) Tie plates
5. Fire protection
6. Shims and blocking
7. Bridge seats
8. Anchors and bearings
9. Expansion
10. Paint
11. Straightness and alinement of members
12. Damage from blows
13. Cracks and breaks
14. Pins, pin holes, and nuts
15. Rivets and turned bolts
16. Corrosion
17. Clearances
18. Movable bridges
19. Vibration, deflection, and side sway.
20. Attachments

Remarks:

Items requiring immediate attention.....................................

Items requiring attention for good condition.............................

REPORT FORM (second and following pages)

NAME OF RAILWAY

Inspection Report, Superstructures of Steel Railway Bridges

............DIVISION BRIDGE NO......... DATE INSPECTED.........

Appendix D

(9) COLUMN TESTS

P. B. Spencer, Chairman, Sub-Committee; A. W. Carpenter, F. O. Dufour, Thos. Earle, G. H. Gilbert, O. E. Hovey, J. B. Hunley, Albert Reichmann, H. N. Rodenbaugh, F. E. Turneaure, W. M. Wilson.

A special committee of the American Society of Civil Engineers, of which Dean Turneaure is Chairman, has been at work during the past two years collecting and studying existing data on column tests. That committee will outline a program of tests based on the findings from the study of former tests, and of certain preliminary tests made recently for its guidance in outlining such a program.

The Committee on Iron and Steel Structures, through Dean Turneaure, who is also a member of this Committee, has maintained contact with the Special Committee of the A.S.C.E. in its work to the present time. When a program of tests is completed, it is intended to arrange for cooperation between the two committees in making the tests.

Appendix E

(10) SPECIFICATIONS FOR THE WATERPROOFING AND DRAINAGE OF SOLID-FLOOR RAILWAY BRIDGES

G. A. Haggander, Chairman, Sub-Committee; P. S. Baker, M. F. Clements, W. R. Edwards, C. S. Heritage, B. R. Leffler, F. P. Turner, H. T. Welty, A. R. Wilson.

(I) GENERAL

1. These specifications apply to membrane waterproofing, which is the only kind recommended for solid-floor railway bridges. The waterproofing shall consist of a membrane covered by a protection course of brick, concrete or asphalt mastic.

(II) DESIGN OF BRIDGE

2. The bridge shall be so designed that it will be adapted to waterproofing by the methods and materials prescribed herein. Special attention shall be given in the design to construction joints, expansion joints, flashing, and drainage. The number of construction joints shall be a minimum. Stiffness is an essential feature. Where contraflexure would injure the waterproofing, special details shall be provided.

3. The application of waterproofing under traffic should be avoided.

4. Surfaces to be waterproofed shall be easily accessible, smooth, and of simple form. Open spaces, joints, holes, pockets, seams, projections, and other features which would increase the difficulty of securing waterproof construction, shall be avoided.

5. Concrete floors shall be of ample thickness and of dense, nonporous construction. Special attention shall be given to the amount and position of the reinforcement.

6. Adequate drainage shall be provided by means of grades which will shed the water by the most direct route. A grade of at least one per cent. is desirable. Grades from points which are difficult to waterproof or drain should be steeper. Surfaces of the floor shall slope away from the joints.

7. Conductor pipes shall be of wrought or cast iron, not less than four inches in diameter, preferably without bends, easy to install and maintain, and protected against clogging or injury. Where low temperatures occur, it is not desirable to encase conductor pipes in concrete. Cleanouts shall be provided if conductor pipes cannot otherwise be cleaned. Gutters preferably shall be of the open type. They shall be of durable material, easy to install and maintain.

8. Outlets for the harmless escape of drainage shall be provided.

9. Waterproofing shall be carried above the highest probable level of water or melting snow.

10. The upper edges of contact between concrete and steel shall be grooved and filled with elastic cement, or protected by metal flashing.

11. The reinforcement in the concrete protection course shall be placed in the middle of the layer of concrete.

12. The edges of the waterproofing shall be protected against percolation and capillary action by means of drip beads.

(III) TYPES OF WATERPROOFING

13. The waterproofing membrane shall be made up of layers of bitumen-treated cotton fabric, or felt and cotton fabric, with alternate layers of bitumen, either asphalt or coal tar pitch.

The following types of membrane are recommended:

Type A. Two layers of asphalt treated cotton fabric and three moppings of asphalt.

Type B. Two layers of pitch treated cotton fabric and three moppings of coal tar pitch.

Type C. Two layers of asphalt treated felt, one middle layer of asphalt treated cotton fabric, and four moppings of asphalt.

Type D. Two layers of pitch treated felt, one middle layer of pitch treated cotton fabric, and four moppings of coal tar pitch.

Type E. Four layers of asphalt treated felt, one middle layer of asphalt treated cotton fabric, and six moppings of asphalt.

Type F. Four layers of pitch treated felt, one middle layer of pitch treated cotton fabric, and six moppings of coal tar pitch.

At places requiring greater strength, additional layers of cotton fabric shall be applied.

Other types may be used at the discretion of the Engineer, but the mopped on material shall be the same as that with which the felt or fabric is treated.

The first mopping of bitumen shall be placed on the surface to be waterproofed, and shall be followed by alternate layers of fabric or felt and moppings of bitumen, ending with a mopping of bitumen on top.

(IV) MATERIALS

(1) Asphalt

14. Asphalt shall be homogeneous and free from water. It shall be the product obtained by the distillation of crude asphaltic base petroleum refined by direct heat without the addition of fluxing or other material during any stage of the process of manufacture. It shall meet the following requirements:

(a) Softening point (ring and ball method) 150° to 170° Fahr.

(b) Penetration:

at 115° Fahr., 50 g., 5 sec......not more than 100
at 77° Fahr., 100 g., 5 sec...............25 to 40
at 32° Fahr., 200 g., 60 sec........not less than 10

(c) Flash point (open cup)..........not less than 400° Fahr.
(d) Loss on heating at 325° Fahr., 50 g., 5 hr................ ....not more than 5 per cent.
(e) Penetration at 77° Fahr., 100 g., 5 sec., of residue after heating at 325° Fahr., as compared with penetration of asphalt before heating........not less than 80 per cent.
(f) Ductility:
  at 77° Fahr.....................not less than 25 cm.
  at 40° Fahr.....................not less than 3.5 cm.
(g) Insoluble in carbon disulphide..not more than 1 per cent.

(2) COAL TAR PITCH

15. Coal tar pitch shall be homogeneous and shall meet the following requirements:

(a) Water.....................................0.0 per cent.
(b) Specific gravity at 77°/77° Fahr............1.22 to 1.31
(c) Softening point (cube in water method) 130° to 155° Fahr.
(d) Distillation Test:
  Total distillate by weight 32° to 572° Fahr.......... ....not more than 12 per cent.
  Residue by weight........not less than 88 per cent.
(e) Specific gravity, at 100°/77° Fahr., of total distillate to 572° Fahr..........................not less than 1.05
(f) Ductility at 77° Fahr...............not less than 20 cm.
(g) Total bitumen (soluble in carbon disulphide)........... ....73 to 88 per cent.

(3) ELASTIC CEMENT

16. Elastic cement shall be an asphalt homogenous and free from water, and meeting the following requirements:

(a) Softening point (ring and ball method)..120° to 130° Fahr.
(b) Penetration:
  At 115° Fahr., 50 g., 5 sec.......not more than 300
  At 77° Fahr., 100 g., 5 sec................50 to 60
  At 32° Fahr., 200 g., 60 sec.........not less than 15
(c) Loss on heating at 325° Fahr., 50 g., 5 hr............... ....not more than 0.5 per cent.
(d) Ductility at 77° Fahr...................not less than 85

The cement shall form a complete and permanent bond with the adjacent materials. The volume shall not be reduced by exposure to weather.

(4) FABRIC

17. Treated fabric shall be woven cotton cloth saturated with either asphalt or coal tar pitch, as specified by the Engineer.

18. In the process of manufacture, the dry cotton fabric shall be treated thoroughly and uniformly with either asphalt or coal tar pitch, at a temperature and speed that will not injure the fabric. This shall be accomplished by passing the fabric through the saturant and then calendering it in the presence of heat, after which it shall be cooled and wound into rolls.

19. The treated cotton fabric shall meet the following requirements:

(a) Width...........not less than 30 nor more than 38 inches
(b) Gross weight of roll.................................. ....not less than 35 nor more than 80 pounds

(c) Average net weight per square yard...not less than 11 ounces
(d) Detached comminuted surfacing on 100 square feet..................................not more than one pound
(e) Moisture content based on net weight..not more than one per cent.
(f) Average strength at 70° Fahr., measured both in the direction of the warp and of the filling.......................................not less than 50 pounds
(g) Elongation before fracture (at 70° Fahr.)......................................not less than 10 per cent.
(h) Pliability at 32° Fahr..................not less than 10
(i) Average loss on heating asphalt treated fabric (exclusive of moisture)...............not more than 4 per cent.
(j) Weight of saturant......not less than twice the weight of the moisture-free untreated fabric in the same area

20. The desaturated cotton fabric shall be wholly of cotton, and shall meet the following requirements:

(a) Average dry weight per square yard.............................not less than 3½ nor more than five ounces
(b) Ash, based on dry weight of fabric..not more than one per cent.
(c) Thread count per inch both in the direction of the warp and of the filling.....not less than 18 nor more than 36

21. Bitumen used in treating fabric shall be either asphalt meeting the requirements of Section 14, or coal tar pitch meeting the requirements of Section 15, as required. It shall be liquefied by heat alone and not by oils, petroleums, or other solvents.

22. The meshes of the fabric shall not be completely closed by the process of saturation. There shall be sufficient porosity to allow the mopped-on bitumen to seep through.

23. The width of the selvage shall be not more than $\frac{3}{16}$ inch.

24. The fabric shall be capable of being unrolled easily without injury from sticking at atmospheric temperatures above 50° Fahr.

25. The surface of the fabric shall not be coated or covered with talc or other substance which might interfere with the adhesion between the fabric and the mopped on bitumen. The use of silica or wood flour will be allowed.

26. The finished fabric shall be free from visible defects, such as ragged or untrue edges, breaks, rents, or cracks. The surface shall be smooth and free from folds, knots, and excess bitumen.

27. The finished fabric shall be wound on wooden mandrels two inches square, extending two to four inches beyond the ends of the rolls. The rolls shall be securely tied or wrapped to prevent unrolling in transit.

(5) FELT

28. Felt shall be rag-felt saturated, but not coated, with either asphalt or coal tar pitch, as specified by the Engineer.

29. In the process of manufacture, the dry felt shall be treated thoroughly and uniformly with either asphalt or coal tar pitch, at a temperature and speed that will not injure the felt. This shall be accomplished by pass-

ing the dry felt through the saturant and then calendering it in the presence of heat, after which it shall be cooled and wound into rolls.

30. The treated felt shall meet the following requirements:

(a) Width..32 or 36 inches with an allowable variation of 1 per cent.
(b) Gross weight of roll...not less than 50 nor more than 80 pounds
(c) Average net weight of 100 square feet...................14 pounds with an allowable variation of 8 per cent.
(d) Detached comminuted surfacing on 100 square feet................................not more than one pound
(e) Maximum deviation from average thickness after removal of the detached surfacing...not more than 15 per cent.
(f) Moisture content based on net weight...not more than 1 per cent.
(g) Average strength at 70° Fahr. with the fiber grain...................................not less than 25 pounds
(h) Average strength at 70° Fahr. across the fiber grain....................................not less than 15 pounds
(i) Pliability at 77° Fahr....................greater than 8
(j) Average loss on heating asphalt treated felt (exclusive of moisture)..................not more than 4 per cent.
(k) Weight of saturant....not less than 1.4 times the weight of the moisture-free untreated felt in the same area

31. The desaturated rag-felt shall meet the following requirements:

(a) Average "Number" (expressed on the basis of pounds per 480 square feet)....................................28, with an allowable deviation of 10 per cent.
(b) Ash based on the dry weight of the felt...not more than 8 per cent.
(c) Composition of the felt, based on a microscopic count of the fibers:
  Cotton and wool fibers......not less than 75 per cent.
  Jute and manila fibers......not more than 15 per cent.
  Mechanical wood, etc., fibers...not more than 5 per cent.
  Chemical wood fibers......not more than 5 per cent.

32. The felt shall be capable of being unrolled easily without injury from sticking at atmospheric temperatures above 50° Fahr.

33. The surface of the felt shall not be coated or covered with talc or other substance which might interfere with the adhesion between the felt and the mopped-on bitumen. The use of silica or wood flour will be allowed.

34. The finished felt shall be free from visible defects, such as holes, ragged or untrue edges, breaks, rents, cracks, or indentations.

The surface shall be smooth and reasonably free from the following defects:

(a) Lumps of under-beaten stocks (that is, stock that has not been completely beaten or shredded into fiber in the process of manufacturing the felt).
(b) Foreign substances such as fragments of stone, metal, leather, straw, wood, etc.
(c) Patches of unabsorbed saturant.
(d) Dry spots.

35. The felt shall be saturated thoroughly and uniformly. Two-inch strips, cut at random across the entire width and split open for their full length, shall show no unsaturated spots.

36. Bitumen used in treating felt shall be either asphalt meeting the requirements of Section 14, or coal tar pitch meeting the requirements of Section 15, as required. It shall be liquefied by heat alone and not by oils, petroleum, or other solvents.

37. The rolls of treated felt shall be wrapped securely in strong paper of the same width as the felt. The wrapper shall encircle the roll completely and shall be pasted at the overlap to prevent shifting.

(6) BRICK

38. Brick for the protection course shall be dense, hard burned, uniform in size and quality, with square corners and free from warp. The absorption of moisture by bricks immersed in water seven hours shall not exceed 10 per cent. of the weight of the dry brick.

(7) CONCRETE

39. The materials used in the concrete protection course shall meet the specifications for materials for concrete of the American Railway Engineering Association, or current revisions thereof.

(8) ASPHALTIC PRIMER

40. Asphaltic primer shall be composed of asphalt and a solvent. The asphalt shall meet the requirements for asphalt in Section 14. The solvent shall be a hydro-carbon distillate having an end point, on distillation, not above 500° Fahr. Not more than 20 per cent. shall distill under 248° Fahr.

41. The primer shall be free from water and shall meet the following requirements:

(a)	Sediment	not more than one per cent.
(b)	Asphaltic base, by weight	25 to 35 per cent.

(9) ASPHALT MASTIC

42. Asphalt mastic shall be either premoulded blocks or poured-in-place mastic.

Poured-in-place mastic shall be composed of (a) asphalt and mineral aggregates, or (b) mastic cake mixed with asphalt and mineral aggregates.

Asphalt

43. Asphalt for poured-in-place mastic shall meet the requirements of Section 14.

Coarse Mineral Aggregate

44. Coarse mineral aggregate shall be well graded crushed stone or washed gravel, that will pass a ⅜ inch screen and be retained on a No. 10 screen. It shall be free from soft particles and organic matter.

Fine Mineral Aggregate

45. Fine mineral aggregate shall be well graded washed sand or crushed stone, that will pass a No. 10 screen. It shall be free from soft particles and organic matter.

Portland Cement

46. Portland cement shall meet the requirements of the current specifications for Portland cement, of the American Society for Testing Materials.

Mastic Cake

47. Mastic cake shall meet the following requirements:

(a) Soluble in pure benzol......14 to 18 per cent. by weight
(b) Insoluble in pure benzol....82 to 86 per cent. by weight

The matter soluble in pure benzol shall be asphalt which, after recovery from the mastic cake, shall meet the requirements of Section 14.

The matter insoluble in pure benzol shall be granular mineral matter which, after recovery from the mastic cake, shall meet the requirements of Sections 45 and 46.

Premoulded Blocks

48. Premoulded blocks shall meet the following requirements:

(a) They shall be 4 inches wide, 8 inches long, and 1¼ inches thick. A deviation either way of ¼ inch in length, or ⅛ inch in width or thickness from these dimensions shall be cause for rejection.

(b) The blocks shall be formed in molds under a pressure of not less than 3300 pounds per square inch of surface. The absorption test shall be made on blocks dried for 24 hours at a temperature of 150° Fahr. and then immersed in water seven days. The absorption of moisture under this test shall not exceed 1 per cent. of the weight of the block.

(10) Reinforcing Material for Concrete Protection Course

49. Reinforcing material shall be steel wire netting with a mesh not less than two inches. The wire shall be not smaller than No. 14 gage.

(11) Marking

50. Bituminous materials, fabric, and felt shall be delivered on the work in the original packages with the manufacturer's brand or label plainly marked on the package.

(12) Inspection and Tests

51. Materials shall be sampled and the specified properties determined by the current methods recommended by the American Society for Testing Materials.

52. Materials to be furnished and applied by a contractor shall be delivered on the work, at least three weeks before they are to be applied, in order that they may be tested and analyzed. No work shall be begun until the materials have been accepted by the Engineer.

53. The bidder shall submit with his bid a sample of the asphalt that he proposes to furnish, accompanied by a test report made by an independent authority, as evidence that he is producing asphalt of the quality specified. The test covered by this report shall meet every requirement of these specifications.

54. Asphalt shall be tested at the place of manufacture by a testing laboratory approved by the Engineer. The drums, when delivered on the work, shall bear the seal of the testing laboratory, the seal numbers corresponding to the test reports submitted by the testing laboratory.

55. When materials are delivered on the work, the Engineer may take samples at random for tests. If the tests show that any material does not meet the specification requirements, the Contractor shall remove such material immediately from the work at his own expense.

(V) APPLICATION

(1) General

56. Waterproofing shall not be done in wet weather nor at a temperature below 50° Fahr. without permission from the Engineer.

57. The work shall be done by competent workmen, skilled in the kinds of work specified.

(2) Preparation of Surfaces

58. Surfaces of concrete and steel to be waterproofed shall be smooth and free from projections which might injure the waterproofing membrane. The surface shall be cleaned of dust, dirt, loose particles, and grease. The use of hand bellows is recommended for removing dust and loose dirt from corners and joints. For removing grease from the steel, freshening the surface of the asphalt where a joining of old and new is to be made, or where elastic cement is to be applied against the steel and the membrane or the protection course, gasoline shall be used. The gasoline may be applied by swabbing or by pouring on a small quantity and setting fire to it. A blow torch also may be used. The surface shall be clean and dry when the waterproofing is applied. Damp surfaces may be dried by covering with a layer of hot sand. The sand shall remain in place one or two hours, after which it shall be removed from enough surface to allow the work to proceed. Another method is to swab with gasoline and set fire to it.

(3) Priming Coat

59. If specified by the Engineer, surfaces of concrete or steel coming in contact with asphalt waterproofing shall be given one coat of asphaltic primer. The primer shall be thoroughly worked in to give a uniform coating.

60. Priming shall be done immediately before applying the waterproofing membrane. The priming coat shall be dry before the membrane is applied.

(4) Floating Membrane

61. If bond between the membrane and the surface to be waterproofed is not desired the surface shall be covered with a waterproof sheathing paper weighing 10 pounds per square of 100 square feet.

(5) Workmanship

62. The felt or fabric shall be laid shingle fashion with the specified number of layers, and with the top layer lapped two inches over the bottom layer. Each strip shall be laid in a mopping of hot bitumen and, when the specified number of layers has been laid, the entire surface shall be mopped. If practicable, the laying of the felt or fabric shall be begun at the lowest part of the surface to be waterproofed. The surface shall be completely covered with a heavy mopping of bitumen before the strip of felt or fabric is put down. The mopping shall be so done that there will be no air bubbles or pockets, or spots where the surface shows through. If fabric is used, this mopping of bitumen shall be sufficient to fill the open meshes in the fabric when it is pressed down. As soon as a strip of felt or fabric has been laid, it shall be pressed into the hot bitumen to eliminate the air bubbles. Creases in the fabric shall be smoothed out carefully by pulling the fabric. The top mopping shall be of such thickness and be so applied as to seal and cover the fabric or felt completely.

63. Special care shall be taken that the felt or fabric is completely sealed down at the laps. The waterproofing membrane shall be continuous and unbroken. The work shall be so regulated that at the end of the day, the fabric or felt that has been laid will have received the final mopping of bitumen. At joints in the membrane, the laps shall be at least 12 inches. The felt or fabric for making the lap shall be left unmopped until the joint is to be completed.

64. The amount of bitumen in one mopping of 100 square feet of surface shall be not less than 4½ gallons.

65. Care shall be taken to avoid overheating the bitumen. The temperature of the bitumen in the kettle shall not be above 350 degrees Fahr., and not below 250° Fahr., just before the bitumen is placed in the work. Kettles shall be equipped with thermometers.

66. Special care shall be taken to make the waterproofing effective along the sides and at the ends of girders, and at stiffeners, gussets, etc.

The waterproofing membrane shall be turned down into the drainage castings without a break.

67. Waterproofing shall be protected against mechanical injury, high temperature, and chemical action as soon as possible after completion.

(6) Concrete Protection Course

68. The concrete protection course shall be not less than one and one-half inches thick, and reinforced as required by the plans. The concrete shall be 1-2-4 mixture of a consistency as dry as is workable. The size

of the coarse aggregate shall not be larger than ¾ inch. The top surface of the concrete shall be true to grade and troweled to a smooth finish.

69. Unless permitted by the Engineer, trains shall not be allowed over waterproofed surfaces until the concrete or mortar last deposited is seven days old.

(7) Brick Protection Course

70. The brick protection course shall be laid over the entire membrane, except around the drainage castings and other places shown on the plans. In such places concrete shall be used.

71. The laying of the brick shall follow the waterproofing closely, and the joints shall be filled immediately. Unless otherwise specified, the joints shall be filled with bitumen of the kind used for the waterproofing. The bricks shall be dry when the joints are filled.

(8) Asphalt Mastic Protection Course

Premoulded Blocks

72. The premoulded-block protection course shall be laid over the entire membrane, except around the drainage castings and other places shown on the plans. In such places poured-in-place mastic or concrete shall be used.

73. The laying of the blocks shall follow the waterproofing closely. The blocks shall be laid in hot asphalt and the joints shall be filled immediately with asphalt. The asphalt shall meet the requirements of Section 14.

Poured-in-Place Mastic

74. The poured-in-place mastic protection course shall be not less than one and one-half inches thick, and shall be laid on one thickness of waterproof paper on the membrane. The paper shall be an insulating paper 36 inches wide and weighing not less than 10 pounds per 100 square feet.

75. Asphalt and mineral aggregates shall be mixed in about the following proportions:

Asphalt	9 to 12 per cent.
Coarse mineral aggregate	35 to 40 per cent.
Fine mineral aggregate	33 to 37 per cent.
Portland cement	15 to 19 per cent.

The proportions may be varied to give a mastic of the greatest density and stability.

76. Mastic cake, asphalt, and mineral aggregates shall be mixed in about the following proportions:

Mastic cake	48 per cent.
Asphalt	5 per cent.
Fine mineral aggregate and cement	19 per cent.
Coarse mineral aggregate	28 per cent.

The proportions may be varied to give a mastic of the greatest density and stability.

77. The asphalt and the mastic cake shall be heated to 350° Fahr. The aggregates shall be mixed and heated, and placed in the melted asphalt in the kettle. The ingredients shall be mixed thoroughly with iron stirring rods until all particles of the aggregates are covered with and incorporated in the asphalt, care being taken to prevent burning. After the mastic is mixed it shall be removed from the kettle and poured while hot. It shall be placed in layers not more than ¾ inch thick, the thickness of the layers being gaged by wooden strips held in position by suitable weights. The layers shall lap not less than six inches at the joints and shall be brought to the required thickness with wooden spreaders and floats. The top layer shall be finished to the required grade and with a smooth surface. On surfaces steeper than 4½ vertical to 12 horizontal, brick or concrete protection shall be used instead of mastic. As soon as the top layer of the mastic is finished, it shall be given a mopping of hot asphalt sanded to a walking surface while hot.

Appendix F

(11) COPPER-BEARING STEEL FOR STRUCTURAL PURPOSES

F. P. Turner, Chairman, Sub-Committee; Thos. Earle, Crosby Miller, W. L. Wilson.

The Sub-Committee has collected information on the use of copper-bearing steel and finds that it is being used in the manufacture of steel cars, tie-plates, track spikes, smoke stacks, and stationary boilers. Copper-bearing steel in such service has been found to last twice as long as ordinary steel. It has been little used in bridge construction, and further investigation should be made to determine if it is suitable for that purpose.

REPORT OF COMMITTEE XVIII—ELECTRICITY

E. B. Katte, *Chairman;*	W. M. Vandersluis, *Vice-Chairman;*
F. Auryansen,	H. M. Bassett,
D. J. Brumley,	R. D. Coombs,
J. C. Davidson,	J. H. Davis,
J. V. B. Duer,	G. Eisenhauer,
F. D. Hall,	L. B. Martin,
R. J. Middleton,	W. L. Morse,
R. J. Needham,	A. E. Owen,
Martin Schreiber,	E. B. Temple,
H. M. Warren,	L. S. Wells,
S. Withington,	G. I. Wright,

Committee.

To the American Railway Engineering Association:

Your Committee respectfully presents herewith report covering the following subjects:

(1) Revision of the Manual (Appendix A).

(2) Study of electrical interference caused by propulsion circuits, including recommendations for eliminating interference with signal, telephone and telegraph lines caused by propulsion circuits and adjacent transmission lines (Appendix B).

(3) Study and report on the utilization of Water Power for Electric Railway Operation (Appendix C).

(4) Collaboration with the American Committee on Electrolysis (Appendix D).

(5) Collaboration with the United States Bureau of Standards in the revision of the National Electrical Safety Code and other codes of similar character. Study of Electric Light, Power Supply and Trolley Lines Crossing Railways, with the view of keeping the Association informed with regard to changes which may be desirable in the adopted specifications to make them conform more nearly to the requirements of Part II of the National Electrical Safety Code, prepared by the United States Bureau of Standards, and with the requirements of Public Service Commissions and other regulatory bodies in the various States (Appendix E).

(6) Study and report on the Specifications for the Construction of Overhead Electric Supply Lines for Railway Use on Railroad Property, collaborating with the appropriate committees of the Signal Section and the Telephone and Telegraph Section, with the view of keeping the adopted specifications revised and up to date (Appendix F).

(7) Study and report on Economics of Railway Location as affected by electric operation, collaborating with Committee XVI—Economics of Railway Location (Appendix G).

(8) Study and report on the Specifications for Adhesive and Rubber Tapes, with the view of recommending any changes or modifications in the adopted specifications and keeping them revised and up to date (Appendix H).

Bulletin 280, October, 1925.

(9) Study and report on Specifications for Porcelain Insulators for Railroad Supply Lines, collaborating with the appropriate committees of the Signal Section and the Telephone and Telegraph Section, with the view of advancing the Tentative Specifications to Recommended Practice (Appendix I).

(10) Revision of the tables showing Third Rail Clearances and Tables Showing Overhead Working Conductor Clearances contained in last year's report (Appendix J).

(11) Study and report on Rules for the Protection of Oil Sidings from Danger Due to Stray Currents, with the view of keeping the adopted rules revised and up to date, co-operating with appropriate committees of other interested associations (Appendix K).

(12) Study and report on Specifications for Track and Third Rail Bonds for Electric Railway Circuits, including gas, electric and thermit welding (Appendix L).

(13) Revision and bringing up to date of the adopted Specifications for Incandescent Lamps and Schedule of Sizes (Appendix M).

Action Recommended

1. Approve as recommended practice, and print in the Manual:
    - (a) Specifications for Maintenance of Overhead Electric Supply Lines (Appendix F).
    - (b) Specifications for the Joint Use of Poles for Power, Communication and Signal Circuits (Appendix F).
    - (c) Specifications for Friction Tape (Appendix H).
    - (d) Specifications for Porcelain Insulators for Railroad Supply Lines (Appendix I).
    - (e) Accept as information and print in the Manual, Clearance Tables for Third Rail and Overhead Working Conductors (Appendix J).
    - (f) Approve as recommended practice and substitute for the existing Schedule in the Manual, Incandescent Lamp Schedule (Appendix M).

2. That the report on Inductive Co-ordination in Appendix B be accepted as an indication of progress and the subject continued.

3. That the report on Water Power in Appendix C be accepted as a progress report and the subject continued.

4. That the report on Electrolysis in Appendix D be accepted as information and the subject continued with representation on the American Committee on Electrolysis without commitment as to subscriptions or dues.

5. That the report on Co-operation with the United States Bureau of Standards and the revision of the National Electrical Safety Code under the procedure of the American Engineering Standards Committee as contained in Appendix E be received as information, and co-operation with the United States Bureau of Standards be continued.

6. The Committee recommends that (a) the Specifications for Maintenance of Overhead Electric Supply Lines, and (b) the Specifications for the Joint Use of Poles for Power, Communication and Signal Circuits, be approved as recommended practice and printed in the Manual.

7. That the report on Collaborating with Committee XVI—Economics of Railway Location, in Appendix G, be accepted as a progress report and the subject continued.

8. That the revised Specifications for Friction Tape be approved as recommended practice and printed in the Manual and that the revision of the Specifications for Rubber Insulating Tape be continued as in Appendix H.

9. That the Specifications for Porcelain Insulators for Railroad Supply Lines, as contained in Appendix I, be approved as recommended practice and printed in the Manual.

10. That the Tables for Clearances for Third Rail and Overhead Working Conductors, as reported in Appendix J, be accepted and printed in the Manual, that the subject be continued and the Tables extended to include data showing the location of the third rail above the plane of the running rails and beyond the gage line.

11. That the report on Protection of Oil Sidings from Danger Due to Stray Currents as contained in Appendix J be accepted as information.

12. That the report on Specifications for Track and Third Rail Bonds, as contained in Appendix L, be accepted as information and the subject continued.

13. That the revised Schedule for Tungsten Lamps be accepted as recommended practice and substituted for existing Schedule now in the Manual, as in Appendix M.

Recommendations for Future Work

1. Revision of the Manual.

2. Continue the study of electrical interference caused by propulsion circuits, including recommendations for eliminating interference with signal, telephone and telegraph lines caused by propulsion circuits and adjacent transmission lines. Continue representation on the American Committee on Inductive Co-ordination and collaborate with the appropriate committees of the Telephone and Telegraph Section and with the Signal Section, with the view of submitting a joint report to the American Railway Association.

3. Continue the study and report on the utilization of Water Power for electric operation with particular reference to Tidal Water Power, and power from the St. Lawrence River.

4. Continue collaborating with the American Committee on Electrolysis, retaining membership thereon but without committing the Association to subscriptions or dues until approved by the Board.

5. Continue collaborating with the United States Bureau of Standards with the revision of the National Electrical Safety Code and other codes of similar character. Continue the study of Electric Light, Power Supply and Trolley Lines Crossing Railways, with a view of keeping the Association informed with regard to changes which may be desirable in the adopted specifications to make them conform more nearly with the requirements of Part II of the National Electrical Safety Code, prepared by the United States Bureau of Standards, and with the requirements of the Public

Service Commissions and other regulatory bodies in the various States. Continue the State Representatives and their Alternates.

6. Continue the study and report on Economics of Railway Location as affected by electric operation, collaborating with Committee XVI—Economics of Railway Location.

7. Continue the study and report on Specifications for Rubber Tape, with a view of recommending any changes or modifications in the Specifications for Rubber Tape which will make them acceptable to the other Sections of the American Railway Association and in co-operation with the A.S.T.M.

8. Revise the Tables showing Third Rail Clearances and Tables showing Overhead Working Conductor Clearances and extend them to include data showing location of the third rail above the plane of the running rails and beyond the gage line.

9. Continue the study and report on Rules for the Protection of Oil Sidings from Danger Due to Stray Currents with a view of keeping the adopted rules up to date, co-operating with appropriate committees of other interested associations.

10. Continue the study and report upon Specifications for Track and Third Rail Bonds for Electric Railway Circuits, including gas, electric and thermit welding.

Respectfully submitted,
The Committee on Electricity,
October 21, 1925. By Edwin B. Katte, *Chairman.*

Appendix A

(1) REVISION OF MANUAL

E. B. Temple, Chairman, Sub-Committee; J. H. Davis, W. M. Vandersluis, W. L. Morse, A. E. Owen, E. B. Katte.

Recommendation

(1) Approve as recommended practice and print in the Manual:

(a) Specifications for Maintenance of Overhead Electric Supply Lines (Appendix F).

(b) Specifications for Joint Use of Poles for Power Communication and Signal Circuits (Appendix F).

(c) Specifications for Friction Tape (Appendix H) to supersede the Specifications for Adhesive Tape now in the Manual.

(d) Specifications for Porcelain Insulators for Railroad Supply Lines (Appendix I).

(e) Accept as information, and print in the Manual, Clearance Tables for Third-Rail and Overhead Working Conductors (Appendix J).

(f) Approve as recommended practice and substitute for existing Schedule in the Manual the Tungsten Lamp Schedule—1925 (Appendix M).

Appendix B

(2) INDUCTIVE CO-ORDINATION

J. C. Davidson, Chairman, Sub-Committee; J. V. B. Duer, W. M. Vandersluis, S. Withington, R. J. Middleton, E. B. Katte.

The activities of the Committee were confined to representation on the American Committee on Inductive Co-ordination, concerning which full information was given in last year's report. This Committee has issued a questionnaire to the various constituent bodies, but up to the present time (November 1st) the results thereof have not been issued. The railroad interests have submitted the reply to the questionnaire through Secretary H. J. Forster, of the American Railway Association. It is expected that a meeting of the American Committee on Inductive Co-ordination will be held prior to the March Convention in which event a supplemental progress report will be submitted.

Conclusions

That the subject be continued and the activities of the Committee for the present be confined to representation on and working with the American Committee on Inductive Co-ordination.

Appendix C

(3) WATER POWER

R. J. Needham, Chairman, Sub-Committee; H. M. Bassett, G. Eisenhauer, L. B. Martin, J. C. Davidson, W. L. Morse.

The work outlined for the Sub-Committee for 1925 was in the nature of a review of the past work of this Sub-Committee, bringing the various data previously prepared up to date.

The Sub-Committee on Water Power was inaugurated in 1916, and its first report appeared in 1917. Information was collected on the utilization of water power for electric railways as of the year 1917, and was published in the A.R.E.A. Proceedings 1919, page 197, Volume 20, which included a table showing the principal steam systems which had been partially electrified up to the end of 1917, giving the source of power and the approximate annual current consumption. The table attached shows this statement revised up to the end of 1924, the additional miles of electrio track over 1917 being 577, with 630 miles under construction.

In the 1920 Proceedings the Sub-Committee reported on the source of electric power for the Chicago, Milwaukee & St. Paul electrification between Harlowton and Deer Lodge and presented a detailed description of the complete electrification, to which no additional data need be added. This information appears on page 251, Volume 21.

In 1921, this Sub-Committee selected the electrification of the Norfolk & Western Railway for consideration, and a complete review of this electrification is given in Volume 22, beginning with page 116, of which no modification is now necessary.

In 1922, the Sub-Committee reported on the available electric power from hydraulic source on the Niagara and St. Lawrence Rivers, and tributaries of the St. Lawrence River. The power at Niagara Falls remains substantially the same as on the date of previous report. Similar data is covered in later report submitted by Sub-Committee on Water Power in November, 1924, appearing in Bulletin 271, of the A.R.E.A., Volume 26. The United States and Canadian sections of the Engineering Board which is engaged in making a survey and study of the St. Lawrence waterways, are making substantial progress, but their report has not been issued at present writing. As regards the tributaries of the St. Lawrence River—notable developments have taken place on the Saguenay River.

The Duke Price Company, Ltd., is now developing power at Isle Maligne on the Saguenay River, several miles below Lake St. John; data concerning this development is given in Bulletin 271, A.R.E.A., Volume 26, dated November, 1924. Eight (8) of the twelve 45,000 horsepower units have now been placed in service, and work has now been started on the development of an 800,000 horsepower plant at Chute a Caron, which is located several miles below the Grand Discharge development, where a head of 220 feet can be obtained.

The Hydro-Electric Power Commission of Ontario has made formal application to the Provincial Government of Ontario for sites on the Ottawa River between Ottawa and Pembroke, principally at Chats Falls, Du Foid Falls, Roche Fendu Falls and Calumet Falls, contemplating an ultimate development of 700,000 horsepower. The Kingdom Mining, Smelting & Manufacturing Company have also purchased sites on the Quebec side at Chats Falls on the Ottawa River, and it is believed that both the Hydro Commission and the Kingdom Mining, Smelting & Manufacturing Company are uniting in this enterprise at Chats Falls, contemplating an ultimate development of 120,000 horsepower at this point.

Reference was made in the Sub-Committee's report in the 1923 Proceedings, Volume 24, page 583, to maps showing power stations and transmission lines in the United States used in public service, as prepared by the Chief Hydraulic Engineer and Chief of the Division of Power Resources. Two additional states have been added to this list since last report, viz., West Virginia and Kentucky. Revised list is shown below:

States	*Dated*
Maine	1922
New Hampshire and Vermont	1921
Massachusetts, Rhode Island and Connecticut	1919
New York	1921
New Jersey	1921
Pennsylvania	1920
Maryland, Delaware and District of Columbia	1922
Indiana	1922
Virginia	1922
Kentucky	1922
West Virginia	1922

These maps can be procured from the Director of the United States Geological Survey, Department of the Interior, Washington, D. C., for 50 cents each, or in lots of ten for $3.00.

Tables showing the developed water power in the United States covering the capacity of water wheels installed in plants of 100 horsepower or more, are listed on page 585, Volume 24, 1923 Proceedings; also Potential Water Power Resources. This information has been revised and brought up to the end of 1923, as follows:

DEVELOPED WATER POWER IN THE UNITED STATES

(Capacity of Water Wheels Installed in Plants of One Hundred Horsepower or more.)

Section	Total		Public Utility and Municipal		Manufacturing and Miscellaneous	
	No. of Plants	Capacity in H. P.	No. of Plants	Capacity in H. P.	No. of Plants	Capacity in H. P.
New England	1,228	1,387,364	249	644,831	979	742,533
Middle Atlantic	607	1,731,881	228	1,408,173	379	323,708
East North Central	342	829,854	212	625,826	130	204,028
West North Central	183	459,736	117	376,864	66	82,872
South Atlantic	259	1,259,978	129	1,045,728	130	250,250
East South Central	50	345,584	32	323,816	18	21,768
West South Central	27	16,727	12	12,515	15	4,212
Mountain	226	880,783	178	860,937	48	19,846
Pacific	289	2,139,051	233	2,049,507	56	89,544
Total—United States	3,211	9,086,958	1,390	7,348,197	1,821	1,738,761

A small increase was made in the number of plants, viz., 91, but a substantial increase was effected in the capacity in horsepower, viz., 1,160,000 h. p.

OUTLYING POSSESSIONS

	Developed Water Power (Horsepower)
Alaska	40,000
Hawaii	25,000
Porto Rico	15,000

POTENTIAL WATER POWER RESOURCES OF THE UNITED STATES

Section	Available 90 per cent of the time		Available 50 per cent of the time	
	Horsepower	Per Cent	Horsepower	Per Cent
New England	998,000	2.87	1,978,000	3.60
Middle Atlantic	4,317,000	12.40	5,688,000	10.35
East North Central	737,000	2.12	1,391,000	2.53
West North Central	871,000	2.50	1,844,000	3.35
South Atlantic	2,476,000	7.11	4,464,000	8.11
East South Central	1,011,000	2.90	2,004,000	3.64
West South Central	434,000	1.25	888,000	1.61
Mountain	10,736,000	30.83	15,513,000	28.19
Pacific	13,238,000	38.02	21,260,000	38.63
Total—United States	34,818,000	100.00	55,030,000	100.00

OUTLYING POSSESSIONS

Alaska	1,000,000	2,500,000
Porto Rico	19,000	28,000
Hawaii	100,000	200,000

This is the latest estimate that has been made of the potential water power resources of the United States, including Alaska, Porto Rico, and Hawaii, which it is physically feasible to develop under present conditions. Absence of market for power and inability to obtain necessary legal rights will delay development, but should not prevent it. The figures given in the estimate show the 24-hour power available 90 per cent of the time, and 50 per cent of the time at 90 per cent overall efficiency at both developed and undeveloped sites.

The estimate of the water power resources of the United States is based on reports prepared by bureau of the Federal Government, by States, by corporations, and by private engineers. In districts for which no water power reports are available the data used are taken from the estimate of the potential water power of the United States prepared by the Geological Survey in 1908. In many of the reports from which the data were taken the estimates of potential power included the use of stored water for generating power. For districts where reservoirs are already built or where detailed field examinations show that such storage is feasible, these estimates have been used. All plans filed with the Federal Power Commission by applicants for permits to develop power on Colorado River show that power developed on this river will include the use of stored water. This estimate, therefore, assumes that stored water will be used to equalize as far as possible the flow of Colorado River below the mouth of Green River. The estimate includes half of the potential power of Niagara River and of the International Section of the St. Lawrence River, though an international agreement is necessary to permit the full use of these resources.

The estimate of the potential water power of the United States prepared by the Geological Survey in 1908 was based on the primary factors of slope and discharge. Very flat sections of rivers were not considered, but all other known potential water power of the United States was included, without regard to the practicability of development.

This estimate is based largely on reports that include only feasible sites and it therefore represents the potential power that can be developed when a market is available, yet it does not differ very materially from the estimate made in 1908. Allowing for the difference in assumed efficiency and for the inclusion in this estimate of the United States' share of the potential power on Niagara and St. Lawrence Rivers, the present estimate of the potential power available 90 per cent of the time is about 21 per cent higher than the estimate of 1908 mainly because of the assumed use of stored water at places where detailed examinations and surveys have shown the existence of good reservoir sites. For the same reason the estimate of power available 50 per cent of the time is 4 per cent higher.

The estimate cannot be considered final in all respects. Surveys and detailed studies are necessary to determine the most economcial method of development, and these studies will probably lead to changes in the estimates of potential power in individual states. Additional data are especially desirable for some of the South Atlantic States. Future studies will probably be concerned principally with the use of stored water. These studies may result in a considerable increase in the estimate of the potential power available 90 per cent of the time, but will probably affect to a much less extent the estimate of potential power available 50 per cent of the time. The estimates made in 1908 of total potential power without storage have been compared with recent estimates for several states where reliable data show the power that can be economically developed, including that available by the use of stored water. As this comparison shows no radical difference in total results, future studies will probably make no great change in the present estimate of the potential water power of the entire country.

Washington stands first among the States in potential water power for power available both 50 per cent of the time and 90 per cent of the time. This State is closely pressed, however, by Oregon, California, and New York. A large proportion of the potential power in New York is available continuously due to the equalization of the flow of Niagara and St. Lawrence Rivers. The same is true of Arizona, whose waterpower resources are mainly on Colorado River, where the flow can be controlled.

RELATION OF PRESENT DEVELOPMENT TO FUTURE POSSIBILITIES

The percentage of the total potential power of the United States that has already been developed can be estimated only in a rough way.

The capacity of water wheels at developed sites in Maine, New Hampshire, Vermont and Massachusetts amounts to 131 per cent of the power available 50 per cent of the time at those sites. The wheel capacity in Massachusetts is nearly double the potential power for 50 per cent of the time at 70 per cent efficiency. A considerable percentage of the water power developed in these four States is used in industries where the power is required only 8 to 12 hours each day, with pondage at the power plant sufficient to store the stream flow at ordinary stages when the plant is not operating. This condition results in a large overdevelopment of equipment in many plants. The developed sites in Canada from coast to coast have an average wheel installation 30 per cent greater than the power available during the six months of greater flow. It will be many years before all the water power sites in the United States are developed to a greater extent than the sites that have been utilized in the four New England States. Assuming that all sites may eventually be developed to a point where the wheel capacity is 131 per cent of the power available 50 per cent of the time, we may say that the installed capacity will reach 72,000,000 horsepower. The present installed capacity of plants of 100 horsepower or more is 9,087,000 horsepower, and on the above assumption of the ultimate installed capacity, about 12.5 per cent of the potential water power of the country has now been developed.

Data showing potential and developed water power resources in Canada, by provinces, follows:

AVAILABLE AND DEVELOPED WATER POWER IN CANADA FEBRUARY 1, 1924

Province	Available 24-hour power at 80 per cent efficiency		Turbine Installation Horsepower
	At Ordinary min. flow Horsepower	At Ordinary 6-months flow Horsepower	
1	2	3	4
British Columbia	1,931,142	5,103,460	355,517
Alberta	475,281	1,137,505	33,067
Saskatchewan	513,481	1,087,756	....
Manitoba	3,270,491	5,769,444	162,025
Ontario	4,950,300	6,808,190	1,445,480
Quebec	6,915,244	11,640,052	1,116,398
New Brunswick	50,406	120,807	44,539
Nova Scotia	20,751	128,264	54,950
Prince Edward Island	3,000	5,270	2,239
Yukon and Northwest Territories	125,220	275,256	13,199
Total—Canada	18,255,316	32,075,998	3,227,414

The figures listed in columns 2 and 3 in the above table represent 24-hour power and are based upon rapids, falls and power sites of which the actual existent drop or the head possible of concentration, is definitely known or at least well established. Many rapids and falls of greater or lesser power capacity are scattered on rivers and streams from coast to coast which are not as yet recorded, and which will only become available for tabulation as more detailed survey work is undertaken and completed. This is particularly true in the relatively unexplored northern districts. Nor is any consideration given to the power concentrations which are feasible on rivers and streams of gradual gradient, where economic heads may be created by the construction of power dams, excepting only at such points as definite studies have been carried out and the results made matters of record.

The figures in column 4 represent the actual water-wheels installed throughout the Dominion. These figures should not be placed in direct comparison with the available power figures in columns 2 and 3 for the purpose of deducing therefrom the percentage of the available water-power resources developed to date. The actual water-wheel installation throughout the Dominion averages 30 per cent greater than corresponding maximum available power figures calculated as in column 3. The figures quoted above, therefore, indicate that the present recorded water-power resources of the Dominion will permit of a turbine installation of 41,700,000 horsepower. In other words, the present turbine installation represents only 8 per cent of the present recorded water-power resources.

The above figures may be said to represent the minimum waterpower possibilities of the Dominion.

As illustrative of this the detailed analyses which have been made of the waterpower resources of the province of New Brunswick and Nova

Scotia have disclosed most advantageous reservoir facilities for regulating stream flow and it is estimated that the two provinces possess within their respective borders 200,000 and 300,000 commercial horsepower. These figures provide for a diversity factor between installed power and consumers' demands.

ELECTRIFIED STEAM RAILROADS—1924

Line	(1924) Miles Electric Track	Trolley Voltage	Kind of Service Passenger Freight	Power From	(1924) K. W. H at Power House for Trains	Reason for Not Using Water Power
N. Y. N. H. & H.	‡620	11,000 AC	P & F	Coal	120,000,000 plus 55,000,000 purchased	No reliable water power available.
B. A. & Pacific	123	2,400 DC	P & F	Water	20,227,759	
Hoosac Tunnel, Boston & Maine	21	11,000 AC	P & F	Water	6,950,481	
Penna. System—						
P. R. R., New York	110	650 DC	P	Coal	97,295,195	None available.
P.R.R., Philadelphia	125	11,000 AC	P	Coal	41,528,540	None available.
W. Jer. & Seashore....	150	650 DC	P	Coal	41,023,508	None available.
Erie	38	11,000 AC	P	Water	1,894,860	
B. & O., Baltimore...	8	650 DC	P & F	Water	6,769,400	
L. I. R. R., New York	*300	650 DC	P	Coal	127,280,000	None available.
Canadian Nat.—						
St. Clair Tunnel....	12	3,300 AC	P & F	Coal	4,334,800	Water supply not immediately available.
Mt. Royal Tunnel...	†31	2,400 DC	P & F	Water	2,905,314	
Southern Pacific......	101	1,200 DC	P	Fuel Oil	25,676,594	Fuel oil generally used in West for generation of power.
C. M. & St. P........	848	3,000 DC	P & F	Water	129,615,274	
Norfolk & Western....	156	11,000 DC	F	Coal	57,449,157	Coal cheaper.
New York Central....	268	660 DC (Third Rail)	P	Coal	130,642,554	None available.
Mich. Cent..........	28	650 DC	P & F	Coal	7,114,820	None available.
Great Northern......	10	6,600 AC	P & F	Water	4,287,900	
Total.............	2,919				879,996,000	

*Includes 58 miles placed in service May, 1925.
†Includes 12 miles electrified in May and June, 1925.
‡Includes 30 miles electrified in June, 1925.
‡Includes 58 miles N. Y. W. & B. R. R.

Power generated by—

Fuel Oil........	25,676,594 KWH
Water Power..	172,650,988 KWH
Coal..........	681,668,418 KWH

Virginian R. R. Electrification—Now under construction. Track miles to be electrified, 213. Trolley voltage, 11,000 AC—22,000 AC service. Heavy freight Water Power not available with economy. Now in operation from Elmore to Princeton (Nov. 1, 1925).

Illinois Central R. R.—Initial electrification to be completed in 1926, covering suburban operation involves sections of from one to six tracks, and a main line trackage of approximately 110 track miles, over total route of about 38 miles. Total program to be completed by 1940, will involve 400 track miles. Trolley voltage 1500 DC. No water power available. For Passenger and Freight.

D. T. & I. R. R.—17 miles electric track now under construction for test. Complete electrification contemplated. Trolley voltage 22,000 volts AC and 600 volts DC at motors. No water power available. For freight only.

The U. S. Department of the Interior issued under date of March 31st, 1925, a memorandum to the press covering the potential and developed water power of the world, to the end of 1923, which is of interest from a comparative standpoint. A recapitulation is shown below for the different Continents:

RECAPITULATION

	Developed H.P.	*Potential H.P.*
North America	13,700,000	66,000,000
South America	675,000	54,000,000
Europe	12,300,000	57,000,000
Asia	2,000,000	69,000,000
Africa	14,000	190,000,000
Oceanica	220,000	17,000,000
Approximate total	29,000,000	453,000,000

It is interesting to note the small percentage of the total potential water power of the world that has been developed. Europe stands foremost in this development with a percentage of 21.58. North America is a close second with 20.8 per cent.

Appendix D

(4) ELECTROLYSIS

M. Schreiber, Chairman, Sub-Committee; W. M. Vandersluis, E. B. Katte.

The Committee has confined its activity to the work of the Sub-Committee on Research of the American Committee on Electrolysis. This Sub-Committee has held several meetings during the year and is at present engaged in an attempt to formulate Grounding Rules which will be acceptable to the various interests represented on the American Committee on Electrolysis. In the event of any decision being reached prior to the Convention a supplemental progress report will be submitted.

Conclusions

That representation on the American Committee on Electrolysis be continued without commitment as to subscriptions or dues until a definite program is submitted to the Board of Direction for their action.

Appendix E

(5) CO-OPERATION WITH THE U. S. BUREAU OF STANDARDS

W. L. Morse, Chairman, Sub-Committee; L. S. Wells, S. Withington, J. H. Davis, J. V. B. Duer, F. Auryansen.

The Committee has conferred with the U. S. Bureau of Standards in the revision of various parts of the National Electrical Safety Code under the procedure of the American Engineering Standards Committee. There have been few if any changes in the personnel of the representatives, and as the members on the various sub-committees were given in detail in last year's report, repetition will not be made.

The present status (November 1st) of revision of the various parts of the Code is as follows:

Part 1—Rules for the Installation and Maintenance of Electrical Supply Stations.—The work has progressed to the printer's proof stage and copies have been submitted for final review of the members of the Committee. It is believed that Part 1 of the Code as now revised will be generally acceptable to the railroads.

Part 2—Rules for the installation and Maintenance of Overhead and Underground Electric Supply and Signal Lines.—The revised draft is in the hands of the printer but copies have not as yet been received by the members of the Committee. There are several factors of safety and clearances which are not, in the opinion of the representatives of the railroads, adequate, and formal protests have been entered. It is likely that the railroad representatives will be forced to submit a minority report on the part of the railroads.

Part 3—Rules for the Installation and Maintenance of Electrical Utilization Equipment.—Printer's proof has been submitted to the representatives of the Committee for their final comments. Exception has been taken to the rule requiring De-energizing Switches in Leads to Current Collecting Devices on Electric Locomotives and Multiple Unit Cars. Also exception has been taken to the mandatory requirement for Insulating Barriers on Booms of Wrecking Cranes, and unless these two features are modified in the final draft of the rules, a minority report will be submitted.

Part 4—Rules for the Observance of the Operation of Electrical Equipment and Lines.—The final draft is in the hands of the printer and as soon as copies are available they will be sent to the members of the Committee for their final review. It is understood that this portion of the Code as revised will be generally acceptable to the railroads.

Part 5—Radio Installations.—The revised draft has been received and is in the hands of the Committee for final review. It is understood that there is nothing objectionable to the railroads in this part of the rules.

Conclusions

That the work be continued in cooperation with the U.S. Bureau of Standards for the revision of the National Electrical Safety Code under the procedure of the American Engineering Standards Committee.

Appendix F

(6) OVERHEAD TRANSMISSION LINE CONSTRUCTION

L. S. Wells, Chairman, Sub-Committee; R. D. Coombs, F. D. Hall, G. Eisenhauer, S. Withington, R. J. Needham, G. I. Wright.

Last year the Committee submitted tentative Specifications for the Maintenance of Overhead and Electric Supply Lines. Also tentative Specifications for the Joint Use of Poles for Power, Communication and Signal Circuits. These Specifications were tentatively accepted as addenda to the Supply Lines Specifications pending final revision after one year's use. A questionnaire was sent to all members of the Association asking for their comments on these addenda. A total of 25 replies were received, all favorable, there being no criticisms or suggestions made in regard to the Specifications for the Maintenance of Overhead and Electric Supply Lines. Replies were received from 25 in answer to the questionnaire covering the Joint Use of Poles Specification, all favorable, and one minor suggestion covering an unimportant detail. The concurrence of the proper Committees of the Telegraph and Telephone Section and of the Signal Section have been received through their Secretaries for both the Maintenance Specification and for the Joint Use of Poles Specification.

As addenda to the Specifications for Construction of Overhead Electric Supply Lines, the accompanying Specifications for the Maintenance of Overhead Electric Supply Lines, and for the Joint Use of Poles for Power, Communication and Signal Circuits are submitted.

Conclusions

The Committee recommends that (a) the Specifications for the Maintenance of Overhead Electric Supply Lines be accepted as addendum to the Specifications for the Construction of Overhead Supply Lines for Use on Railroad Property, as recommended practice and printed in the Manual, and (b) that the Specifications for the Joint Use of Poles for Power and Communication Circuits be accepted as an addendum to the Supply Lines Specifications, approved as recommended practice and printed in the Manual.

AMERICAN RAILWAY ENGINEERING ASSOCIATION

COMMITTEE ON ELECTRICITY

October 14, 1925

SPECIFICATIONS FOR THE MAINTENANCE OF OVERHEAD ELECTRIC SUPPLY LINES

TABLE OF CONTENTS

GENERAL

Section *Page*

INSPECTION AND MAINTENANCE DETAILS

MISCELLANEOUS

SPECIFICATIONS FOR THE MAINTENANCE OF OVERHEAD ELECTRIC SUPPLY LINES

Addendum to Specifications for the Construction of Overhead Electric Supply Lines for Railroad Use on Railroad Property

GENERAL

1. Scope

These instructions and specifications are for the guidance of forces engaged in maintaining overhead electric supply lines for railroad use on railroad property.

2. Maintenance Forces Shall—

Have a clear understanding of the requirements called for by these instructions.

Make themselves thoroughly familiar with the specifications and instructions furnished them. They shall keep such specifications and instructions in good condition and convenient for reference.

Keep informed as to the character and condition of the supply lines and the conditions which may affect their stability and operation, reporting whenever necessary such conditions to the proper official.

Be responsible for the preventable troubles and shall make every effort to reduce the so-called unpreventable troubles.

Be responsible for the proper maintenance of all classes of construction. In case of abnormal conditions due to storms they shall make such light repairs as may be necessary to keep the line in working condition, securing the co-operation of other available forces when practicable. When conditions arise which they are unable to handle themselves, they shall make prompt report to the proper official.

Prevent unauthorized attachments to pole lines and report any foreign attachments in non-standard or unsafe condition.

Report all unsafe conditions at wire crossings.

Report all cases of prospective foreign line construction crossing over or under or paralleling the railroad lines.

3. Inspections, Examinations, Replacements, Etc.

Lines shall be inspected frequently. Careful examinations of the component parts of supporting structures and of attachments as a whole shall be made periodically. Repairs and replacements shall be made to insure stability as required below.

4. General Maintenance Requirements

All parts of the supporting structures shall be properly maintained. They shall be strengthened or replaced when the wood poles and crossarms or the guys have deteriorated to 50 per cent of the required initial strength, i.e., to twice the allowable initial unit stress. Structural steel and other metal parts shall be strengthened or replaced when deteriorated to 80 per cent of the required strength, i.e., to 1¼ times the allowable initial unit stress.

INSPECTION AND MAINTENANCE DETAILS

5. Steel Towers

Inspect footings for back fill and condition of concrete if in water. Examine members for straightness, condition of crossarms, nuts, bolts, paint, galvanizing, etc., and correct by means of replacements or otherwise any irregularities that may require attention.

Steel poles, towers or supporting structures, bolts, nuts, washers, anchor rods and similar parts or material subject to corrosion under the prevailing conditions shall be painted as occasion requires. They shall be thoroughly cleaned before painting and no painting shall be done on frosted or wet surfaces.

Pole numbers and danger signs shall be properly maintained.

6. Wood Poles

Inspect footings for back fill and poles for possible displacements. Examine poles for decay or other imperfections, noting in particular their condition at the ground lines.

Defective poles must be replaced or reset before the depreciation exceeds the allowable limits. When reset they must be placed at the standard depth and the alignment must be preserved. Poles washed out must be reset either in their original location or in adjacent location where conditions are more favorable.

In cases of temporary repairs when it is impracticable to obtain standard depth or setting, permanent repairs must be made at the earliest possible time thereafter.

Leaning poles must be straightened.

Pole numbers and danger signs shall be properly maintained.

7. Guys

The examination of guys shall include anchors, clamps, guy insulators, guards, etc. The guys or appurtenances must be replaced before the depreciation exceeds the allowable limit.

Slack guys shall be pulled to proper tension. In pulling guys care should be taken not to get the line wire too tight or "rake" the corner poles too much. Guys at light corners can not be kept tight and must be left with some sag, care being taken to properly clear the line wires. When pulling slack guys watch anchor rod to see if it gives. If anchor rod gives it should be replaced.

8. Crossarms

Examine carefully for decay and other imperfections. If arms are painted test for dry-rot.

Straighten or tighten crossarms when necessary.

Replacements must be made before the depreciation of any part of the crossarms or fittings exceeds the allowable limit.

9. Pole Fittings

Inspection and maintenance of hardware and insulators shall include: Tightening of all loose bolts, spreading of cotter keys, replacement of thimbles in joints if missing, inspection of horns for pitting, inspection of insulators for chips or cracks, inspection of pin type insulators for tightness of pins, alignment of pins and tightness of nuts and the correction of any irregularities that may be noted.

10. Conductors and Ties

Conductors shall be examined for crystallization, pits due to flash-over, broken strands, proper condition of shims, abnormal sag, etc.

Ground wire shall be examined for crystallization, broken strands and condition of clamps, bolts and nuts. Ground leads attached to poles shall be examined for tightness, corrosion at butt and connection to overhead ground wire.

Ties should be examined for tightness. Improper tying introduces weak places in wires. When wires are retired damaged ties should be replaced.

Particular care should be taken in pulling old wire; in general, old wire should not be pulled as tight as new wire except when on the same arm.

When wire begins to give trouble from corrosion it should be carefully inspected and the bad wire removed.

In repairing broken wires the entire span should be examined to guard against kinks and improper sagging.

11. Clearances and Separations

Specified clearances and separations of conductors of various classes of circuits shall be maintained at railroad crossings and at all other locations.

MISCELLANEOUS

12. Trees, Foliage, Brush, Etc.

Trees growing near the line shall be kept trimmed so as to give at least a four-foot clearance from all wires, making due allowance for movement of trees and swinging or increased sagging of conductors.

Report to proper official any danger-timber that may affect the line.

Fire-hazard—the space around poles shall be kept free from underbrush, grass or other inflammable material.

Foliage and Brush—foliage and vines around the pole and brush under the line shall be removed. Where brush conditions are especially bad report should be made to proper official.

Birds' nests should be promptly removed.

Approved for the Committee on Electricity,

By Edwin B. Katte, *Chairman.*

AMERICAN RAILWAY ENGINEERING ASSOCIATION

COMMITTEE ON ELECTRICITY

October 14, 1925

SPECIFICATIONS FOR THE JOINT USE OF POLES FOR POWER, COMMUNICATION AND SIGNAL CIRCUITS

TABLE OF CONTENTS

Section *Page*

SPECIFICATIONS FOR THE JOINT USE OF POLES FOR POWER, COMMUNICATION AND SIGNAL CIRCUITS

Addendum to Specifications for the Construction of Overhead Electric Supply Lines for Railroad Use on Railroad Property

1. Scope

This Addendum describes the standard practice for the joint use of electric power, transmission, and distribution circuits, as defined below, with signal and communication circuits on wood pole lines for railroad use, on railroad property. These provisions do not apply to pole lines where Class "S" and "T" circuits only are involved.

These provisions are to be used in connection with the foregoing specifications, all the requirements of which, except as modified by this Addendum, are to be followed.

Where Class "P-1" and "P-2" circuits are concerned with communication circuits, joint construction is not recommended but may be used where the right-of-way is restricted and the construction of separate pole lines would result in close clearance to tracks, buildings, etc., and between lines unless the character of the circuits makes joint use undesirable.

2. Classification of Circuits

The circuits involved are classified as follows:

(a) Power Transmission and Distribution Circuits

P-1 Constant potential alternating current circuits not exceeding 750 volts between conductors, 440 volts to neutral or ground, and direct current circuits not exceeding 750 volts to ground.

P-2 Constant potential alternating current circuits of voltages between 750 and 5000 volts between conductors (or voltages between 440 and 2900 to neutral or ground) and constant current circuits of not more than 7.5 amperes.

S Constant potential circuits, alternating current or direct current, not exceeding 550 volts between conductors or 320 volts between neutral or ground and the transmitted power of which does not exceed 1600 watts.

(b) Communication and Signal Circuits.

T Communication or signal circuits which operate at not exceeding 440 volts to ground or 750 volts between any two points of the circuits or the transmitted power of which does not exceed 150 watts, below 150 volts no limit is placed on the capacity of the system.

3. Relative Position of Different Classes

The relative position on a pole of the line conductors of different classes, when present, shall in general be from the top of the pole downward, as follows:

Class P-2
Class P-1
Class S
Class T

Where all circuits are owned or operated by one party or cooperative consideration determines that the circumstances warrant and the necessary coordinating methods are employed, double braid weatherproof covered wires carrying a voltage not to exceed, where practicable, 440 volts, or in exceptional cases, 550 volts between conductors with transmitted power not in excess of 1600 watts when involved in the joint use of poles with signal circuits, may be carried below the signal circuits under the following conditions:

(1) That such supply circuits are of wire having a good grade of commercial weatherproof covering not smaller than No. 8 A.W.G. medium hard drawn copper or its equivalent in strength, and the construction otherwise conforms with the requirements for supply circuits of the same class.

(2) That the supply circuits be placed on the adjacent end pins of the bottom crossarm, and that a climbing space of at least thirty inches be maintained up the pole. Special precautions shall be taken to render such circuits conspicuous, such as painting a stripe on the crossarm or using a different form of insulator from the others on the pole line. That there shall be a vertical clearance of at least two feet between the crossarm carrying these supply circuits and the next crossarm above. That the other pins of the crossarm carrying the supply circuit may be occupied by signal circuits not used for telephone and telegraph service but used in the operation or control of railway or supply apparatus.

(3) That such supply circuits shall be equipped with fuses and arresters installed in the supply end of the circuit. The fuses shall have a capacity not in excess of twice the maximum operating current value of the circuit they protect but in no case less than seven amperes. The arresters shall be designed so as to break down at a voltage of approximately twice the voltage between the wires of the circuit, but which need not be less than 500 volts. Where the supply circuits are alternating current, fuses shall be installed in the secondary side of the supply transformer which will successfully open the circuit when the voltage is as great as that of the primary voltage of the transformer.

4. Vertical Separation

In order to provide for future growth and at the same time avoid encroachments on the vertical separation, the vertical clearance between Class P-1 primary or series lighting line conductors, and Class T attachments, shall in general be at least seventy-two inches.

In no case, however, except as specified immediately below, shall the vertical separation at the pole between Class P-1 and T attachments be less than the values shown below:

Crossarms (center to center)	**48 inches**
Other attachments (crossarm braces and guys excepted)	40 inches

Where crossarm braces are attached to metal crossarms, or are in contact with transformer cases or hangers, they are subject to the same clearance requirements as the other attachments.

5. Climbing Space

A clear climbing space at least thirty inches wide between wires and attachments, shall be maintained up the pole. This climbing space may be on one side or corner of the pole only. Where practicable, such climbing space shall be continuous through the wires and attachments of the various classes.

On junction, corner, or other poles where additional crossarms are employed out of parallel with normal crossarms for changing the direction of the line or for branch line, and such construction is below another class, the attachments shall be so located and maintained as to provide and keep open on one side of the pole and next to the pole, as a vertical climbing space, a square of not less than thirty inches on a side. The pole itself and crossarm back braces may be included within the climbing space so measured.

6. Method of Supporting Line Conductors and Cables

Where cable attachments are made directly to the pole, the full climbing space of thirty inches horizontally shall be maintained for a distance of forty-eight inches vertically above and below such attachment.

Class P-1 secondary conductors shall not be above, and preferably not on the same crossarm, with Class P-1 primary or series lighting conductors, except on poles carrying only one Class P-1 crossarm, in which case the secondary conductors may be carried on the same arm, but on the opposite side of the pole from the primary or series lighting conductors.

Class P-1 secondary conductors not exceeding 300 volts to ground may be carried on suitable insulators on malleable iron or steel brackets or racks, attached directly to the pole, confined to the Class P-1 space. Clearance from face of pole, specified in Section 22 of the specification, shall be observed.

Class T twisted pair distributing wires, or suspension wires carrying Class T cables or distributing wires, may be attached directly to the pole within the Class T space by malleable iron or steel fixture. Where more than eight Class T twisted pair wires are carried along the line they shall be grouped and carried in rings on a suspension strand.

Where a suspension wire carrying any cable is attached directly to the pole and is more than twenty-four inches below any Class P-1 attachment, and less than seventy-two inches below the nearest Class P-1 attachment other than cable, a wooden guard-arm shall be attached to the pole immediately above and substantially parallel to such suspension wire.

The guard arm shall be at least forty-eight inches in length and shall be securely fastened to the pole by a through-bolt and properly braced. On corner poles, where the cable turns, the guard-arms shall be placed along the climbing side of the pole.

One line conductor may be carried on a suitable bracket attached to the pole at the top by through-bolts.

The use of pole top extension fixtures, except as clearance attachments on joint poles, shall in general be avoided.

7. Conductors and Cables

Line conductors of Classes P-1 and P-2 circuits shall be of a size not less than No. 6 A.W.G. copper.

Line conductors of Class T circuits, which occupy a position above line conductors or cables of another class (except Class S circuits or Class P-1 circuits) shall be of a size not less than that required for line conductors of similar voltages when placed above Class T circuits.

Class S circuits shall be not smaller than No. 8 A.W.G. copper or its equivalent in strength.

Material other than copper may be used for line conductors, provided the wires of such other material have a strength not less than that of the wires specified above.

No iron or steel line conductors shall be used above line conductors or cables of another class except as noted below:

(1) Where above Class S.

(2) Where above Class P-1 and the iron or steel line conductors are not smaller than No. 10 B.W.G. or in rural districts or arid regions No. 12 B.W.G.

(3) Lightning protection wires as provided in next paragraph.

Lightning protection wires shall be regarded as supply conductors of the voltage in connection with which they are used in respect to size, material, sag, and strength of attachments, provided, however, that they may be of galvanized stranded iron or steel of a diameter not less than $\frac{5}{16}$ inch, except in locations where corrosion of iron or steel is unusually severe.

8. Vertical Conductors

Wires or cables run vertically upon a pole, except above a point not less than forty inches vertically above the highest Class T attachment, shall comply with the following requirements:

(a) Vertical conductors, except ground wires, shall have an insulation conforming to or equivalent to the requirements of the National Electrical Code for rubber covered wire, for the voltage involved.

(b) Vertical runs of Class P-1 conductors shall be carried taut down the pole by means of insulators on pins or metal brackets and securely maintained at approximately five inches from the surface of the pole, and if carried through Class T position shall be enclosed in conduit as specified for metal sheathed cables as in the next paragraph. Multiple conductor cable may be used for vertical runs of two or more Class P-1 conductors of the same circuit.

(c) Vertical runs of Class P-1 metal sheathed cable shall be enclosed within a conduit of suitable insulating material for its entire length, except that, where more than six feet below the lowest Class T attachment, iron pipe may be used. Such conduit and pipe shall be securely fastened to the pole, and iron pipe shall be permanently and effectively grounded.

(d) Vertical runs of Class T metal sheathed cable which run through wires of another class, shall be enclosed within a conduit of suitable insulating material between points not less than six feet below and forty inches above such wires. Such conduit shall be securely fastened to the pole.

(e) Twisted pair wires from a Class T terminal box to a Class T arm or bracket may be attached directly to the pole, if within the Class T position.

(f) Ground wires which pass through attachments of another class shall be covered with a suitable protective insulating guard between points not less than six feet below and forty inches above such attachments. Ground wires shall be suitably insulated and protected from mechanical injury for at least eight feet above the ground. Such protective covering shall be securely fastened to the pole.

(g) The same ground wire shall not be used for grounding the attachments of more than one class. Where practicable, ground wires or vertical connections to underground wires of more than one class shall not be attached to the same pole.

9. Apparatus

Cable boxes, signal boxes, switches, cutouts and similar apparatus may be installed on the pole at a height convenient for operation, provided:

(a) They do not interfere with climbing the pole.

(b) The requirements as to vertical spacing are observed.

(c) They do not prevent the installation of vertical runs.

(d) They shall, when below attachments of another class, have all live parts protected from accidental contact.

(e) Transformers shall not be located below attachments of a lower class.

10. Pole Steppings

Poles carrying vertical runs, lamps, transformers, cable boxes, terminals, or other apparatus which may require attention, should be provided with pole steps.

11. Guy Insulators

One strain insulator shall be placed in every guy at a point between six and eight feet in horizontal distance from the pole, except that, in short guys, where a point six feet from the pole would be less than eight feet above the ground, the strain insulator shall be placed not less than eight feet above the ground.

A second strain insulator shall be placed in every guy, except those attached to a wood guy stub at a point more than eight feet above the ground. The second strain insulator shall be placed at a point between six and eight feet from the object to which the farther end of the guy is attached, except that, where this point is less than eight feet above the ground, the second strain insulator shall be placed not less than eight feet from the ground. In anchor guys the strain insulator shall be placed between eight and ten feet from the ground.

In short guys, in which the two strain insulators here required would be located within five feet of each other, only one strain insulator need be used.

Note.—For mechanical and electrical characteristics of strain insulators see Section 62 of the Supply Line Specification.

12. Crossarms

Crossarms, if of selected yellow pine or fir, shall have dimensions not less than the following:

Number of Pins Carried	*Dimensions of Cross-Section*
2 or 4	3x4 inches
6 or 8	3¼x4¼ inches

If of other material, crossarms shall be the equivalent in strength and durability of the above.

Approved for the Committee on Electricity,

By Edwin B. Katte, *Chairman.*

Appendix G

(7) COLLABORATION WITH COMMITTEE XVI—ECONOMICS OF RAILWAY LOCATION

D. J. Brumley, Chairman, Sub-Committee; A. E. Owen, J. C. Davidson,
H. M. Bassett, R. J. Middleton, H. M. Warren.

The Committee has collaborated with Sub-Committee 2 of Committee XVI—Economics of Railway Location, in the preparation of an outline report to be submitted this year to the Convention.

Conclusions

That the Committee on Electricity continue the study and report on Economics of Railway Location as affected by electric operation in cooperation with Committee XVI—Economics of Railway Location.

Appendix H

(8) STANDARDIZATION OF ADHESIVE AND RUBBER TAPES

H. M. Warren, Chairman, Sub-Committee; G. I. Wright, M. Schreiber,
H. M. Bassett, J. H. Davis, E. B. Katte.

The Committee has reviewed the Association's Specifications for Adhesive Tape and for Rubber Insulting Tape, and have held meetings with representatives of the Telegraph and Telephone Section, and of the Signal Section, in order to agree upon a standard specification which all Sections of the American Railway Engineering Association may adopt, and as a result of these meetings revised specification is herewith submitted for Friction Tape as a substitute for the Specification for Adhesive Tape that is now contained in the Manual, and it is believed that this Specification is acceptable to the other Sections of the Association.

The Specifications for Rubber Tape are now under consideration by the representatives of the various Sections of the American Railway Association, but revised specifications will probably not be ready for submission to the Convention this year.

Conclusions

That the revised Specifications for Friction Tape be accepted, approved as recommended practice, and substituted for the specifications now printed in the Manual.

That the subject of Specifications for Rubber Tape be continued with a view of suggesting changes or modifications which will make these specifiations acceptable to the other Sections of the American Railway Association and in cooperation with the A.S.T.M. and to maintain these specifications representative of the best practice.

AMERICAN RAILWAY ENGINEERING ASSOCIATION

COMMITTEE ON ELECTRICITY

October 14, 1925

SPECIFICATIONS FOR FRICTION TAPE

I. MANUFACTURE

1. Cotton Sheeting

The tape shall be made from cotton sheeting which shall be well, evenly and firmly woven from good cotton and free from defects, dirt, knots, lumps and objectionable irregularities of twist. The fabric shall have from 56 to 60 warp filler threads per inch and run not less than 3.6 yards per pound forty inches wide.

The cotton sheeting after impregnation shall be cut into rolls of the specified width. In this process care shall be taken not to cut the warp threads unnecessarily.

2. Frictioning Compound

The frictioning material shall be an adhesive insulating compound having a rubber base without free sulphur in excess of one-half of one per cent, or containing other substances which will act injuriously upon copper wire or its insulation.

3. Impregnation of Fabric

The fabric shall be thoroughly impregnated and evenly covered on both sides with the adhesive compound which shall be applied on a calender between rolls revolving at different peripheral speeds.

II. PHYSICAL PROPERTIES AND TESTS

4. Adhesive Test

(a) The room temperature and the temperature of the tape shall be not less than 20 deg. C. (68 deg. Fahr.) nor more than 22.2 deg. C. (72 deg. Fahr.).

The sample shall be tested on a mandrel one-quarter inch in diameter which shall be held level in ball bearings of the Fafnir Bearing Co. Cat. .096 or other make and shall turn freely under a weight of 5 grams suspended from a cotton thread wound in a single layer on the center of the mandrel.

A sample sixteen inches long shall be taken from the roll, care being taken not to touch the surfaces to be tested with the hands or otherwise, and two inches of the sample shall be wound on the mandrel and then a weight of ten pounds per inch of the width of the tape shall be attached and the tape wound on the mandrel for twelve inches at the uniform rate of twelve inches per minute.

The tape shall be allowed to stand for three minutes with the weight attached, after which a weight of four pounds per inch of width shall be substituted and the tape allowed to unwind.

After two inches have unwound the rate of unwinding shall not be greater than six inches in three minutes.

(b) A 16 inch strip shall be exposed to dry air at a temperature of not less than 99 deg. Cent. (210.2 deg. Fahr.) nor more than 101 deg. Cent. (213.8 deg. Fahr.) for 16 hours and then cooled to room temperature. A test specimen shall withstand the test prescribed in Section 4 (a) except that the weight applied to unwind the tape shall be two pounds per inch of width in place of four pounds.

5. Tensile Strength

The tensile strength of the tape shall be not less than 40 pounds per inch of width. The initial distance between the jaws of the testing machine shall be twelve inches and the rate of separation of the jaws shall be 20 inches per minute.

6. Pin Holes

The tape shall be tested over a slot in a box eight by eight by eighteen inches inside dimensions and painted white inside, in which a 25 watt incandescent lamp is mounted in the center at the bottom. The number of pin holes in the three yards of tape unrolled not faster than one yard in ten seconds shall not exceed the limits given in the following table:

TABLE I

Width In.	*Max. No. in 3 Yards*	*Max. Number in Single Yard*
½	6	3
¾	6	3
1	9	4
1½	12	5
2	15	6

7. Dielectric Strength Test

The tape shall stand the following test: The tape shall be wound spirally with one-third lap for a distance of six inches on a smooth metal rod one inch in diameter. Two inches in the center shall be covered with metal foil and securely bound with tape. Alternating potential of 1000 volts (r.m.s. value) and having a frequency not exceeding 65 cycles per second shall be applied for five minutes between the metal rod and the metal foil without puncturing the tape.

8. Test Samples

One roll for each 250 rolls shall be taken at random for test. At least two feet of the outer layers shall be removed and discarded before taking specimens for test.

If the tape fails in any one test of those prescribed in these specifications two additional specimens shall be taken and submitted to that test. If either of these two additional specimens fails, the lot of tape represented by that specimen shall be rejected.

III. STANDARD WEIGHT, DIMENSIONS AND VARIATIONS

9. Weights, Dimensions and Yardage

The tape shall conform to the following requirements:

The width shall not vary more than 1/32 inch or the thickness 0.002 inch from that specified in Table II.

Table II

Nominal Width In.	*Nominal Thickness In.*	*Net Weight per Roll Lb.**	*Minimum Length per Lb. in Yards**
½	0.015	¼	82
¾	0.015	½	55
1	0.015	½	41
1½	0.015	1 or 1¼	27
2	0.015	1½	20

---

* Exclusive of core, wrappings and box.

IV. PACKING AND MARKING

10. Packing

Each roll shall be enclosed in a tin box or wrapped in metal foil and enclosed in a paper box to secure and fully protect the contents.

11. Marking

Each box shall be marked with the name of the Manufacturer, a trade mark and an A.R.A. designation, together with the nominal width and weight of the tape. The month and year of manufacture shall be stamped on the side of the roll or marked on a paper placed between the roll and core.

Packages of tape shall be plainly marked on the outside with the Railroad Company's name and address, the order, requisition and package number and the name of the Contractor.

12. Inspection

(a) The Purchaser shall have the right to inspect the materials and processes of manufacture. The Contractor shall submit samples of tape for test according to these specifications, which shall be tested within eight weeks of their receipt.

(b) If the tape has not been accepted at point of production, and if, upon arrival at destination, it does not meet the requirements of these specifications, it may be rejected, and the Contractor, upon request, shall advise the Purchaser what disposition shall be made of the defective material. The Contractor shall pay all freight charges.

Approved for the Committee on Electricity,
By Edwin B. Katte, *Chairman.*

Appendix I

(9) STANDARDIZATION OF INSULATORS

F. D. Hall, Chairman, Sub-Committee; M. Schreiber, H. M. Warren, G. I. Wright, E. B. Temple, R. J. Needham.

Specifications for Porcelain Insulators for Railroad Supply Lines were submitted to the Association at the 1924 Convention and tentatively adopted. The following year a questionnaire was sent to the membership with regard to the use of this specification and thirty-eight (38) replies were received. Of these, thirty-seven (37) were endorsements of the specifications and one (1) suggesting modifications. During the past year the specifications have been reviewed and revised with the assistance of several manufacturing firms, and the Committee now submits the attached Specifications for Porcelain Insulators.

Conclusions

That the Specifications for Porcelain Insulators for Railroad Supply Lines be accepted as recommended practice and printed in the Manual.

AMERICAN RAILWAY ENGINEERING ASSOCIATION

COMMITTEE ON ELECTRICITY

SPECIFICATIONS FOR PORCELAIN INSULATORS FOR RAILROAD SUPPLY LINES

October 14, 1925

SPECIFICATIONS FOR PORCELAIN INSULATORS FOR RAILROAD SUPPLY LINES

(Approved by the Committee, October 14, 1925)

GENERAL

1. Scope

The purpose of these specifications is to describe porcelain insulators suitable to support and insulate wires for the transmission and distribution of electricity for railroad use.

2. Design

The form shall be such that the insulator will carry successfully the electrical and mechanical stresses that will be imposed upon it in service. It shall be so designed as to permit expansion and contraction due to temperature changes without cracking and so that it will not interfere unnecessarily with the cleaning action of the rain and have a suitable groove adequate for the tie and line wires intended, which shall be smooth, free from sand and sharp edges.

Insulators shall be so designed that their flashover voltage is not more than seventy-five per cent of their puncture voltage as described in Section 23.

MATERIALS, PROPERTIES AND USES

3. Porcelain

Insulators shall be made by the wet process. The porcelain shall be dense, fine grained, homogeneous, non-absorptive, strong, tough, without voids or air pockets, laminations, metallic substances, or internal stresses. It shall have been burned to complete vitrification, but not over-fired. It shall be true to shape with smooth surfaces, except where sanded for cementing.

4. Glaze

The porcelain shall be glazed with a smooth, hard, continuous firmly adherent coating, uniform in thickness and of good color, which shall have the same thermal expansion as the porcelain body. The glaze shall be impervious to moisture, not affected by sudden changes in temperature or by ozone, locomotive gases, acid or alkali dust.

5. Sanding

The surfaces to be cemented shall be sanded with a porcelain sand of a size best adapted to the kind and dimensions of the insulator. It shall form an evenly distributed layer firmly vitrified to the shell.

6. Hardware

Metal pins and studs shall be drop forged or cut from rolled stock or of high grade malleable iron or annealed cast steel. Caps and clamps shall be of high grade malleable iron or pressed, forged or annealed cast steel. Cotter pins shall be of brass or non-corrodible metal.

7. Galvanizing

The ferrous hardware shall be hot galvanized in accordance with the American Railway Engineering Association specifications for galvanizing.

INSPECTION

8. Factory Inspection

The purchaser reserves the right to inspect at the works all the processes entering into the manufacture of the insulators and the inspector will reject any part or parts, or any finished product which does not comply with these specifications.

PRELIMINARY TESTS

9. Testing the Individual Parts

The individual shells of multipart insulators shall be tested for dielectric strength before assembly. The character of the testing equipment, method of measuring voltage, mounting of insulators and application of the testing current shall conform to the Standards of the American Institute of Electrical Engineers.

(a) **Preliminary Test—Pin Type:** Before assembly, all shells shall be subjected to vigorous dry flashover potential at normal frequency 25 to 60 cycles for three minutes. If more than 5 per cent fails the lot shall be retested. If on retest more than 3 per cent fails the lot shall be rejected.

(b) **Preliminary Test—Suspension Type:** Before assembly, all shells shall be subjected to vigorous dry flashover potential at normal frequency 25 to 60 cycles for five minutes. If any shell fails during the fourth or fifth minute of the test, the test shall be continued until no shell fails during the last two minutes of test. The excess time is based on the testing of quantities up to 100 at one time. For quantities greater than 100 the excess time after the last failure may be less than two minutes by agreement between manufacturer and purchaser. If more than 5 per cent fails the lot may be retested. If on retesting more than 3 per cent fails the lot shall be rejected.

ASSEMBLY

10. Pin and Suspension Types

The component porcelain parts of a cemented insulator and its metal parts shall be cemented together with the best quality of neat Portland Cement carefully mixed. There shall be suitable provision for expansion of the component parts after the assembly. This requires the use of elastic media, temporary paper collars or similar devices. The cement shall be kept moist for not less than 48 hours immediately after the assembly. Suspension type insulators shall be kept in a steam treating chamber at not less than 130 deg. Fahr. for not less than 12 hours, or for not less than 110 deg. Fahr. for 48 hours immediately after the assembly. Where required, pin type insulators in which the pins are mounted at the factory shall be subjected to the same treatment.

TESTING COMPLETED UNITS

11. Pin Insulators

After complete assembly and cleaning, all insulators shall be tested in groups. The character of the testing equipment, method of measuring voltage, mounting and application of the testing current shall conform to the Standards of the American Institute of Electrical Engineers.

Pin Fit: Ten per cent of insulators which are to be mounted on threaded pins shall be tested for pin fit. They shall be screwed to a seat, then unscrewed two full turns without releasing from the pin. If any undersized or oversized pin holes are found, the entire lot shall be tested and all poor fits rejected.

Final Test: After assembly all units shall be subjected to dry flashover test at normal frequency 25 to 60 cycles for three minutes. Voltages shall be such that insulators shall flashover occasionally. All units failing under this test shall be rejected.

12. Suspension Type Insulators

(a) **Mechanical Test:** All assembled units shall withstand for three seconds without sign of distress a mechanical pull in line with the axis of the insulator amounting to approximately 40 per cent of the rated ultimate strength. This test shall be given before the final electrical test, and in the case of cemented units shall be made not more than 7 days after cementing.

(b) **Electrical Test:** Following the mechanical test each suspension insulator unit shall be subjected to a vigorous dry flashover test at normal frequency 25 to 60 cycles for three minutes. All units failing shall be rejected.

DEFINITIONS

13. Pin Insulator

A "Pin Insulator" is a complete insulator, consisting of one insulating member or an assembly of such members without tie wires, clamps, thimbles or other accessories, the whole being of such construction that when mounted on an insulator pin it will afford insulation and mechanical support to the conductor.

14. Suspension Insulator

A "Suspension Insulator" consists of a porcelain body with its means of suspension in place.

15. Shell

A "Shell" is a single insulating member of porcelain without cement, pin, cap, stud or other attachment; a component part of a multipart insulator.

16. Insulator Unit

An "Insulator Unit" is a single insulator with or without its pin or thimble if of pin type, but with its means of attachment if of the suspension type.

17. String

A "String" is the total number of suspension insulators connected in series as required at one point of support.

18. Sanded Surface

A "Sanded Surface" is any surface of a shell which is covered with a sand-like coating to facilitate the adhesion of cement.

19. Ultimate Mechanical Strength of Insulators

The "Ultimate Mechanical Strength" is the loading in pounds at which the insulator will fail when subjected to mechanical stress.

20. Ultimate Combined Mechanical and Electrical Strength

The "Ultimate Combined Mechanical and Electrical Strength" is the loading in pounds at which the unit fails to perform its function as an insulator. Mechanical stress and voltage being applied simultaneously as required by the standards of the A.I.E.E.

21. Dry Flashover Voltage

"Dry Flashover Voltage" is that at which the air surrounding a clean dry insulator or shell breaks down between electrodes with the formation of a sustained arc at 60 cycles per second. Test to be made as required by the standards of the A.I.E.E.

22. Wet Flashover Voltage

"Wet Flashover Voltage" is that at which the air surrounding a clean insulator or shell under "A.I.E.E. Standard Spray Conditions" breaks down between electrodes with the formation of a sustained arc at 60 cycles per second. Test to be made as required by the standards of the A.I.E.E.

23. Puncture Voltage

"Puncture Voltage" is that at which an insulator or shell is electrically punctured when immersed in oil and subjected to a gradually increasing voltage, as required by the standards of the A.I.E.E.

APPROVED FOR THE COMMITTEE ON ELECTRICITY,
BY EDWIN B. KATTE, *Chairman.*

Appendix I

SPECIFICATIONS FOR PORCELAIN INSULATORS

SOME CAUSES OF INSULATOR FAILURES

Design Failures

- Insulators not self-cleaning by rain.
- Expansion and contraction causing cracking and failure.
    - Porcelain too thick.
    - Porcelain has sharp corners.
    - Porcelain too large diameters.
    - Too large metal parts.
    - No elastic medium or other provision for expansion to prevent damage either from continued hydration of cement or from direct expansion of the shells or hardware.
    - Poorly distributed mechanical or electrical stresses.

Faults of Manufacture

- Porcelain overfired, coarse grained, brittle.
- Porcelain underfired, soft and absorptive.
- Porcelain has internal stresses.
- Air pockets or voids.
- Laminations.
- Metallic substances or other foreign matter.
- Imperfect glazing.
- Cracks and flaws.
- Low thermal conductivity.

Service

Improper selection and mounting, dry flashover value too low for line conditions. Arcing, low thermal conductivity causes excessive cracking of surfaces and breaking of shells.

SELECTION OF INSULATORS FOR RAILROAD USE

Flashover Value, Wet and Dry

The "Wet Flashover Value" of an insulator best expresses its effectiveness as a dielectric, but since it is much more difficult to secure uniform conditions for wet testing than for dry testing and since in standard designs there is some relation between the wet and dry flashovers, the dry flashover value is considered to be a more satisfactory basis for the rating and selection of insulators.

The ratio of dry flashover to line voltage should vary for different atmospheric conditions, classes of construction, and length of line.

ATMOSPHERIC AND LOCAL CONDITIONS

Classes of Construction

The conditions affecting the flashover value of an insulator to be taken under consideration are shown in the following tabulation.

While no definite values can be assigned to these conditions an approximate correction is given for each.

Class "A" represents the average cross-country construction where not affected by railroad conditions.

Class "B" represents the especially favorable conditions, as in parts of Oregon and Washington.

Class "C" such conditions as in California.

		Correction in Per Cent
"A"	Intermittent rains, moderate lightning, wood pole construction, wood crossarms, grounded neutral in open country away from Railroad, Table A. Taken as	100%
	For other conditions the following corrections should be made:	
"B"	A definite rainy followed by a long dry season with heavy dust accumulation, little or no lightning, wood pole construction, wood crossarms, grounded neutral	Add 10 to 20%
"C"	Unusually heavy lightning	Add 10%
"D"	Steel construction or metal pins	Add 10%
"E"	Ungrounded neutral	Add 10%
"F"	Line of over 100 miles in length	Add 10%
"G"	Energy of over 2500 KW transmitted	Add 10%
"H"	Importance of continuity of service	Add 10%
"I"	Smoke or chemical deposits	Add 25 to 50%
"J"	Proximity to the sea and districts with heavy fogs	Add 25 to 50%

Since certain of these conditions affect all railroad supply lines and others affects them but little or are covered by others used, we may take these three cases as representing usual conditions for railroad use.

Case 1.—Line in open country along the right-of-way, Wood Poles, Wood Crossarms, Wood Pins, Ungrounded Neutral.

"A"	100%
"E"	10%
"H"	10%
"I"	25%
	145%

Indicating the selection of an insulator having a dry flashover value of not less than 145 per cent of that for "A" condition alone.

Case 2.—Line in open country along right-of-way, Steel or Wood Poles, Steel or Wood Arms and Ungrounded Neutral.

"A"	100%
"D"	10%
"E"	10%
"H"	10%
"I"	25%
	155%

Indicating the selection of an insulator having a dry flashover value of not less than 155 per cent of that for "A" condition alone.

Case 3.—Where exceptionally heavy smoke conditions prevail near the sea with Steel Poles, Steel Arms, Steel Pins, Ungrounded Neutral.

"A"	100%
"D"	10%
"E"	10%
"H"	10%
"I"	50%
"J"	50%
	230%

Indicating the selection of an insulator having a dry flashover value of not less than 230 per cent of that for "A" condition alone.

These instances illustrate combinations of these corrections and the sums represent desirable increases to cover the conditions referred to as compared with "A" condition alone.

In all cases, a careful study of local conditions should be made and a suitable correction applied to cover any unusually severe conditions which will probably be encountered.

Since in the lower voltages the requirements of mechanical strength produce a dry flashover voltage of higher value than is perhaps needed and the requirements of some State Regulations or Safety Codes must be met, the given factors, while appearing excessive, are not unwarrantably so.

In general the values of the factors and the corrections diminish with increase in line voltage.

TABLE A—DRY FLASHOVER VALUES FOR CLASS "A" CONDITIONS

Nominal Line Voltage Between Phases in KV	*Dry Flashover KV*
.75	10
2.3	25
4.4	35
6.6	40
7.5	45
11.	55
22.	85
33.	110
44.	135
55.	165
66.	195
88.	240
110.	330
132.	390
150.	420
200.	560

Interpolate for intermediate values.

Conclusions

Case 1.—Line in open country along right-of-way, Wood Poles, Wood Crossarms, Wood Pins, Ungrounded Neutral.

Voltage Between Phases

.75 KV line use 15 KV dry flashover insulator
2.3 KV line use 36 KV dry flashover insulator
4.4 KV line use 50 KV dry flashover insulator
6.6 KV line use 58 KV dry flashover insulator
7.5 KV line use 65 KV dry flashover insulator
11. KV line use 80 KV dry flashover insulator
22. KV line use 120 KV dry flashover insulator
33. KV line use 160 KV dry flashover insulator
44. KV line use 195 KV dry flashover insulator
55. KV line use 245 KV dry flashover insulator
66. KV line use 280 KV dry flashover insulator

Case 2.—Line in open country along right-of-way, Steel or Wood Poles, Steel or Wood Arms, Steel Pins and Ungrounded Neutral.

.75 KV line use 16 KV dry flashover insulator
2.3 KV line use 40 KV dry flashover insulator
4.4 KV line use 55 KV dry flashover insulator
6.6 KV line use 62 KV dry flashover insulator
7.5 KV line use 70 KV dry flashover insulator
11. KV line use 85 KV dry flashover insulator
22. KV line use 130 KV dry flashover insulator
33. KV line use 170 KV dry flashover insulator
44. KV line use 210 KV dry flashover insulator
55. KV line use 255 KV dry flashover insulator
66. KV line use 300 KV dry flashover insulator

Case 3.—Where exceptionally heavy smoke conditions prevail, near the sea, with Steel Poles, Steel Arms, Ungrounded Neutral.

.75 KV line use 23 KV dry flashover insulator
2.3 KV line use 55 KV dry flashover insulator
4.4 KV line use 80 KV dry flashover insulator
6.6 KV line use 92 KV dry flashover insulator
7.5 KV line use 105 KV dry flashover insulator
11. KV line use 125 KV dry flashover insulator
22. KV line use 195 KV dry flashover insulator
33. KV line use 252 KV dry flashover insulator
44. KV line use 310 KV dry flashover insulator
55. KV line use 380 KV Suspension insulator
66. KV line use 450 KV Suspension insulator

These values need not be considered exact and may be varied 10 per cent up or down to cover the standard designs of reliable manufacturers.

Appendix J

(10) CLEARANCES FOR THIRD RAIL AND OVERHEAD WORKING CONDUCTORS

H. M. Bassett, Chairman, Sub-Committee; F. D. Hall, A. E. Owen, D. J. Brumley, W. M. Vandersluis, F. Auryansen.

The Clearance Tables for Third Rail and Overhead Working Conductors presented at the 1924 Convention have been revised by means of questionnaires and brought up to date and are herewith submitted.

Conclusions

That the revised Tables of Clearances for Third Rail and Overhead Working Conductors be accepted as information and printed in the Manual.

That the work be continued and that next year the Third-Rail Tables be extended to include data showing the location of the third-rail above the plane of the running rails and beyond the gage line.

AMERICAN RAILWAY ENGINEERING ASSOCIATION

Statement 1
Page 1

Data Regarding Third Rail Clearance.

Name of Company	Top or Under Contact	Protection	Uses Steam Equipment	Structures Clear Prop. Lines	Mileage in Operation	Mileage planned for immediate future	Mileage using Steam Equipment	Remarks
Albany Southern R.R. Co.	Top	No	No	Yes	53.50	None	None	1 Mile O.H. Trolley included in total.
Baltimore & Ohio R.R. Co	"	Partly	Yes		7.96	"	7.96	Rail completely protected at Stations & partially protected at other points by guard boards 1" above rail
Boston Elevated Ry.	"	No	No		48.619	"	None	Partially Protected.
Chicago Rapid Transit Co.	"	No	No	No	193.39	"	"	24 Miles O H. Trolley not included.
Chicago, Aurora & Elgin R.R. Co	"	"	Yes	"	98.68	"	98.68	4¼ Miles O.H. Trolley included in total.
Central California Traction Co	Under	Yes	Emergency Only	Yes	70.00	"	None	24 " " " " " "
Detroit River Tunnel Co.	"	"	Yes	"	28.55	"	4.83	2.7 " " " " " "
Grand Rapids, Grand Haven & Muskegon R.R.	Top	No	No		46.00	"	None	10. " " " " " "
Hudson & Manhattan R.R. Co	"	Yes	"	No	20.00	"	"	Subway.
Interborough Rapid Transit Co.	"	"	"	"	382.96	26.00	"	Subway & Elevated Lines.
Lackawanna & Wyoming Valley R.R.	"	No	Yes	"	52.00	None	52.00	10 Miles O.H. Trolley included in total.
Long Island R.R. Co.	"	Yes	"		296.32	Approx. 1 Mile	296.32	
Michigan R.R. Co.	"	No	"		224.00	None	224.00	O.H. & Underground Conductors at X-ings.
New York Central R.R. Co.	Under	Yes	"	Yes	266.36		218.38	2.17 Miles O.H. Conductors.
New York State Rys.	"	"	"		105.10	None	103.18	
New York Rapid Transit	Top	About 48%	No		294.049	8 Miles	None	
Northwestern Pacific R.R. Co	"	Sta's only	Yes		38.69	None	38.69	
Philadelphia & Western R.R. Co	"	Yes	"	Yes	37.15	"	None	9 Miles O.H. Trolley Yds & Sidings not in total
Pennsylvania R.R. (New York Div.)	"	"	"	"	101.56	"	22.70	1.18 Miles O.H. Contact at X-overs in N.Y. Station.
Penn'a R.R. (West Jersey & Sea Shore)	"	"	"		150.30		150.30	8.61 Miles O.H. Trolley included
Philadelphia Rapid Transit Co.	Under	"	No	No	34.673	None	None	Subway & Elevated Lines.
Puget Sound Electric Ry	Top	No	"	"	63.30	"	"	21.65 Miles O.H. Trolley included in total.
Sacramento Northern R.R.	"	Sta Grounds	Emergency Only	"	217.87	"	"	55.03 " " " " " "
Scioto Valley Ry. & Power Co.	"	No	No	Yes	75.11	"	"	6.81 " " " " " "
Staten Island Rapid Transit Ry	"	Yes	"	"	48.63	"	"	All passenger service electrically operated
Wilkes-Barre & Hazelton Ry. Co.	"	Yes	No	Slight	30.74	"	"	1.54 Miles O.H. Trolley on Lehigh Tract Co not in total.

Revised, November 1, 1925.

AMERICAN RAILWAY ENGINEERING ASSOCIATION

Data Regarding Overhead Clearance

Statement 2
Page 1

Name of Company	Conductor	Height Above Rail	Electrified Single Track Miles	Steam Equip Handled	Clearance Diagram	Current & Voltage	Contact Device	Special Construction of X-ings, other Roads.	Remarks
Bangor Ry. & Elect. Co.	2/0 Band 0	Max. 23'-0" Std. 19'-0" Min. 15'-0"	67.69	None	None Submitted	D.C. 600	Trolley		
Boston & Maine R.R.	4/0 Grooved	Std. 22'-0" Min. 15'-10"	21.385	21.385 Mi.	Submitted	Single Phase A.C. 11.000	Pantagraph	Print Submitted	Berkshire St. Ry. at No. Adams 20'-0" 15'-10" Standard for Hoosac Tunnel.
British Columbia Elec. Ry. Co.	4/0 Grooved & Round	22'-6"	183 Mi. Inter 185 Mi. City	None		D.C. 550-600	Trolley	None	Steam Road Equipment handled in daily Inter Change of Freight Freight handled by Elec. Locomotives.
B.M.T. System & Brooklyn City R.R. Co.	Round 1/0-2/0-3/0-4/0	Max. 21'-6" Std. 18'-0" Min. 12'-0"	548.328	See Note	Outline of Equipment	D.C. 575	Trolley	None	Freight handled by Elec. Loco.
Butte, Anaconda & Pacific Ry. Co.	4/0 Grooved	Max. 22'-0" Std. 22'-0"	122.69	42.25 Mi.	None Submitted	D.C. 2400	Pantagraph		
Cedar Rapids & Iowa City Ry	4/0	Max. 22'-0" Avg. 19'-0"	45.7	5 Mi.	Submitted	D.C. 600	Trolley	Yes	Main Line only. 17 Mi Catenary Balance direct suspension Freight handled by Electric Locos.
Central New York Southern R.R.									Operation discontinued
Chautauqua Traction Co.	2/0	16'-0"	28	None	None Submitted	D.C. 600	Trolley	Overhead X-ings	Steam Road Equipment handled in daily interchange of Freight. Handled by Electric Locomotives
Chicago South Shore & South Bend Ry. Co.	4/0 Grooved	Max. 22'-6" Std. 21'-0" Min. 15'-6"	105.1	105.1 Mi.	Submitted	Single Phase A.C. 6600	Pantagraph	None	Freight handled by 2 Electric Locomotives
Chicago, Milwaukee & St. Paul Ry. Co.	4/0 Grooved	Std. 24'-2"	847.71	None	None Submitted	D.C. 3000	Pantagraph		647.89 Mi. 1st Main - 4.59 Mi 2d Main - 195 23 Mi Siding and Yard
Chicago, North Shore & Milwaukee R.R. Co.	3/0 Grooved	Max. 22'-6" Std. 22'-0" Min. 14'-9"	182.65	A Few Freight Cars	None Submitted	D.C. 600	Trolley	Catenary	
Cincinnati, Georgetown & Portsmouth R.R.	3/0 - 4/0 Grooved	Max. 22'-0" Avg. 19'-0"	62	None	None Submitted	DC 600	Trolley	None	Freight Equipment Interchanged
Clinton, Davenport & Muscatine Ry. Co.	3/0 - 4/0 Round	No Standards in State	66	None	None Submitted	D.C. 600-1200	Trolley	Double Spans Heavy Poles Back Guys	Catenary Construction 25 Miles.
Detroit United Railway	2/0 - 3/0 Grooved Round & 8	Max. 22'-6" Std. 18'-6" Min. 14'-6"	613.9	A Few Freight Cars	Std. Line Construction	D.C 600	Trolley	According to Specifications of Michigan Ry Comm	
Erie Railroad Co.	3/0 Grooved	Max. 24'-0" Std. 22'-0" Min. 16'-0"	38	34	None Submitted	11.000	Pantagraph	None	Operates Standard Steam Engines For Freight.

Revised, November 1, 1925.

AMERICAN RAILWAY ENGINEERING ASSOCIATION.

Statement 2
Page 2

Data Regarding Overhead Clearance

Name of Company	Conductor	Height Above Rail	Electrified Single Track Miles	Steam Equip Handled	Clearance Diagram	Current & Voltage	Contact Device	Special Construction of X-ings, other Roads	Remarks
Evansville Suburban & Newburg Ry. Co.	3/0 Grooved	Max. 22'-0" Avg. 18'-0"	25.	25 Mi.	None Submitted	D.C. 600	Trolley	22' Height at X-ings required by State Law	Operates Standard Steam Engines for Freight.
Fonda, Johnstown & Gloversville R.R. Co.	4/0 Grooved	Max. 22'-0" Std. 18'-0" Min. 15'-0"	78.	½ Mi.	None Submitted	D.C. 600	Trolley	22' Height at Steam X-ings.	
Fort Dodge, Des Moines & Southern R.R. Co.	3/0 - 4/0 Grooved	Max. 24'-0" Std. 23'-0" Min 21'-0"	150.	150 Mi.	None Submitted	D.C. 1200	Trolley	None	Handles Std. Freight Cars with Electric Locomotives.
Galveston Electric Co.	2/0 Round	Max. 22'-0" Std. 18'-0" Min. 17'-0"	36.19	None	None Submitted	D.C. 600	Trolley		
Grand River Railway Co.	3/0	Max 22'-6" Avg. 18-6"	22.	½ Mi	None Submitted	D.C. 1500	Trolley	None	Std Freight & Pass Equip. handled with Electric Locomotives and occasionally by Steam.
Great Northern Ry. Co. (Cascade Tunnel)	2-4/0 Grooved 1" C to C	Max. 22'-6" Min. 17'-4"	8.5	8.5 Mi.	Submitted	3 Phase 25 Cycle A.C. 6600 V	Trolley	None	Includes 3.8 Mi. Side Tracks Max. Height in Yds. Min in Tunnel
Grand Trunk Ry. System (St. Clair Tunnel)	4/0 & 300.000 C.M. Grooved	Max. 22' in Yds. Min. 15'-4" Tunnel 16'-6"	12.	About 10 Miles	Submitted	Single Phase A.C. 3300	Pantagraph	None	
Illinois Traction System (Main Div.)	3/0 Grooved	Max. 23'-0" Std. 20'-0" Min. 15'-6"	505.15	None	None Submitted	D.C. 600	Trolley	As per State Comm Rules for Height only.	Handles Standard Cars but no Locomotives.
Illinois Traction System (Illinois Valley Div.) (Formerly Chicago Ottawa & Peoria Ry)	3/0 8 & Grooved	Max 22'-6" Avg. 18'-0"	106.56	None	Submitted	D.C. 650	Trolley	Yes	Steam Road Equip. handled in daily Interchange of Freight.
Interstate Public Service Co.	4/0 Grooved	Max. 21'-0" Avg. 18' 0"	117.6	None	None Submitted	D.C. 600	Trolley	Elevated Trolley wires to clear legal requirements	Exchanges Equip. (Pass & Freight) with other Electric Lines
Illinois Central R.R. Co. (Chicago Terminal)	3/0 - 4/0	Max. 23'-0" Min 16'-6" Norm. 22' 0" and 18' 6"	Proposed 125.	None Proposed	Submitted	D.C. 1500	Pantagraph	Yes	Suburban Service only. Will be put in operation in 1926.
Indiana, Columbus & Eastern Traction Co	4/0 Grooved & Round	Max. 22'-0" Std. 21'-0" Min. 16'-0"	205.77	None	See Note	D.C. 600-650	Trolley	A.E.R.E. Assn.	Bldgs. 10' from ℄. 200.38 Miles owned Trackage rights 5.06 Miles. Joint owned .33 Miles.
Joplin & Pittsburg Ry. Co.	4/0 0&8 2/0 0	Max. 22'-0" Avg. 19'-0"	104.	None	None Submitted	D.C. - 600	Trolley	22' Wire Clearance	Handles Std Equip. in Interchange with Steam Roads.
Kansas City, Clay County & St. Joseph Ry. Co.	4/0 Grooved	Max. 23'-0" Avg 19' 0"	70	See Note	None Submitted	D.C. 1400	Trolley		Freight Equipment interchanged
Lake Erie & Northern R.R.	4/0 Grooved	Max. 22'-6 Std 21'-6 Min. 16'-6	55.1	55.1	Submitted	D.C. 1500	Trolley & Pantagraph		Std. Freight & Pass Equip. handled with Elec Loco & Occasionaly by Steam.

Revised, November 1, 1925.

AMERICAN RAILWAY ENGINEERING ASSOCIATION.

Statement 2
Page 3

Data Regarding Overhead Clearance

Name of Company	Conductor	Height Above Rail	Electrified Single Track Miles	Steam Equip Handled	Clearance Diagram	Current & Voltage	Contact Device	Special Construction of X-ings, other Roads	Remarks
Lake Shore Electric Ry. Co.	4/0 Grooved	Max 22'-0" Std. 18'-0" Min. 14'-6"	218.	7 Mi.	All New Work	D.C. 575	Trolley	None	Trolley raised to 22
Lehigh Valley Transit Co.	2/0 - 4/0 Round & 8	Std. 18'-0"	208.	None	None Submitted	D.C. 600	Trolley		
Lima Toledo R.R. Co.	3/0 Round 3/0 - 4/0 Grooved	Max 22'-0" Std 21'-0" Min. 16'-0"	70.7	None	None	D.C 600	Trolley	None	
London & Port Stanley Ry.	4/0 Catenary	Max 23' 2" Min. 16' 0"	24.6	24.6 Mi	None Submitted	D C 1500	Pantagraph	Yes	
Mason City & Clear Lake R.R. Co.	2/0 Round	Max. 23'-0" Min. 21'-0"	20.6	None	None Submitted	D.C. 650	Trolley	None	Interchanges Freight Equip. with Steam Roads
Minneapolis, Anoka & Cuyuna Range Ry. Co.	4/0	Max. 22'-0" Avg. 16'-0"	19.21	None	None Submitted	D.C. 650	Trolley Shoe Wheel	Yes	
Montreal & Southern Counties Ry. Co.	4/0 Grooved	Max. 23'-0" Std. 22'-0" Min. 15'-0"	53.66	None	None Submitted	D.C. 600	Trolley	None	Interchanges Freight Equip with Steam Roads.
Mt. Royal Tunnel & Terminal Ry. (Canadian National Rys.)	4/0 Catenary	Max. 23'-0" Min. 16'-0"	26.	10 Mi		D.C 2400	Pantagraph	Yes	No Steam used on Electrified Tracks.
New York Central R.R. Co (Overhead)	8 & T	So. 144 St. No. 144 St. Max. 15'-3" 15'-5" Min. 15'-1" 15'-3"	2.17	.071 Mi.		D.C. 660	Shoe	None	Running Position 15'-1" Low 14'-7⅞" to 14'-9½" High (NYC) 15'-5⅞" to 15'-6"
N.Y. N.H. & H.R.R. Co. (Main Line)	4/0 Grooved	Max. 23'-0" Std. 20'-3" & 22'-0" Min. 15'-6"	562.0	562.0 Mi.	Submitted	A.C. 11.000	Pantagraph	Yes	Includes 11.6 Mi on New York Connecting R.R
N.Y. N.H. & H.R.R. Co. (N.Y. W. & B)	4/0 8	Max. 23'-0" Std. 22'-0" Min. 16'-0"	58.	None	Submitted	A.C. 11.000	Pantagraph	None	
N.Y. N.H. & H.R.R. Co (P.W. & B)	4/0 Round	21'-0"	48.5	48.5 Mi.	Submitted	D.C. 650	Trolley	Yes	Sliding Contact
N.Y. N.H. & H.R.R. Co. (Nantasket Beach)	4/0 - 6/0 8	21'-0"	16.61	16.61 Mi.	Submitted	D.C. 600	Trolley	None	Sliding Contact
N.Y. N.H. & H.R.R. Co. (Berlin-Middletown)	4/0 Round	22'-0"	10.88	10.88 Mi.	None Submitted	D.C. 600	Trolley	None	
New York State Railways	2/0-3/0-4/0	Max. 22'-0" Std. 20'-0" Min. 18'-0"	493.97	None	Submitted	D.C. 575-650	Trolley	None	22' Std on Electric Steam Roads and R.R. X-ings. 18'-20' Std. on Trolley or City Lines.

Revised, November 1, 1925.

AMERICAN RAILWAY ENGINEERING ASSOCIATION

Statement 2.
Page 4.

Data Regarding Overhead Clearance

Name of Company	Conductor	Height Above Rail	Electrified Single Track Miles	Steam Equip Handled	Clearance Diagram	Current & Voltage	Contact Device	Special Construction of X-ings, other Roads.	Remarks
Niagara St Catharines & Toronto (Canadian National Rys)	4/0 Grooved	Avg 22' 6" Min 19 - 0"	85.7	63.5 Mi		D.C. 600	Trolley		23.9 Mi of Sidings & Spurs included.
Norfolk & Western Ry. Co.	3/0 Grooved	Std 24'-0" Min 23' 9"	205.	205. Mi	Submitted	A C 11000	Pantagraph	See Note.	Foreign Lines are required to cross using steel poles and giving 60' clearance above rails
Norfolk Southern R R Co	4/0 Grooved	Max 21'-0" Std 21'-0" Min 19'-4"	44.14	44.14 Mi	Submitted	D C 550 A C 13.200 25 cycle	Trolley		Includes 9.46 Mi. 2nd Track and 13.04 Mi. Sidings
Northern Ohio Traction & Light Co	3/0 - 4/0 Grooved	Max 22' 0" Std 18' 0"	294 8	None	None Submitted	D C 600	Trolley	Max Height at R.R.X'ings	
Northern Texas Traction Co.	2/0 - 3/0 - 4/0	Max 23 - 0" Avg 19'-0"	146.48	None	None Submitted	D C 600	Trolley	None	
Olean, Bradford & Salamanca Ry (Formerly Western NY & Pa Traction)	4/0 Round	Max 22'-0" Min 18'-0"	99	None	None Submitted	D C 650	Trolley	None	Interchanges Freight Equip. with 4 Steam Roads.
Oregon Electric Ry	4/0 Grooved	Max 23'-0" Std 22'-0" Min 16'-0"	195.91	None	None Submitted	D. C 10 Mi - 600 V 185.91 Mi - 1300 V	Trolley	Yes	
Pacific Electric Ry Co	3/0 - 4/0 Grooved	Max 22'-0" Min 19'-0"	1162.10	1020 Mi.	Submitted	D.C. 600 & 1200	Trolley	Insulated X-ings	
Pacific Northwest Traction Co	2/0 to 4/0 Round 2/0 Grooved 4/0	Max 21'-0" Std 20'-0" Min 19'-0"	66.41	66.41 Mi.	Submitted	D.C 600	Trolley	23' Clearane over Steam Lines.	Includes Northern and Southern Division.
Pennsylvania R.R. Co. (New York Div)	25 lb Rail "T" Shape	Max 15' 5" Std 15' 4" Min 15' 2"	1.18	None	Submitted	D C. 650	Pantagraph	None	Used at X'overs in N.Y. Station.
Pennsylvania R.R. Co. (Phila, Paoli, Chestnut Hill)	3/0 Grooved	Max 24' 0" Std. 22' 0" Min 15'-7¼"	125 40	125.40 Mi.	Submitted	Single Phase A.C. 11.000	Pantagraph	None	Also includes Ft. Washington Branch.
Pennsylvania R.R. Co. (West Jersey & Seashore)	4/0 Grooved	Max 22' 0" Std 22'-0" Min 16'-8"	8.65	8.65 Mi	Submitted	D.C 675	Trolley	None	
Pennsylvania R.R. Co (Cumberland Valley)	4/0 Grooved*	Max. 22'-2" Std. 22'-0" Min 16' 8"	9.06	9.06 Mi.		D.C. 550	Trolley	None	
Pennsylvania R.R. Co (Williamsport)	3/0 Grooved	Max. 22'-0" Std. 22'-0" Min. 19'-5"	0.47	0.47 Mi.	Submitted	D.C 550	Trolley	None	
Portland Electric Power Co. (Formerly Portland Railway Light & Power Co.)	1/0 - 3/0 - 4/0 Grooved & 8	Interurb. Max. 22'-0" Avg. 21'-0" City 21'-0" 19'-0"	310.268	None	Submitted	D.C 600	Trolley	Insulated X-ings.	185 268 Mi. City Lines Owned 10.581 " " " operated not owned .044 " " " partly owned 112 407 " Interurb " owned 1 3 " " " operated, not owned

Revised, November 1, 1925.

AMERICAN RAILWAY ENGINEERING ASSOCIATION.

Data Regarding Overhead Clearance

Statement 2.
Page 5.

Name of Company	Conductor	Height Above Rail	Electrified Single Track Miles	Steam Equip Handled	Clearance Diagram	Current & Voltage	Contact Device	Special Construction of X-ings, other Roads.	Remarks
Puget Sound Electric Ry.	4/0 Grooved	Max. 22'-0" Avg. 19'-0"	63.30	None	Submitted	D.C. 600	Trolley	Trolley Height 22'0"	
Quebec Railway Light Heat & Power Co.	2/0 Round.	Std. 21'-0"	46.89	46.89	None Submitted	D.C. 550	Trolley	Built according to Spec. of Canadian Ry. Comm.	
Rock Island Southern R.R.Co. (Galesburg & Western R.R.)	3/0 8 & Grooved	Max 22'-0"	15.	None	None Submitted	D.C. 600	Trolley	None	
Sacremento Northern R.R. (Formerly Northern Elec. Ry.)	4/0 - 2/0	22'-0"	55.03	None	Submitted	D.C. 600	Trolley		
Salt Lake & Utah R.R. Co.	4/0 Grooved	Max. 22'-0" Std. 22'-0" Min. 18'-0"	92	None	Submitted	D.C. 1500	Trolley	See Note	By contract or under tentative general order of Public Utilities Comm of Utah effective Sept. 1, 1917.
San Francisco, Napa & Calistoga Ry.	3/0 Grooved	19'-0" New Const. 22'	45.31	7 Mi.	Submitted	A.C. 3300	Pantagraph	Gen'l. Order 64 C.S.R.C.	22' Trolley Clearance on Reconstruction or New Work.
San Francisco Sacremento R.R.	4/0 Grooved	Max 22'-0" Std 20'-0" Min. 19'-0"	103	None	Submitted	D.C. 1200	Trolley	None	Height of Trolley Clearance now 22' minimum in this State for all new Construction.
Southern Illinois Ry & Power Co.	4/0	Max. 22'-0" Avg. 18'-0"	15.13	All Freight	None Submitted	D.C. 1200	Trolley	None	
Southern New York Ry.	2/0	Avg 18'-0"	68	None	None Submitted	D.C. 600	Trolley	Yes	Handles Std. Freight Equipment over entire mileage.
Southern Ohio Public Service Co. (Formerly Columbus, Newark & Zanesville)	4/0 Grooved & Round	Max. 22'-0" Std 21'-0" Min. 16'-0"	85.10	None	See Note	D.C. 600 to 650	Trolley	A.E.R.E. Assn.	Pole line 8' & Bldgs. 10' from ℄ of Track
Southern Pacific Co. (East Bay Elec. Div.)	4/0 Grooved	Max. 22'-0" Std. 22'-0" Min. 18'-0"	* 118.92	× 56 Mi	None Submitted	D.C. 1200	Pantagraph	Double Insulation with grounded Section.	* Includes 19.23 Mi. Sidings & Spurs × Includes 12.8 Mi. Sidings & Spurs
Southern Pacific Co. (Portland Div.)	4/0 Grooved	Avg. 22'-0"	* 172.45 + # 27.09 Mi of St Car Lines	× 137.01 Mi	Submitted	D.C. 1600	Pantagraph	Double Insulation with ungrounded dead Section.	* 17.91 Mi. Sidings & Spurs & 1.09 Mi. 2d. Trk # .30 Mi. 2nd Trk. × 14.21 Mi. Sidings & Spurs.
Spokane & East. Ry. & Pow. Co. Inland Empire R.R.	3/0 - 4/0 8 & Grooved	Max 22'-0" Avg. 19'-0"	184.4	None	None Submitted	A.C. 6600 D.C. 600	Pantagraph Trolley	None	
Tacoma Ry. & Power Co.	2/0 Round	Max. 22'-0" Avg 19'-0"	106.28	None	None Submitted	D.C. 600	Trolley	Trolley Height 22'0"	Includes Pacific Traction Co.
Tarrant County Traction Co	4/0 Grooved	Max. 23'-0" Std. 19'-0" Min. 17'-0"	29.77	None	None Submitted	D.C. 600	Trolley	National Trolley Guards	

Revised, November 1, 1925.

AMERICAN RAILWAY ENGINEERING ASSOCIATION.

Data Regarding Overhead Clearance

Statement 2
Page 6

Name of Company	Conductor	Height Above Rail	Electrified Single Track Miles	Steam Equip Handled	Clearance Diagram	Current & Voltage	Contact Device	Special Construction of X-ings, other Roads	Remarks
Texas Electric Ry.	4/0 Grooved	Max 23'-0" Std 19'-0" Min 17'-0"	229 94	None	None Submitted	D. C. 600 & 1200	Trolley	National Trolley Guards	Interurban Main Line
Toledo & Western R R Co.	3/0 8	Max 21'-0" Std 19'-0" Min 18'-0"	73.5	None	None Submitted	D.C. 600	Trolley	Tower over Foreign Lines	
Toronto Suburban Ry (Canadian Nat'l Rys)	4/0 Catenary & 2/0	Avg 20'-0" Min 13'-6"	68.82	46.5 Mi.		D. C. 600 & 1500	Trolley		Sidings, Wyes, etc 4 7 Mi.
Twin City Lines (Minneapolis, Minn)	2/0 8	Max 22'-6" Std 18'-0" Min 17'-0"	9 0	None	None Submitted	D C. 600	Trolley	22'0" Trolley above Steam Road Tracks	
Union Traction Co of Indiana.	1/0 - 2/0 - 3/0 Round - 8 & Grooved	Max 22'-0" Std 18' to 20' Min 15' at Bridges	408 Inter-urban 45 City	1 Mi.	Submitted	D. C. 600 to 650	Trolley	None	
United Electric Rys Co. (Formerly Rhode Island Co)	2/0 - 4/0 Round & Grooved	Max 22'-0" Std 19' to 20' Min 13' under Br	338.87	None	None Submitted	D C 600	Trolley	Double span 1 each side of Crossings & Trolley Guards	With Catenary Construction.
United Railways Co. (Part of Spokane, Portland & Seattle)									Trolley fixtures rem[illegible]d. Now Steam operated
Utah Idaho Central R R Co.	2/0 - 4/0 Grooved	Interurban 22'-	130 4	None	As per Railway Line Clearance Guide	D C. 750 to 1500	Trolley	Yes	Interurban Lines
Utah Rapid Transit Co.	2/0 - 4/0 Grooved	18'0" except at X-ings then 20'	28 38	None		D C 600	Trolley	Trolley Height 20'	City Lines.
Virginian Railway Co.	3/0 Grooved	Max 24'-6" Std 24'-6" Min. 18'-0"	90	90 Mi.	None Submitted	A.C. 11.000	Pantagraph	None	Still under Construction Estimated as of Nov 1, 1925
Visalia Electric R.R	3/0	22'-0"	51.8	19.86 Mi	None Submitted	A.C. 3300	Pantagraph	None	Interchanges Equipment with Steam Lines.
Walla Walla Valley Ry Co	4/0	21'-0"	30.3	24.4 Mi.	None Submitted	D.C. 575	Trolley		
Washington, Baltimore & Annapolis Elec. R.R. Co.	4/0 Grooved	Max. 21'-0" Std 19'-0" Min. 15'-0"	137.1	40 Mi.	None Submitted	D.C. 1200	Trolley	None	
Washington & Old Dominion R.R.	4/0 Grooved	22'-0"	88.3	None	None Submitted	D.C. 650	Trolley	None	
Waterloo, Cedar Falls & Northern Ry Co	4/0 Grooved 2/0 Round	Interurb City Max 23'0" 22'0" Std. 21'0" 18'6" Min 15'0" 18'0"	138.64	117.54 Mi.	None Submitted	D.C. 650 & 1300	Trolley	A.E.R.E.A. Std. Specifications	Interchanges Freight Equip. with Steam Roads.

Revised, November 1, 1925.

AMERICAN RAILWAY ENGINEERING ASSOCIATION.

Statement 2.
Page 7.

Data Regarding Overhead Clearance

Name of Company	Conductor	Height Above Rail	Electrified Single Track Miles	Steam Equip Handled	Clearance Diagram	Current & Voltage	Contact Device	Special Construction of X-ings other Roads.	Remarks
Western Ohio Ry Co	2/0 Round 3/0 Grooved	Max 22'-0" Min 18'-0"	112	None	None Submitted	D C 650	Trolley	None	
Youngstown & Suburban Ry Co	3/0 Grooved	Std 17'-6"	20	None	None Submitted	D C 625	Trolley	None	

Revised, November 1, 1925.

Appendix K

(11) PROTECTION OF OIL SIDINGS FROM DANGER DUE TO STRAY CURRENTS

S. Withington, Chairman, Sub-Committee; J. V. B. Duer.

There have been no new developments with regard to the Rules for the Protection of Oil Sidings from Danger Due to Stray Currents during the past year, and so far as is known, the installation of the proposed protection is proceeding on many railroads without confusion. The question has been raised by the Bureau of Explosives of the American Railway Association, in connection with the unloading of tank cars by the use of air pressure, with particular reference to the consideration of accumulation of static charge on account of the rapid flow of air and gasoline through pipes. It is the opinion of the Committee on Electricity that the provisions of the Rules for the Protection of Oil Sidings, if properly followed, will adequately take care of any static discharge.

Conclusions

That the subject be continued and the Committee authorized to confer with representatives of other interested associations with a view of revising the Rules if and when necessary.

Appendix L

(12) SPECIFICATIONS FOR TRACK AND THIRD-RAIL BONDS

J. H. Davis, Chairman, Sub-Committee; W. M. Vandersluis, J. C. Davidson, E. B. Katte, J. V. B. Duer, S. Withington.

Inasmuch as this is the first time the subject of bonding has been considered by the Committee on Electricity and the fact that comparatively little has been done through any channel toward the standardization of bond practice, particularly in the field of welded type of bonds, it has been necessary to give considerable study to this subject before undertaking the preparation of tentative specifications covering the various kinds of bonds that are used in heavy electric traction service.

The work of the Sub-Committee this year has been confined largely to securing and tabulating data covering the latest bonding practice as being used in steam railroad electrifications in the United States and Canada. The results of this survey are given in the tables accompanying this report, which covers twenty-one installations of track bonds as used on eighteen railroads and eight installations of third rail bonds as used on seven railroads.

It will be noted that track rail bonding as well as third-rail bonding practice varies widely even where conditions that affect the selection of the bonds are similar. Reliable data covering relative merits and performance of the different types of bonds is lacking and it is felt that further experimenting and engineering study is necessary before it will be practicable to standardize modern practice to an appreciable extent.

Track Rail Bonding:

There are two general classifications of bonds in use:

(a) Mechanically applied bonds to web of rail
(b) Heat applied bonds to head of rail.

Mechanically Applied Bonds: There are fourteen installations of mechanically applied bonds, which may be divided into three groups, viz.:

Exposed
Concealed
Semi-concealed (Bond behind splice bar but terminals exposed).

There are three installations of exposed bonds, ten installations using both concealed and semi-concealed and one using both exposed and concealed. The length of mechanically applied bonds varies from 10 inches to 53¼ inches, while the size varies from No. 1/0 AWG to 500,000 c.m. The pin expanded terminal bond predominates, there being thirteen installations of this type and only one of the compressed terminal type. The fact that this type of bond can be installed and maintained very easily under traffic and without danger of derailment of trains is largely the reason for its widespread use.

The advantages and disadvantages of the mechanically applied type of bonds may be summed up as follows:

Advantages:

Easy to install.
Wide range in choice of length of bond and flexibility of design to suit rail joints.
Low labor cost of application and replacement.
Small and inexpensive installation tools.

Disadvantages:

High first cost.
Necessity of being designed to suit the rail joints, length being fixed by splice bar and bolt hole spacings.
Larger capacity than otherwise necessary when long lengths are used.
Uncertainty of securing and maintaining uniform and low contact resistance unless special care taken to insure proper application and maintenance.

Heat Applied Bonds: There are seven installations of heat applied bonds which may be divided into three groups, viz.:

Gas weld bonds, five installations.
Electric weld bonds, one installation.
Brazed bonds, one installation.

Two general designs are used, viz.: U-shaped and straight bonds, both types being applied to the head of the rail. In general the U-shaped bonds have been confined to installations employing one bond per joint and the straight form of bond where two bonds per joint are used. The lengths vary from 7 inches to 15½ inches and sizes from No. 1/0 AWG to 250,000 c.m. With the exception of soldered bonds, which have been used to only a limited extent because of difficulty of successful application, the heat applied type of bonds has been a comparatively recent development which was made possible through improvements in gas and electric arc welding processes.

The advantages and disadvantages of the welded type of bonds may be summed up as follows:

Advantages:

Low first cost installed.
Low resistance due to short lengths and character of contact.
The use of small capacity bonds all being of 250,000 c.m. or less.
Easily inspected.
Uniformity of design.
Permanency of contact and consequently permanency of contact resistance, provided the weld holds.

Disadvantages:

Skilled operators required for installation.
Special tool equipment which is more or less cumbersome.
Exposed to mechanical injury of several kinds.
Exposed to theft.
Limited resistance to fatigue stresses on account of short length.
Expensive to replace, particularly when only a few applications are to be made.
Limited to rail head application.
Possibility of starting detailed fractures in rail due to heat necessary in application.

Third Rail Bonding:

Due to the different kinds and shapes of third rail in use, third-rail bonds must necessarily be of more or less special type and the design must be adapted to the type of rail with which it is used. There are eight installations comprising four mechanically applied type of bonds and four heat applied. Of the mechanically applied bonds three are of the compressed terminal type and one the pin expanded terminal type. Of the heat applied bonds two are gas welded, one electrically welded and one of the soldered type. The number of bonds per joint vary from one to four and the size of each bond varies from No. 4/0 AWG to 500,000 c.m. Comparatively little opportunity is offered at present for standardization of third-rail bonding practice because of the widely differing types of third-rail construction.

With respect to thermit welding, practically nothing has been done in steam railroad field with the exception of an experimental installation in third-rail work, although this type of welded joint is widely used in the street railway field for running tracks.

Conclusions

That the report be accepted as progress and the subject continued with especial reference to:

Development of standard basis for measurement of bond resistance.
Securing data on current carrying capacity of bonds.
Study of details of bond design and practice for the purpose of determining to what extent standardization is practicable without interfering with the progress of the art, with a view of developing specifications covering the different classes of bonds.

Data Regarding Rail Bonding Practice

TRACK RAIL BONDS—ALTERNATING CURRENT SYSTEM

NAME OF ROAD	BUTTE-ANACONDA & PACIFIC R.R.	BALTIMORE & OHIO R.R.	CANADIAN NATIONAL RAILWAYS	CLEVELAND UNION TERMINAL	CHICAGO-MILWAUKEE & ST. PAUL R.R	ILLINOIS CENTRAL RAILROAD	LONG ISLAND RAILROAD	MICHIGAN CENTRAL RAILROAD	NEW YORK CENTRAL RAILROAD	PENNA RAILROAD (TUNNELS)	PENNA RAILROAD (MAIN LINE)	SOUTHERN PACIFIC RAILROAD	STATEN IS. RAPID TRANSIT CO.	WEST JERSEY & SEASHORE RR
VOLTAGE	2400	650	2400		3000		650	650	650	650	650	1200	650	650
WEIGHT AND TYPE OF RAIL	85* 8531	130 RE 39'-0" LONG	90 ARA. 80 ASCE		90# ARA TYPE A		100* P.R.R. STD.	105# TYPE K	105# DUDLEY	130# P.R.R. ST.	130# P.R.R. ST.	90* ARA-A	100# ARA-B	100* PRR STD
TYPE OF JOINT	ANGLE BAR 4 BOLT-24"	REINFORCED 4 BOLT-25"	ANGLE BAR 4 BOLT		REINFORCED 4 BOLT-24		REINFORCED 4 BOLT-24"	PLATES BOLTED	ANGLE BAR 6 BOLT-38"	REINFORCED 4 BOLT-24"	REINFORCED 4 BOLT-24"	REINFORCED 4 BOLT-24"	REINFORCED 4 BOLT-25"	REINFORCED 6 BOLT-30"
TYPE OF BOND	F-CONCEALED-E-EXPOSED	EP EXPOSED	ST-1 GAS WELD		ST-2 GAS WELD		BRAZED	ST-2 GAS WELD	EP CONCEALED	EP EXPOSED	EP EXPOSED	EP CONCEALED	ST-5 GAS WELD	EP CONCEALED
CAPACITY OF BOND	4/0	400000 C.M.	4/0		4/0		250000 C.M.	4/0	400000 500000 C.M.	400000 C.M.	250000 C.M.	4/0	250000 C.M.	400000 C.M.
NUMBER BONDS PER JOINT	ONE	ONE	ONE		ONE		TWO	TWO	TWO	TWO	TWO	ONE & TWO	TWO	TWO
DIAMETER AND LENGTH OF TERMINAL	3/4" DIA. 7/8" LONG	1" DIA. 7/8" LONG						3/8" x 1"	1" DIA.	1" DIA. 13/16" LONG	1" DIA.	7/8" DIA. 5/8" LONG.		11/16" DIA. 5/8" LONG
CONDUCTOR CONSTRUCTION	DOUBLE-61 WIRE-SINGLE-37 WIRE	SINGLE 91 WIRE	DOUBLE 61 WIRE		DOUBLE 61 WIRE		SINGLE 127 WIRE	STRANDED WIRE	DOUBLE 127 WIRE	SINGLE 91 WIRE	SINGLE 61 WIRE	SINGLE 61 WIRE	SINGLE 91 WIRE	DOUBLE 127 WIRE
LENGTH OF BOND FORMED	F-10" E-36" E-48"	32 11/16"	3"		3"		14 1/2"	2 3/4" & 9"	16.8"	43" 48"	32"	11 1/2"	12 1/2"	12 1/2"
LENGTH OF BOND DEVELOPED	F-10" E-36" E-48"	42"	7"		7"		15 1/2"	7" & 12"	17.3"	49" 53 1/4"	46"	12 1/2"	13 1/2"	12 1/2"
WHERE APPLIED	RAIL WEB	RAIL WEB	RAIL HEAD		RAIL HEAD		RAIL HEAD	RAIL HEAD	RAIL WEB	RAIL WEB	RAIL WEB	RAIL WEB	RAIL HEAD	RAIL WEB
LOCATION OF BOND HOLE FROM END OF RAIL									5.55" 11.15"	$20\frac{13}{32}"-22\frac{29}{32}"$	$14\frac{5}{32}"-17\frac{21}{32}"$	5 3/4"		$3\frac{3}{8}"-8\frac{11}{16}"$
RAILROAD SPEC. UNDER WHICH FURNISHED									#107	#39	#39			
RAILROAD DRAWING NUMBER	S-1014	S-3531						OHIO BRASS CO.	1995 CC 1212 CC	S-1174	9197		Q-130-A	C-854-B

---

*Specified on order.

NOTE—Letters opposite type of bond indicate the manufacturer's type of bond.
EP, FP, GU, FU are pin-driven terminal bonds.
ST steel armored terminal bonds.

Data Regarding Rail Bonding Practice

TRACK RAIL BONDS—DIRECT CURRENT SYSTEM

NAME OF ROAD	BALTIMORE & OHIO R.R.	LONG ISLAND RAILROAD	LONG ISLAND RAILROAD	MICHIGAN CENTRAL RAILROAD	NEW YORK CENTRAL RAILROAD	PENNA RAILROAD (NEW YORK)	STATEN ISLAND RAPID TRANSIT	WEST JERSEY & SEASHORE R.R.	
VOLTAGE	650 OVER RUN	650 OVER RUN	650 OVER RUN	650 UNDER RUN	650 UNDER RUN	650 OVER RUN	650 OVER RUN	650 OVER RUN	
WEIGHT AND TYPE OF RAIL	100# ARA-B	150#	150#	70# BULL HEAD	70# BULL HEAD	150#	150#	100#	
TYPE OF JOINT	BAR 2 BOLT-12"	BAR 4 BOLT - 22 1/2"	BAR 4-BOLT-22 1/2"	BAR BOLTED	BAR 2 BOLT-13"	BAR 4 BOLT-22 1/2"	BAR 2 BOLT	BAR 4 BOLT-22"	
TYPE OF BOND	EP EXPOSED	SPEC. COMPRESS	ELECTRIC WELD	GU-4 WELDED	SOLDERED	SPEC. COMPRESS	SPEC GAS WELD	FP CONCEALED	
CAPACITY OF BOND	400000 CM	450000 C.M.	500,000 423,000	400,000 CM	500000 C.M.	450000 C.M.	400000 CM	500000 CM	
NUMBER BONDS PER JOINT	ONE	FOUR	TWO EACH FOUR	TWO	TWO	FOUR	FOUR	TWO	
DIAMETER AND LENGTH OF TERMINAL	1" DIA	15/16" DIA	3" LONG	1" x 3/8"		15/16" DIA.		1" DIA.	
CONDUCTOR CONSTRUCTION	SINGLE 91 WIRE	RIBBON 60 RIBBONS	SINGLE & DOUBLE 127 WIRE	RIBBON	RIBBON 37 RIBBONS	RIBBON 60 RIBBONS	DOUBLE 91 WIRE	RIBBON 40 RIBBONS	
LENGTH OF BOND FORMED	15 7/16"	5" -10"	11 1/2" 3"	3"	8 1/2"	5" 10"	7 3/4"	9 1/4"	
LENGTH OF BOND DEVELOPED	16"	7"- 12"	12 1/2" 7"	4"	11"	7" 12"	9 3/4" 11 1/2"	9 1/4"	
WHERE APPLIED	RAIL WEB	RAIL BASE	RAIL BASE	RAIL HEAD	RAIL HEAD	RAIL BASE	RAIL BASE	RAIL WEB	
LOCATION OF BOND HOLE FROM END OF RAIL		2 3/8"-4 7/8"				2 3/8"-4 7/8"		3 11/16"-5 3/8"	
RAILROAD SPEC. UNDER WHICH FURNISHED					107	#36			
RAILROAD DRAWING NUMBER	S-3531	B 1444		E.R.I.CO. TYPE.	1016 CC	B-1310	S-157	743-A	

NOTE—Letters opposite type of bond indicate the manufacturer's type of bond.
EP, FP, GU, FU are pin-driven terminal bonds.
ST steel armored terminal bonds.

Data Regarding Rail Bonding Practice

TRACK RAIL BONDS—DIRECT CURRENT SYSTEM

NAME OF ROAD	BOSTON & MAINE RR	CANADIAN NATIONAL SARNIA TUN.	DETROIT TOLEDO & IRONTON RR	GREAT NORTHERN R.R.	NORFOLK & WESTERN	N.Y. N.H. & H.R.R.	N.Y.W.C. & B.R.R.	P.R.R. (PHILA)	VIRGINIAN R.R.	
VOLTAGE	11000	3300	22000	11000	11000	11000	11000	11000	11000	
WEIGHT AND TYPE OF RAIL	100# 1002 N H	100# ARA	90# ASCE	90# 130#	130#	107# N.Y. N.H.B.H.	90# ASCE	130# P.R.R.ST	100#-130# ARA-B.	
TYPE OF JOINT	100% ANGLE BAR	REINFORCED 4-BOLT	2-ANGLE 4 BOLT 24"		REINFORCED	REINFORCED NY. NH.& H.	ASCE	REINFORCED 4 BOLT-24"	REINFORCED	
TYPE OF BOND	F P CONCEALED	FU CONCEALED	L HEAD ELEC WELD	GAS WELD	E.P. CONCEALED	E.P CONCEALED	F.P. CONCEALED	E.P. CONCEALED	E P CONCEALED	
CAPACITY OF BOND	4/0	4/0	1/0	4/0	1/0	1/0	4/0	1/0	1/0	
NUMBER BONDS PER JOINTS	ONE	ONE	ONE	ONE	ONE	ONE	ONE	TWO	TWO	
DIAMETER AND LENGTH OF TERMINAL	7/8" DIA. 19/32" LONG	3/4" DIA 3/4" LONG			3/4" DIA * LONG	7/8" DIA. 11/16" LONG	7/8" DIA 5/8" LONG	3/4" DIA * LONG	3/4" DIA * LONG	
CONDUCTOR CONSTRUCTION	DOUBLE 61 WIRE	DOUBLE 29 WIRE	SINGLE 37 WIRE	DOUBLE 61 WIRE	SINGLE 37 WIRE	SINGLE 37 WIRE	DOUBLE 37 WIRE EACH	SINGLE 37 WIRE	SINGLE 37 WIRE	
LENGTH OF BOND FORMED	25"	9"	3"	3"	32"	25"	24"	32½"	32½-37½"	
LENGTH OF BOND DEVELOPED	25"	9"	7"	7"	32"	25"	24"	32½"		
WHERE APPLIED	RAIL WEB	RAIL WEB	RAIL HEAD	RAIL HEAD	RAIL WEB	RAIL WEB	RAIL WEB	RAIL WEB	RAIL WEB	
LOCATION OF BOND HOLE FROM END OF RAIL	6"-8½"	4½"			6"			14⅝"-16⅛"		
RAILROAD SPEC. UNDER WHICH FURNISHED					N-51			P-17	V-125-C	
RAILROAD DRAWING NUMBER					3-D-1106	S-830	614-3	D-6452	9D-586-3	

NOTE—Letters opposite type of bond indicate the manufacturer's type of bond.
EP, FP, GU, FU are pin-driven terminal bonds.
ST steel armored terminal bonds.

Appendix M

(13) SPECIFICATIONS FOR INCANDESCENT LAMPS

E. B. Katte, Chairman, Sub-Committee; F. D. Hall, L. B. Martin, R. J. Middleton, R. J. Needham, A. E. Owen.

The Committee has reviewed and revised the Tungsten Lamp Schedule as now appears in the Manual with the view of suggesting one Schedule of Lamps acceptable to all sections of the American Railway Association. It is understood that the accompanying Lamp Schedule is acceptable to the Signal Section. The subject was not referred by the Secretary of the Mechanical Division to the appropriate committee in time for that committee to submit its suggestions. It is believed, however, that the revised Lamp Schedule is more nearly acceptable to all Sections of the American Railway Association than that which we now have in the Manual, and therefore will be of more assistance to the Purchasing Agents of the various railroads than the existing Standards.

Conclusions

That the accompanying Tungsten Lamp Standards—1925, be accepted as recommended practice and substituted for the Lamp Schedule now in the Manual.

TUNGSTEN LAMP STANDARDS—1925

(Revised October 13, 1925)

Size in Watts	*Voltages*	*Type and Size of Bulbs*	*Base*	*Type*	*Remarks*
10	110, 115, 120, 125	S-14	Med. Screw	B	
15	110, 115, 120, 125	S-17	Med. Screw	B	
25	110, 115, 120, 125	S-17	Med. Screw	B	
40	110, 115, 120, 125	S-19	Med. Screw	B	
50	110, 115, 120, 125	S-19	Med. Screw	B	
75	110, 115, 120, 125	PS-22	Med. Screw	C	
100	110, 115, 120, 125	PS-25	Med. Screw	C	
150	110, 115, 120, 125	PS-25	Med. Screw	C	
200	110, 115, 120, 125	PS-30	Med. Screw	C	
250	110, 115, 120, 125	G-30	Med. Screw	C	Floodlighting
300	110, 115, 120, 125	PS-35	Mogul Screw	C	
500	110, 115, 120, 125	G-40	Mogul Screw	C	Floodlighting
500	110, 115, 120, 125	PS-40	Mogul Screw	C	
750	110, 115, 120, 125	PS-52	Mogul Screw	C	
1000	110, 115, 120, 125	PS-52	Mogul Screw	C	
25	220, 230, 240, 250	P-19	Med. Screw	B	Coil Filament
50	220, 230, 240, 250	P-19	Med. Screw	B	Coil Filament
100	220, 230, 240, 250	PS-25	Med. Screw	C	
200	220, 230, 240, 250	PS-30	Med. Screw	C	
300	220, 230, 240, 250	PS-35	Mogul Screw	C	
500	220, 230, 240, 250	PS-40	Mogul Screw	C	
750	220, 230, 240, 250	PS-52	Mogul Screw	C	
1000	220, 230, 240, 250	PS-52	Mogul Screw	C	
Mill Type					
25	110, 115, 120, 125	P-19	Med. Screw	B	Coil Filament
50	110, 115, 120, 125	P-19	Med. Screw	B	Coil Filament
Car Axle Lighting					
15	30 to 34, 60 to 65	S-17, G-18½	Med. Screw	B	
15	30 to 34, 60 to 65	PS-16	Med. Screw	C	
25	30 to 34, 60 to 65	S-17, G-18½	Med. Screw	B	
25	30 to 34, 60 to 65	PS-16, PS-18	Med. Screw	C	Frosted
50	30 to 34, 60 to 65	PS-20	Med. Screw	C	Frosted
75	30 to 34, 60 to 65	PS-22	Med. Screw	C	Frosted
100	30 to 34, 60 to 65	PS-25	Med. Screw	C	Frosted
Motor and Trailer Car and Locomotive Lighting and Headlights					
15	33	S-17	Med. Screw	B	Cab Lighting
23	110, 115, 120, 125, 130	S-17	Med. Screw	B	Series
36	110, 115, 120, 125, 130	S-19	Med. Screw	B	Series
56	110, 115, 120, 125, 130	S-21	Med. Screw	B	Series
94	110, 115, 120, 125, 130	S-24½	Med. Screw	B	Series
100	32	P-25	Med. Screw	C	Headlight
150	32	P-25	Med. Screw	C	Headlight
250	32	G-30	Med. Screw	C	Headlight

Signal Lamps

Amperes	*Voltage*	*Type and Size of Bulbs*	*Base*	*Filament*	*Remarks*
.3	3.5	S-11	S. C.	C-2	
.25	8.0	S-11	S. C.	C-3	
.25	10.0	S-11	S. C.	C-3	
.25	12.0	S-11	S. C.	C-3	
.25	13.5	S-11	S. C.	C-3	

STATE REPRESENTATIVES AND ALTERNATES

Representing the Committee on Electricity, Relative to Wire and Cable Crossings Over Railways

NOTE: The first name is the State Representative. The second name is the Alternate.

ALABAMA	H. S. Jones, Chief Engineer, Gulf, Mobile & Northern; Mobile. S. E. Sims, Roadmaster, Southern Railway, Selma.
ARIZONA	P. T. Robinson, Division Engineer, Southern Pacific, Tucson. R. C. Kline, Division Engineer, Santa Fe, Winslow.
ARKANSAS	W. H. Vance, District Engineer, Missouri Pacific, Little Rock. H. J. Armstrong, Chief Engineer, Missouri & North Arkansas, Harrison.
CALIFORNIA	W. H. Kirkbride, Engineer Maintenance of Way & Structures, Southern Pacific, San Francisco. F. M. Siefer, Division Engineer, Southern Pacific, Stockton.
COLORADO	A. O. Ridgway, Chief Engineer, Denver & Rio Grande Western, Denver. R. C. Gowdy, Chief Engineer, Colorado & Southern, Denver.
CONNECTICUT	S. Withington, Electrical Engineer, New York, New Haven & Hartford, New Haven. W. T. Dorrance, Des. Engineer, New York, New Haven & Hartford, New Haven.
DELAWARE	J. C. Wrenshall, Engineer Maintenance of Way, Reading Company, Reading, Pa. A. J. Penrod, Jr., Signal Supervisor, Baltimore & Ohio, Wilmington.
FLORIDA	H. N. Rodenbaugh, Vice-President—Operation, Florida East Coast, St. Augustine. A. S. Butterworth, Chief Engineer, Muscle Shoals, Birmingham & Pensacola, Pensacola.
GEORGIA	L. L. Beall, Chief Engineer, Atlanta, Birmingham & Atlantic, Atlanta. S. R. Young, Assistant Chief Engineer, A. & W. P., Atlanta.
IDAHO	L. W. Althof, Division Engineer, Oregon Short Line, Pocatello. J. R. Smith, Division Engineer, Oregon Short Line, Pocatello.
ILLINOIS	G. I. Wright, Office Engineer, C. T. I., Illinois Central, Chicago. R. H. Ford, Assistant Chief Engineer, Rock Island, Chicago.

INDIANA	J. W. Burt, Division Engineer, Maintenance of Way, Big Four, Indianapolis. M. V. Hynes, General Superintendent, Chicago, Indianapolis & Western, Indianapolis.
IOWA	F. W. Thompson, Division Engineer, Rock Island, Des Moines. W. E. Heimerdinger, Division Engineer, Rock Island, Des Moines.
KANSAS	T. S. Stevens, Signal Engineer, Santa Fe, Topeka. C. C. Cunningham, Division Engineer, Rock Island, Herington.
KENTUCKY	C. F. Burrell, Engineer Maintenance of Way, K. & I. Terminal, Louisville. J. F. Burns, Assistant Engineer, Maintenance of Way, Louisville & Nashville, Louisville.
LOUISIANA	J. W. Kern, Jr., District Engineer, Illinois Central, New Orleans. H. E. Chalstrom, Assistant Engineer, Illinois Central, New Orleans.
MAINE	F. D. Hall, Electrical Engineer, Boston & Maine, Boston, Mass. Murdock Sutherland, Signal Engineer, Maine Central, Brunswick.
MARYLAND	J. H. Davis, Electrical Engineer, Baltimore & Ohio, Baltimore. E. G. Lane, Engineer Maintenance of Way, Baltimore & Ohio, Baltimore.
MASSACHUSETTS	F. D. Hall, Electrical Engineer, Boston & Maine, Boston. J. C. Irwin, Valuation Engineer, Boston & Albany, Boston.
MICHIGAN	J. C. Mock, Signal Electrical Engineer, Michigan Central, Detroit. G. C. Tuthill, Bridge Engineer, Michigan Central, Detroit.
MINNESOTA	C. A. Christofferson, Signal Engineer, Northern Pacific, St. Paul. E. A. Whitman, Chief Engineer, Soo Line, Minneapolis.
MISSISSIPPI	H. J. Rhodes, Engineer Maintenance of Way, A. & V., Vicksburg. T. M. Pittman, Jr., Roadmaster, Illinois Central, Water Valley.
MISSOURI	H. Austill, Bridge Engineer, Mobile & Ohio, St. Louis. S. L. Wonson, Assistant Chief Engineer, Missouri Pacific, St. Louis.
MONTANA	R. Beeuwkes, Electrical Engineer, Chicago, Milwaukee & St. Paul, Seattle, Wash. F. J. Taylor, Division Engineer, Northern Pacific, Livingston.
NEBRASKA	C. M. Delano, Division Engineer, Chicago, Burlington & Quincy, Lincoln. W. H. Eiker, District Engineer, Chicago, Burlington & Quincy, Lincoln.

NEVADA	R. W. Cattermole, Chief Engineer, Tonopah & Goldfield, Goldfield. John Reddy, Roadmaster, Southern Pacific, Sparks.
NEW HAMPSHIRE	F. D. Hall, Electrical Engineer, Boston & Maine, Boston, Mass. J. H. Gallivan, Division Engineer, New York, New Haven & Hartford, Boston, Mass.
NEW JERSEY	A. E. Owen, Chief Engineer, Central of New Jersey, Jersey City. G. Eisenhauer, Electrical Engineer, Erie, New York City.
NEW MEXICO	J. W. Brozo, Division Engineer, Southern Pacific, San Marcial. A. B. Truman, Division Engineer, Santa Fe, Las Vegas.
NEW YORK	L. S. Wells, Electrical Superintendent and Superintendent Telegraph, Long Island, New York City. F. Boardman, Manager Buildings, Grand Central Terminal, New York Central, New York City.
NORTH CAROLINA	F. W. Brown, Assistant to General Manager, Atlantic Coast Line, Wilmington. A. M. Griffin, Architect, Atlantic Coast Line, Wilmington.
NORTH DAKOTA	S. H. Knight, Office of Assistant Engineer, Northern Pacific, Jamestown. H. E. Yeomans, Assistant Engineer, Great Northern, Grand Forks.
OHIO	G. Eisenhauer, Electrical Engineer, Erie, New York City. G. H. Tinker, Bridge Engineer, New York, Chicago & St. Louis, Cleveland.
OKLAHOMA	G. N. Toops, Chief Engineer, Kansas, Oklahoma & Gulf, Muskogee. F. T. Beckett, Engineer Maintenance of Way, Rock Island, El Reno.
OREGON	R. C. Charlton, Signal Engineer, Oregon-Washington Railroad & Navigation Company, Portland. W. E. Burkhalter, Assistant Engineer, Oregon-Washington Railroad & Navigation Company, Portland.
PENNSYLVANIA	Clark Dillenbeck, Assistant Chief Engineer, Reading Company, Philadelphia. H. E. Hilts, Principal Assistant Engineer, State Highway Department, Harrisburg.
RHODE ISLAND	S. Withington, Electrical Engineer, New York, New Haven & Hartford, New Haven, Conn. J. S. Ruff, Divison Engineer, New York, New Haven & Hartford, Providence.

SOUTH CAROLINA	W. J. Gooding, Division Engineer, Seaboard Air Line, Charleston. C. J. Kelloway, Signal Superintendent, A. C. L., Wilmington, N. C.
SOUTH DAKOTA	J. E. Hills, Superintendent, Chicago, Milwaukee & St. Paul, Aberdeen. E. D. Barton, Assistant Signal Supervisor, Chicago, Milwaukee & St. Paul, Webster.
TENNESSEE	Hunter McDonald, Chief Engineer, Nashville, Chattanooga & St. Louis, Nashville. G. F. Blackie, Assistant Chief Engineer, Nashville, Chattanooga & St. Louis, Nashville.
TEXAS	R. H. Gaines, Engineer Maintenance of Way, Texas & Pacific, Dallas. K. H. Hanger, Engineer Maintenance of Way, Missouri-Kansas-Texas, Dallas.
UTAH	R. K. Brown, Superintendent and Chief Engineer, Salt Lake & Utah, Salt Lake City. B. H. Prater, Assistant Chief Engineer, Oregon-Washington Railroad & Navigation Company, Salt Lake City.
VERMONT	L. G. Morphy, Chief Engineer, Rutland, Rutland. P. D. Fitzpatrick, Chief Engineer, Central Vermont, St. Albans.
VIRGINIA	J. C. Davidson, Engineer, Electric Traction, Norfolk & Western, Bluefield, W. Va. E. M. Hastings, Chief Engineer, Richmond, Fredericksburg & Potomac, Richmond.
WASHINGTON	R. Beeuwkes, Electrical Engineer, Chicago, Milwaukee & St. Paul, Seattle. W. J. Bennett, Assistant Engineer, Great Northern, Seattle.
WEST VIRGINIA	J. C. Davidson, Engineer, Electric Traction, Norfolk & Western, Bluefield. C. M. McVay, Division Engineer, Ohio Central Lines, Charleston.
WISCONSIN	B. R. Kulp, Division Engineer, Chicago & North Western, Madison. W. H. Stedje, Resident Engineer, Soo Line, Superior.
WYOMING	N. P. Nelson, Division Engineer, Chicago, Burlington & Quincy, Casper. W. G. Tinney, Division Engineer, Union Pacific, Cheyenne.

REPORT OF COMMITTEE XVI—ECONOMICS OF RAILWAY LOCATION

E. E. King, *Chairman;*	H. C. Searls, *Vice-Chairman;*
F. L. Batchelder,	E. C. Schmidt,
John C. Beye,	A. K. Shurtleff,
A. S. Cutler,	C. W. Stark,
A. S. Going,	P. E. Thian,
C. P. Howard,	R. H. Washburn,
Frank Lee,	Walter Loring Webb,
Fred Lavis,	A. H. Woollen,
F. R. Layng,	F. E. Wynne,
C. L. Persons,	M. A. Zook,
I. L. Pyle,	*Committee.*

To the American Railway Engineering Association:

Your Committee respectfully presents herewith report covering the following subjects:

1. The economics of railway location as affected by the introduction of electric locomotives, conferring with the Committee on Electricity (Appendix A).
2. The relative merits of a 0.4 per cent ruling grade as compared with a 0.3 per cent grade (Appendix B).

Action Recommended

1. That the material in Appendix A, including the conclusions, be accepted as a progress report.

2. That the material in Appendix B be accepted as a progress report.

Recommendations for Future Work

To continue the following subjects:

1. Revision of the Manual.
2. The economics of railway location as affected by the introduction of electric locomotives, conferring with the Committee on Electricity.
3. Locomotive tractive force, giving special attention to oil-burning locomotives, collaborating with the appropriate Committee of Division V—Mechanical, American Railway Association.
4. The relative merits of increasing tonnage by the reduction of ruling grades or by the introduction of more powerful locomotives, including the consideration of momentum grades and the availability of the locomotive booster.
5. The relative merits of a 0.4 per cent ruling grade as compared with a 0.3 per cent grade.
6. Outline of work for the ensuing year.

Respectfully submitted,

The Committee on Economics of Railway Location,

E. E. King, *Chairman.*

Bulletin 280, October, 1925.

Appendix A

(2) THE ECONOMICS OF RAILWAY LOCATION AS AFFECTED BY THE INTRODUCTION OF ELECTRIC LOCOMOTIVES, CONFERRING WITH THE COMMITTEE ON ELECTRICITY

A. H. Woollen, Chairman, Sub-Committee; A. S. Going, Frank Lee, C. L. Persons, F. E. Wynne, Fred Lavis.

The location of a new railway line would be definitely affected by the introduction of electricity as motive power, irrespective of where the power would be derived, so that a discussion of the kind of electric system is not pertinent to this subject.

1. **Alinement and Profile.**—The principal economy to be effected by the introduction of the electric locomotive as a form of motive power for a projected railway line lies in the modification of the ruling grade, it being possible to follow more closely the natural topography of the country. Unless the country were level in character, less linear curvature would be possible, shortening the total mileage of the system accordingly. In mountainous country and in crossing rivers or other waterways, tunnel construction of any length (as far as operating conditions are concerned) can be employed.

2. **Characteristics of Electric Locomotives.**—The maximum tractive effort which may be exerted by an electric locomotive is dependent upon the weight on drivers and may be maintained from zero speed up to some speed determined by the motor characteristics. The tractive effort is uniform at any given speed, decreasing as the speed increases, and always has a definite relation to speed, depending on the characteristics of the motors used. A steam locomotive, on the other hand, is limited by grate area and boiler capacity and its tractive effort is governed by the mean effective pressure that can be maintained in the cylinders. Because of the reciprocating motion of the steam locomotive and the necessity for absorbing the reciprocating forces, there is not a uniform torque on the wheels; but the real limiting feature is the boiler, as it is only fair to assume that running gear could be designed adequately to produce the equivalent of the uniform torque of the electric locomotive. Electric locomotives of the side-rod type introduce some of the reciprocating motions of the steam locomotive; but while affecting the efficiency of transmission to some degree, these do not affect the uniform turning moment of the motors.

The advantage gained by the electric locomotive is in the ability to put the desired power into a practical locomotive frame and maintain that power independent of such limitations as boiler size, grate area, stokers, fuel and water. In other words, we may consider the boiler and combustion equipment of a locomotive as moved to a stationary power plant where it is not limited and can grow as the demand increases. The amount of power that can be delivered to the locomotive through the transmission, conversion and distribution systems is practically unlimited.

Electric locomotives operated on the multiple unit principle can be designed as a unit and as many units employed as necessary within the limits of draft-gear design to move a given tonnage over the line, with but one crew.

3. **Availability of Motive Power.**—It has been demonstrated by the electrified railroads of this country that electric locomotives can be operated at greater distances from repair shops and for longer periods between shoppings for inspection or overhaul than steam locomotives, due to the lesser necessity for and the greater ease of making renewals to electric locomotives.

This feature of the electric locomotive should affect the economics of railway location, in that terminal facilities for turning of locomotives, inspection and repairs could be located at the most economic points, and raw supplies and labor more readily and cheaply obtained.

4. The foregoing discussion applies to electric locomotives that take energy from an external source, such as a contact wire or rail. The Committee wishes to draw attention to the consideration being given at the present time toward the internal combustion engine as a form of prime mover for locomotives, which, in combination with electric drive, makes an independent unit with some of the desirable characteristics of the electric locomotive and without the attendant disadvantages of transmission, distribution and conversion equipment. In addition, a thermal efficiency from fuel to rail of some 25 to 30 per cent is indicated, as against 12 per cent for the electric locomotive and power system, and 5 to 6 per cent for a steam locomotive. The introduction of this type of electric locomotive will affect railway location, as these locomotives can carry sufficient fuel and other supplies for six to seven days' run. It is yet to be shown whether the internal combustion engine electric locomotive will also have the advantages stated in paragraph 3. We omit from consideration the turbine-driven and turbo-electric driven locomotives.

Conclusions

1. The introduction of the electric locomotives may affect the economics of railway location with respect to:

(a) The ruling grade,
(b) Total curvature,
(c) Length of tunnels,
(d) Location of repair, inspection and terminal facilities.

2. Each proposed railway must be studied and a separate determination made as to whether electrification is economically justified.

3. This subject should be continued and data collected which could be used for the economic study referred to in Conclusion 2.

4. The performance of self-contained power plant locomotives should be followed as affecting further reports on this subject.

MINORITY REPORT

The undersigned member of Sub-Committee No. 2 does not agree with the form or matter of the report presented.

He believes that the effect of electric traction on the economics of railway location can only be set forth in a report of this kind in the most general terms. The details of the subject should be either much more voluminous or be omitted entirely.

The details and ramifications of this subject are so many and varied that, in the writer's estimation, they could not be properly covered except in an extensive treatise, and even then could only be applied to a specific case by a group of civil, electrical and mechanical engineers and operating men having extensive, intimate knowledge of the subject.

The undersigned also objects to the Conclusions of the Sub-Committee, No. 1 of which states that the introduction of electric locomotives may affect the economics of railway location with respect to:

(a) The ruling grade.
(b) Total curvature.
(c) Length of tunnels.
(d) Location of repair, inspection and terminal facilities.

While this is true, it is also true that they may not, and this can hardly be called a conclusion. Conclusion 2 is also a truism, which applies to almost anything.

In regard to Conclusions 3 and 4, it is the opinion of the writer that it is unwise to set forth as conclusions, or include in the Manual, anything but the broadest general principles in regard to this subject.

Respectfully submitted,

F. Lavis.

Appendix B

(5) THE RELATIVE MERITS OF A 0.4 PER CENT RULING GRADE AS COMPARED WITH A 0.3 PER CENT GRADE

Walter Loring Webb, Chairman, Sub-Committee; A. S. Going, C. P. Howard, Fred Lavis, F. R. Layng, M. A. Zook.

The Sub-Committee has been investigating this subject, by study and correspondence, during the past year and has held two meetings. A progress report is now submitted, giving the general consensus of opinion of the Committee, as far as this appears to be warranted by the known facts and experience in operation.

During the coming year it is expected that additional information will be obtained from roads which have had experience in the operation of such light ruling gradients, which will enable the Committee to submit a more comprehensive report.

General Conclusions

1. **The lighter the grade, the better.**—As a general proposition, the lighter the ruling grade, the better, or, stated in another way, the ideal grade is level, provided traffic is the same in each direction. It is noted, however, that in actual operation the question of drainage sometimes becomes important in long cuts on very light grades. This, however, is an element of cost of construction and should be taken care of by increasing the grades of the roadbed ditches or by the use of tile drains, as may be most expedient.

2. **Primary advantage of the lighter gradients.**—Heavily-loaded cars, such as are usually loaded with coal and ore, will ordinarily develop a frictional resistance of about 4 lb. per ton. Grade resistances for 0.4 per cent, 0.3 per cent and 0.2 per cent grades are, respectively, 8, 6 and 4 lb. per ton. Consequently, neglecting engine resistances (which are higher per ton, but which are relatively small in gross amount for very long trains on low grades) the total train resistances per ton for heavy tonnage trains on grades of 0.4 per cent and under may be stated approximately as follows:

0.4 per cent	12 lb. per ton
0.3 per cent	10 lb. per ton
0.2 per cent	8 lb. per ton

It is evident, therefore, that the primary advantage of the lighter grades in the weigths of trains which can be handled, as compared with a 0.4 per cent grade, is for a 0.3 per cent grade 20 per cent increase, and for a 0.2 per cent grade 50 per cent increase. This primary advantage will usually be offset to some extent by the increased time required to haul the heavier trains. But in most cases it would appear more economical to utilize this advantage as far as practicable by the elimination of unnecessary stops for the heavy trains.

3. **Uniform speed.**—With the lighter grades there will be less variation in the rate of grade and consequently less variation in the speed, a condition which tends to economy in maintenance of road as well as of equipment.

4. **Starting resistance.**—It would appear that starting resistance rarely limits the tonnage of trains on light gradients, inasmuch as the locomotive starts one car at a time and there is a great deal of slack in long trains handled on very light grades. However, it is undoubtedly good practice to lighten the grades at necessary stops, say 0.1 per cent, wherever practicable, and limit the number of necessary stops. The Committee has some data tending to show that engines loaded for 0.2 per cent grades are able to start on such grades, but further information is being sought on this point. In any case, due to the inertia of very heavy trains and the time necessary to get up speed, it is considered good practice to limit such stops as far as practicable and lighten the grades at points where stops will usually be necessary, provided it does not involve too much expense. Of course, the use of a booster will tend to reduce any disadvantage as to starting resistance and time lost for stops.

5. **Data in Manual.**—The Manual, including the Supplement of August, 1925, Volume 27, Bulletin 278, gives the necessary information and rules for computing the tonnage that can be handled by a given steam locomotive on any grade, and also the method of preparing a speed-time profile and of computing speed, time and fuel consumption for a given train on any division. Evidently each case must be considered on its own merits. We recommend a speed-time profile, as described in Supplement to the Manual, as the best method of comparing these various elements of expense.

6. **Experience with light grades.**—A number of roads are now operating one or more divisions with ruling grades from 0.2 to 0.3 per cent with favorable results, as far as known to your Committee, but it is hoped that further information will be obtained by means of a questionnaire. Among these roads may be mentioned:

New York Central, including Lake Shore
    & Michigan Southern
Pittsburgh & Lake Erie
Erie
Virginian
Baltimore & Ohio
Illinois Central
Chesapeake & Ohio
Norfolk & Western
Duluth, Missabe & Northern

7. **Length of Grade.**—Experience has shown heretofore that ruling grades of excessive length have required reduction in the weight of trains. To what extent this disadvantage may be eliminated by the use of automatic stokers, or the use of oil as fuel, is a matter on which further information is desired. This should be kept in mind in designing the location on very light grades. It is a disadvantage, however, which is not confined to light grades. In certain cases the use of a lighter gradient may require longer maximum grades, but in other cases this result will not necessarily follow, as the adoption of lighter gradients will require the finding of lower summits, the use of tunnels instead of open cuts, or the adoption of a line which from its topography produces less rise and fall.

REPORT OF COMMITTEE XIII—WATER SERVICE

C. R. Knowles, *Chairman;*
R. A. Baldwin,
C. M. Bardwell,
W. M. Barr,
S. C. Beach,
O. W. Carrick,
R. W. Chorley,
R. E. Coughlan,
J. H. Davidson,
B. W. DeGeer,
E. A. Dougherty,
J. M. Fitzgerald,
C. H. Fox,
E. M. Grime,
J. P. Hanley,
J. R. Hickox,
R. C. Bardwell, *Vice-Chairman;*
C. P. Hoover,
C. D. Johnson,
J. H. Knowles,
C. H. Koyl,
P. M. LaBach,
E. G. Lane,
A. B. Pierce,
O. T. Rees,
H. H. Richardson,
T. D. Sedwick,
D. A. Steel,
C. P. VanGundy,
H. W. Van Hovenberg,
F. J. Walter,
F. D. Yeaton,
Committee.

To the American Railway Engineering Association:

Your Committee on Water Service presents below its report to the Twenty-Seventh Annual Convention on the following subjects:

(1) Revision of the Manual.
Report of Sub-Committee on this subject appears in Appendix A.

(2) Drinking Water Supply on Trains and Premises of Railways.
Progress report on this subject appears in Appendix B.

(3) Pitting and Corrosion of Boiler Tubes and Sheets.
Progress report on this subject is submitted in Appendix C.

(4) Value of Water Treatment and Comparison of Methods.
Progress report on the Value of Water Treatment appears under Appendix D.
Progress report on Methods of Water Treatment appears under Appendix E.

(5) Relative Merits of Different Methods of Deep Well Pumping.
A final report is submitted in Appendix F.

(6) Design, Construction and Maintenance of Pipe Lines.
A final report is submitted in Appendix G.

(7) Design and Construction of Water Station Buildings.
A final report is submitted in Appendix H.

(8) Hot Water Boiler Washing Plants.
A final report is submitted in Appendix I.

(9) Frost Protection of Water Stations and Water Facilities.
Progress report is submitted under Appendix J.

Action Recommended

Your Committee requests the following action on its report:

(1) That the revised list of definitions be accepted for publication in the Manual, and that the examination of subject-matter in the Manual be again referred to the Committee for further study and report.

(2) That the report on the progress of drinking water regulations be received as information and that the subject be reassigned to the Committee for further study and report.

Bulletin 281, November, 1925.

(3) That the progress report on Pitting and Corrosion of Boiler Tubes and Sheets be received as information and that the subject be reassigned to the Committee for further study and report.

(4) That the progress report on the Value of Water Treatment and Methods followed in treatment of water be accepted as information and the subject reassigned to the Committee for further study and report.

(5) That the final report on Relative Merits of the Different Methods of Deep Well Pumping be accepted as information. This report will later be abstracted for inclusion in the Manual, and abstract resubmitted a year hence.

(6) That the final report on the Design, Construction and Maintenance of Pipe Lines be accepted as information. This report will later be abstracted for inclusion in the Manual, and abstract resubmitted a year hence.

(7) That the final report on Design and Construction of Water Station Buildings be accepted as information.

(8) That the report upon the use of Hot Water Boiler Washing Plants Effecting Water Supply be accepted as information.

(9) That the report on Methods of Heating Water Stations and Protecting Tanks, Water Columns and other Water Facilities against Frost be reassigned to the Committee for further study and report.

Suggested Subjects for Next Year's Study and Report

(1) Continue study of subject-matter in the Manual with a view to recommendations for changes.

(2) Continue study of progress of regulations of Federal and State authorities pertaining to drinking water supplies.

(3) Continue study and report on pitting and corrosion of boiler tubes and sheets, taking into consideration character of metal used, method of manufacture, construction of boilers and quality of water.

(4) Continue study on the cost of impurities in locomotive water supply and the value of water treatment, together with comparisons of the different methods and a study of the costs of blowing off, washout and water changes.

(5) Continue the study on methods of heating water stations and protecting tanks, water columns and other water facilities against frost.

(6) Study and report upon the necessity for providing duplicate or standby pumping units.

(7) Study and report upon the use of gravity and pressure filters.

(8) Study and report on methods of disposal of sludge at water softening plants.

(9) Study and report upon the design and maintenance of track pans for locomtive supply.

(10) Study and report on methods used in securing successful wells in fine sand formation.

Respectfully submitted,

THE COMMITTEE ON WATER SERVICE,
C. R. KNOWLES, *Chairman.*

Appendix A

(1) REVISION OF THE MANUAL

C. R. Knowles, Chairman, Sub-Committee; E. M. Grime, F. J. Walter, C. P. Van Gundy.

ITEM I—DEFINITIONS OF TERMS

The Committee recommends that the following revised and supplemented definitions of terms as used in Railway Water Service be substituted for definitions now in the 1921 Manual, pages 625, 626, 627 and the first half of page 628; page 32, Volume 25, Bulletin 257, Supplement to the Manual, and page 41, Volume 24, Bulletin 249, Supplement to the Manual.

In order to permit of the reader distinguishing between the definitions now in the Manual, revised definitions and additions, reference letters are used as follows:

"M" designated opposite terms on revised list as submitted indicates definitions now in the Manual.
"MR" indicates revisions of present definitions in the Manual.
"A" indicates added items and definitions thereof.

GENERAL TERMS

Definitions

MR Aeration.—A process of bringing water into intimate contact with air in order to introduce oxygen for the oxidation of iron or organic matter, and for washing out gases and odors.

This is usually accomplished by spraying the water through the air in fine jets.

A Air Chamber.—A closed chamber used on the discharge or suction end of a pump for the purpose of promoting a uniform flow of water and to equalize stresses upon the pump.

A Air Compressor.—A machine for compressing air from one pressure, usually atmospheric pressure, to a higher pressure for use as a motive force in mechanical operations.

It is used extensively for raising water from wells by means of air lift.

M Air Lift.—An installation for introducing air into the column of water in a well, thereby causing it to rise.

The air is forced to the bottom of an air pipe where it is liberated either from an open pipe or through a foot piece. The air mixing with the water imparts a buoyancy to it which causes it to rise to the surface.

A Algæ.—Flowerless plants of simple cellular structure without roots, stems or leaves.

They live entirely submerged in water; those common to fresh water are chiefly green, yellow and blue. Brown algae are common to both fresh and salt water.

MR Alkali Water.—A term commonly used to designate water containing in solution any compound of sodium or potassium in appreciable amounts.

A Boiler.—A closed vessel in which water is evaporated into steam, by the application of heat.

A Boiler, Locomotive Type.—A cylindrical shell and rectangular firebox surrounded by water.

The flames and heated gases of combustion, after heating the walls and crown sheet of the firebox, pass through tubes to the front end of the boiler where they escape through the stack.

A Boiler, Return Tubular.—A closed cylindrical shell having a number of tubes running lengthwise through the shell below the water line, and through which the flames and heated gases of combustion pass to the stack.

A Boiler, Vertical.—A closed cylindrical shell with the lower head or flue sheet placed part way up from the bottom of the boiler; this lower head, being smaller than the outside diameter of the boiler, permits of a water space between the inner and outer shell, forming the firebox.

Tubes extending from the firebox to the upper head carry the flames and gases of combustion to the stack.

A Boiler Compound.—A combination of chemicals applied direct to boilers or to the water in tenders of locomotives for the purpose of preventing scaling, corrosion and foaming.

Compounds are usually termed anti-scaling, anti-corrosive and anti-foaming.

A Blowoff.—The act of letting out water from a boiler to carry off sediment, or to reduce the concentration of foaming salts.

A Blowoff, Pipe Line.—A tee and valve located at a low point in a pipe line for the purpose of removing sediment and wasting the water when repairs are necessary.

The necessity for a blow-off depends upon the character of the water and the service of the pipe line.

A Calk.—The process of driving yarn or jute into the bell of cast iron pipe and calking the lead tight into the joint after pouring.

A Chime.—The rim around the base of the tub of a wooden water tank, formed by the ends of the staves projecting below the bottom of the floor.

A Coagulation.—The process of gathering into flocs or groups, particles of finely divided suspended matter by adding coagulent to the water.

Coagulation serves a double purpose as it not only forms groups or flocs of particles that are not readily removed by subsidence or filtration, but it also forms a honeycombed layer on the filter sand which allows the water to pass and at the same time retains bacteria and suspended matter.

M Continuous Plant (Water Treatment).—A plant so designed that the untreated water may be pumped to it without interruption and where the volume of the chambers through which it passes before flowing to storage is sufficient for complete reaction and precipitation.

A Control Panel.—A panel usually of slate or marble, containing fuses, switches, meters, gages and other equipment, for the control of electrical machinery.

M Corrosion.—The eating away of the surface of metal by chemical action, either regularly and slowly as by rusting in air, or irregularly and rapidly as by pitting and grooving in the interior of boilers.

A Croze.—The cross groove cut in the staves of a wooden tank in which the edge of the floor or bottom plank are inserted.

A Dam.—An artificial obstruction such as a bank of earth, a frame of wood or a wall of masonry or of concrete thrown across a valley or waterway to impound a body of water.

A Drop.—The difference between the static head and the pumping head of water in a well.

A Dry Steam.—Steam which contains no moisture. It may be either saturated or superheated.

A Electrolysis.—The process whereby an electric current passing from an electrode to an electrolyte or vice versa causes chemical changes to take place in the electrolyte. Electrolysis also includes any chemical changes at the surface of an electrode resulting from the chemical changes in the electrolyte.

Electrolysis from stray currents is very destructive to underground water lines and other structures in the path of the currents.

M Engine, Two Cycle.—An internal combustion engine receiving a power impulse at each revolution.

M Engine, Four Cycle.—An internal combustion engine receiving a power impulse at each second revolution.

M Engine, Gas.—An internal combustion engine using natural or manufactured gas as fuel.

M Engine, Gasoline.—An internal combustion engine using gasoline, naphtha or other volatile petroleum products as fuel.

M Engine, Internal Combustion.—A prime mover in which the power is derived from the explosive force of the fuel compressed and ignited in a cylinder and acting directly against the piston.

M Engine, Oil.—An internal combustion engine which is started and operated on a non-volatile oil of medium low Baume degrees, the fuel being ignited from a surface heated by previous combustion of the fuel.

M Evaporation.—The process by which water is changed from the liquid to the gaseous state.

M Filtration.—A mechanical process for removing suspended matter or bacteria from water by passing through sand or other close-grained medium.

A Float Switch.—A switch designed to regulate the height of water in a tank by controlling the operation of electrical pumps, the switch being opened and closed by a float.

M FOAMING.—The term applied to the action of a boiler when the steam bubbles up over the surface of the water to such extent that the steam space and dome are filled, and syphoning action is started which causes water to be carried over with the steam into the engine cylinders.

A FROST BOX.—A box insulated for protecting pipes against freezing. Frost boxes are usually constructed of dressed and matched lumber with one or more air spaces and lined with building paper.

HARDNESS.—The quality of water due to incrusting solids held in solution.

MR HARDNESS, PERMANENT.—Formerly that hardness which remained in water after boiling at atmospheric pressure, but from use it now refers to non-carbonate hardness or that hardness due to sulphates and chlorides of calcium and magnesium, which results in forming hard scale.

MR HARDNESS, TEMPORARY.—Formerly that hardness which was removed from water by boiling at atmospheric pressure, but from use it now refers to carbonate hardness or that hardness due to calcium and magnesium carbonates, or bi-carbonates in solution.

A HEAD, FRICTION.—The increased head due to friction losses through pipe lines, pumps and fittings when discharging a given quantity of water.

A HEAD PUMPING.—Static head plus friction head when discharging a given quantity of water.

A HEAD, STATIC.—The difference in elevation between the surface of of the water at the source of supply and the elevation at any given point.

A HEAD, TOTAL.—The difference in elevation between the surface of the water at the source of supply and the elevation of the water at the outlet or the surface of the water at the highest point in a tank plus friction.

A HYDRANT, FIRE.—Of two general types, the post hydrant in which the barrel of the hydrant extends above the surface of the ground, and the depressed hydrant in which the barrel and hose connections are placed in a box or pit, the top of which is flush with the surface.

The former is commonly used, except in congested areas where it would be in the way. The valve is located at the bottom below the frost line and is operated by a valve stem extending through the barrel. A drip valve is provided for draining the barrel to prevent freezing.

A HYDRAULIC RAM.—A machine for raising water by utilizing the momentum of water flowing by gravity through a pipe to lift a portion of the water to an elevation greater than the source of supply.

A HYDRAULIC GRADE LINE.—An imaginary line joining the points to which water flowing through a pipe line under pressure will rise at various point at atmospheric pressure.

A HOOP.—A metal band of round or other cross-section encircling a wooden water tank for the purpose of holding the staves in place.

A INDICATOR, WATER TANK.—Commonly a strip of wood or metal bearing foot marks and numbers, used to indicate the depth of water in a tank.

A INJECTOR.—A device for feeding water to boilers under pressure. The water is lifted from the source of supply through the creation of a vacuum and is carried into the boiler by the momentum of a jet of steam.

A INTAKE.—That portion of a pipe or other apparatus through which water enters from the source of supply, such as the end of an intake pipe. A structure built out into a body of water for the purpose of providing a place from which the water may be pumped without interruption.

A INTAKE PIPE.—A line of pipe conveying water by gravity from the source of supply to an intake well or sump.

M INTERMITTENT WATER TREATING PLANT.—A plant so designed that the water is pumped alternately into two or more treating tanks and there retained until chemical reaction and precipitation are complete.

M INTERCEPTION.—That part of the precipitation prevented from reaching the ground.

A LEAD POT.—A round iron pot in which lead is melted.

Lead pouring pots are commonly made about 6 in. to 8 in. deep, the bottom being somewhat flat with slightly rounded sides while the top has a lip spout and a wire bale with a hook at the top. Near the bottom of the pot and on the side opposite the spout is a small hook by which the pot is tilted to pour the contents. These metal pouring receptacles vary from 5 in. to 12 in. in diameter and hold from 12 lb. to 130 lb. of lead. They are used in joining water pipe with bell and spigot ends, in soldering, etc.

M LIME, HYDRATED.—A dry flocculent powder resulting from the hydration of quicklime.

It is used as a reagent in the treatment of boiler waters containing carbonate hardness.

M MATTER, COLLOIDAL.—Matter in a state of semi-solution which must be coagulated before removal by sedimentation or filtration.

M MATTER, ORGANIC.—Vegetable or animal matter occasionally encountered in waters.

A MATTER, SUSPENDED.—Matter contained in water which may be removed by filtration, coagulation or sedimentation.

A METER, CURRENT.—A device for measuring the velocity of flow in streams and channels.

A **Meter, Venturi.**—A device consisting of two parts, a tube which is in the shape of two truncated cones joined at their smallest diameters by a short throat piece, and the recorder which registers the quantity of water passing through the tube.

Pressure chambers are located at the upstream end and at the throat, at which points the pressures are taken.

A **Meter, Water.**—An instrument for measuring and recording automatically the flow of water through it.

A **Motor, Slip Ring.**—A polyphase induction motor adapted for a speed variation ranging from 50 per cent to 100 per cent, as a result of which it has a relatively low starting torque.

It is used extensively for automatic pumping outfits starting under full load as well as for other power purposes.

A **Motor, Squirrel Cage.**—A polyphase induction motor of the squirrel cage rotor type, having a nearly constant speed with a resultant high starting torque.

This type is largely used for driving machinery.

A **Motor, Synchronous.**—So called because it runs at the same speed or in a certain ratio to the speed of the generator.

This type of motor is used principally for power factor correction.

M **Outlet Pipe.**—The pipe through which the water is delivered from the tank to the spout.

M **Percolation.**—The act of water descending through the earth from the ground surface.

The passage of water through a mass of porous earth, rock, sand or other material.

A **Pipe, Cast Iron** (Sand Cast).—A pipe made of pig iron, cast in a cylindrical sand mould with a round central core.

A **Pipe, Cast Iron** (Centrifugally Cast).—A pipe made from pig iron cast in a revolving water-cooled mould.

A **Pipe, Continuous Stave.**—A wood pipe built of staves milled to radial planes and correct curvatures for the interior and exterior of pipe.

The staves are assembled in a circle and banded with steel rods, the joints are staggered and the ends of the staves have a saw kerf cut across the face in which a metal tongue is inserted in order to strengthen the joint and make it water tight.

A **Pipe, Wood Stave.**—A pipe made of matched staves milled to radial planes and correct curvature for the interior and exterior of pipe, assembled in sections from 6 to 20 ft. long, and banded either with wire or flat bands.

A **Pipe, Riveted Steel.**—Pipe made up of steel plates which are bent so that a complete circle is made from a sheet, forming one section of pipe; the ends of the sheets are lapped the required distance and riveted.

Four sheets are usually riveted together, making the lengths of pipe 28 to 30 ft. long.

A **Pipe, Spiral Riveted Steel.**—Pipe formed by winding a strip of sheet steel into a helical shape, with one edge overlapping the other for riveting the seam.

A **Pipe, Wrought Iron.**—Seamless or rolled and welded from wrought iron, usually in random lengths of about 20 ft. with threaded ends designed to be joined by couplings with corresponding threads.

A **Pipe, Wrought Steel.**—Seamless or rolled and welded from wrought steel, usually in random length of about 20 ft. with threaded ends, designed to be joined by couplings with corresponding threads.

A **Pipe, Universal.**—Cast iron pipe with machined hub and spigot ends, held together by two bolts passing through suitable lugs cast on the hub and spigot ends of the pipe.

A **Pipe Bend** (or Elbow).—A short pipe bend, usually 45 or 90 deg. curve, provided with either hub end, threaded or flanged joints.

Special bends are furnished with any desired degree of curvature. Ninety degree bends are also provided with a base casting designed as a support.

A **Pipe, Blowoff Branch.**—A casting with an opening of smaller diameter than the pipe, placed at the base and at right angles with the main pipe, designed to form a connection for a blowoff valve.

Blowoff branches for large pipe lines are frequently fitted with manholes and covers.

A **Pipe Cap.**—A casting designed to fit over the outside of the end of a pipe to close the aperture.

Where desired the cap may be tapped for small pipe connections.

A **Pipe Coupling.**—A short length of pipe threaded on the inside, used for connecting threaded wrought pipe.

A **Pipe, Cross.**—A branch casting provided with connections on four sides at right angles.

Connections may be for different sizes of pipe and for either hub end, threaded or flanged joints.

A **Pipe Joint, Bell and Spigot.**—A joint used on standard cast iron pipe, formed by a bell on one end of the pipe, the other end of the pipe being straight except for a short bead.

The beaded end is inserted into the bell, leaving a space between the bell and pipe which is caulked with yarn and filled with lead which is caulked after pouring.

A **Pipe Joint, Flanged.**—A standard flange cast or threaded to the ends of pipe; gaskets of rubber or other material are placed between the flanges which are held in place by bolts.

This was the earliest type of joint for cast iron pipe but has been largely superseded by the less expensive and more flexible bell and spigot type of joint for underground pipe.

A **Pipe Offset.**—A casting in the form of a reverse curve, designed for the continuation of a line of pipe in a line parallel to its beginning.

Offsets are sometimes formed of two standard bends placed end to end.

A **Pipe Plug.**—A casting designed to be placed in the end of a pipe or fitting to close the aperture.

It may be either threaded or fitted for cast iron pipe; it may also be tapped for small pipe connections.

A PIPE REDUCER.—A short tapering casting designed to connect two pipes of different size.

It may be fitted on either or both ends for threaded pipe or with hub and spigot or flanged ends. The taper may be produced with plain converging walls, or it may be bottle shaped with short curves making a shoulder in the middle of the casting. Reducers used in suction lines are usually eccentric with the taper on one side of the reducer only.

A PIPE SLEEVE.—A short casting for connecting the ends of pipe.

A term often applied to couplings for all classes of pipe but applying particularly to cast iron pipe with hub and spigot joints. It is also furnished in flanged halves bolted together, which is termed a split sleeve.

A PIPE TEE.—A pipe connection used for the purpose of joining a pipe line with another pipe at right angles.

The ends of the tee may be of the same size or of different sizes.

A PIPE VISE.—A vise made especially to hold metal pipes. This device is essentially a bench tool, consisting of upper and lower oppositely serrated jaws, the upper jaw being movable while the lower jaw is stationary and integral with or fastened to a metal base plate.

A PIPE Y.—A pipe connection providing for two lines of pipe diverging from one line at equal angles or for one diverging and one straight line.

The angle of the branches is usually 45 deg. unless otherwise specified.

M PIPE LINE, DISCHARGE.—A line of pipe through which the water is forced by the action of the pump.

M PIPE LINE, DROP.—The vertical line of pipe in a well through which the water is discharged.

M PIPE LINE, INTAKE.—A line of pipe conveying water by gravity from a source of supply to an intake well.

A PIPE LINE, SERVICE.—A line through which water is distributed to points of actual use as distinguished from suction lines and discharge lines to tanks or reservoirs.

M PIPE LINE, SUCTION.—A line of pipe through which a pump draws its supply.

M POWER HEAD.—A machine placed over a well connected to the power unit and which, by means of the pump rods, operates the piston in the working barrel.

M PRIMING.—The sudden evolution of steam from a heating surface which throws water in sudden, large volumes up into the steam space.

It is due either to poor design of the boiler and to its being worked beyond capacity, or to the sudden opening of the throttle. While the effect upon the locomotive is temporarily the same, priming is different from foaming and can be mechanically controlled to a large extent by proper handling of the engine.

M PUMP, SINGLE ACTING.—A pump in which only one end of the plunger or piston acts on the fluid column.

M PUMP, DOUBLE ACTING.—A pump in which the plunger or piston acts upon the fluid column on both the forward and return stroke.

MR Pump, Simplex Double Acting.—A pump having only one piston operated inside of a cylinder, which fills at one end and discharges at the other at each stroke.

MR Pump, Duplex Double Acting.—A pump having two pistons operating inside of cylinders which fill at one end and discharge at the other at each stroke.

A Pump, Centrifugal.—A circular casing within which revolves an impeller mounted on a shaft. The water enters the impeller at the center and passes outward between the vanes of the impeller into the surrounding casing and to the discharge pipe.

A Pump, Compound.—A direct connected steam pump in which the steam is allowed to expand in two or more cylinders.

When the expansion takes place in two cylinders it is said to be compound; if the expansion takes place in three cylinders it is said to be triple expansion, etc.

M Pump, Double Stroke Deep Well.—A pump that employs two separate balanced lines of pump rods and attached water pistons.

The two lines of pump rods and their respective pistons alternate with each other in such a way that the weight or load, lifted by each rod is carried only in its tension, or up stroke.

M Pump, Piston.—A pump in which a finished cylinder is closely fitted with a reciprocating piston and forces a volume of water varying with the area of piston and the stroke.

M Pump, Plunger.—A pump in which the reciprocating part is a plunger which enters the cylinder through packing glands and displaces a volume of water equal to the volume of the plunger entering the cylinder.

M Pump, Reciprocating.—A pump in which the piston or plunger alternately draws the water in and discharges it from the cylinder.

A Pump, Rotary.—A pump, the working part of which is a revolving shaft to which are secured discs or cans, which are in close contact with the walls of the enclosing chamber or shell at two or more points.

This type differs from the centrifugal pump in that the fluid is continuously scooped out of its chamber or shell and into the discharge pipe, while in the centrifugal type the velocity is imparted to the stream of liquid by means of a fan or impeller.

A Pump Stage.—A term used in connection with centrifugal pumps to indicate the number of impellers, a single stage pump having one impeller, a two stage two impellers, etc.

A Pump, Triplex.—A power pump consisting of three cylinders, the pistons of which are driven by connecting rods carried by a three-throw crank shaft.

A Pump, Vertical Steam.—A pump driven directly by steam in which the steam pistons and pump are usually on the same rod, used chiefly in pumping from wells.

A Pump Governor.—A device for regulating the pressure of water delivered by a pump by controlling the power delivered to the pump.

M Pump Rods.—The line of rods which connect the piston in the working barrel with the power head.

A Pump Valve, Ball.—A ball usually made of bronze or iron, although steel and hard rubber balls are also used. The valve seat or cage may be screwed in the place of a regular valve seat, the lift of the ball being regulated by a cap which screws into the top of the cage.

This type of valve is used for handling thick liquids. It is also a very efficient valve for pumps handling lime-soda ash solution.

A Pump Valve, Clapper.—A clapper valve ground to its seat and hinged so that when the valve is lifted the maximum opening in the valve deck is obtained.

This type of valve is largely used for handling tar, molasses and other thick liquids.

A Pump Valve, Rubber.—A flat rubber disc with a central hole for the valve stem by which the valve is guided.

The head of the stem forms a guard for the spring which assists in seating the valve after the passage of the water.

A Pump Valve, Wing.—A valve with a conical seat and provided with wings, usually four in number, which guide the valve in its seat.

This type of valve is used largely in high pressure pumps operating against pressures up to 5,000 lb. and as a rule has a comparatively low lift.

A Pulsometer.—A device for pumping water by steam applied direct to the water. It consists of two pear-shaped vessels in one casting, the necks of which terminate in a single chamber having two valve seats with one ball valve which oscillates between them. It also has an air chamber and suction and discharge valves.

When charged with water, steam is admitted, the pressure of which is applied to the surface of the water in one chamber, forcing it through the discharge valve into the discharge pipe. When the steam reaches the opening leading to the discharge pipe it comes in contact with the water already in the pipe and is immediately condensed, creating a vacuum in the chamber just emptied. This vacuum draws the ball valve to the seat opposite, and prevents the further admission of steam until the empty chamber is filled with water through the suction pipe by the vacuum thus created, these operations being repeated alternately.

MR Quicklime.—A material, the major part of which is calcium oxide, which will slake on the addition of water.

It is used as a reagent in the treatment of boiler waters containing carbonate hardness.

Reagent.—Any chemical used for the treatment of water.

MR Runoff.—The name applied to that part of the precipitation which is carried off from the land upon which it falls.

A Saturated Steam.—Steam of the temperature due to its pressure, not superheated.

M Seepage.—Water escaping through the ground.

M Sludge.—The precipitate resulting from chemical treatment, coagulation or sedimentation.

A SLUICE GATES.—Devices similar in construction to the gate of a valve, so arranged that they may be built into the masonry of reservoirs and other structures.

They are designed for holding water against moderate heads only.

M SODA ASH.—The anhydrous normal carbonate of soda.

It is used as a reagent in the treatment of boiler waters containing sulphate hardness.

A SODIUM ALUMINATE SOLUTION.—Aluminate of soda ($Na_2Al_2O_4$) held in solution by an excess of sodium hydrate; an intermediate product in the manufacture of metallic aluminum from bauxite, obtained by digesting bauxite with steam at about 60 lb. pressure, together with lime and soda ash. After filtration the effluent is concentrated to a gravity above 1.35 which approaches saturation.

It is used as a coagulant and as an aid to the reactions involved in softening water with lime and soda.

M SOLIDS, INCRUSTING.—Matter in solution or suspension which upon the application of heat forms scale.

M SOLIDS, NON-INCRUSTING.—Matter in solution whose solubility is above that usually found in boiler water concentrations.

A SPILLWAY.—A low-level passage serving a dam or reservoir through which surplus water may be discharged; usually an open ditch around the end of the dam, a gateway or a pipe in a dam opened by lifting a gate or opening a door or valve by means of machinery, sometimes automatic, lowering the stage of water and thus reducing the pressure behind the dam and preventing the water from overtopping it.

A STANDPIPE.—A tank in which the bottom is located at or near the surface of the ground, the interior of the entire structure being utilized for the storage of water.

A STARTING TORQUE.—The pull on an electric motor when starting.

The starting torque of a constant speed motor is twice the full load torque on full voltage. As a general rule the torque varies as the square of the applied voltage. When 50 per cent voltage is applied to the motor, half full load torque is given.

A STEEL.—An alloy principally of iron and carbon cast from the molten state into a mass which is usually malleable, initially at least, in the same range of temperature.

A STOP COCK.—An iron or brass body fitted with a brass plug ground to seat. An opening through the plug corresponds to the opening through the body.

A quarter turn of the plug opens or closes the plug.

A SUCTION.—The creation of a more or less perfect vacuum in the suction chamber of the pump and suction pipe, filling them with water by atmospheric pressure.

M SULPHATE OF ALUMINA.—The commercial product known as basic sulphate of alumina. It is used as a coagulant in removing suspended matter from water.

A Sulphate of Iron.—Known as sugar of iron, the theoretical formula of which is $FeSO_4 7H_2O$. It is used as a coagulant and forms a coagulum of greater specific gravity than sulphate of alumina.

It is employed chiefly in the treatment of municipal water supplies in conjunction with lime.

A Superheat Steam.—Steam heated to a temperature above that due to its pressure.

MR Suspended Matter.—Undissolved particles of matter in water which may be removed by filtration, coagulation or sedimentation.

They may be organic, that is, vegetable or animal matter, usually in a state of decay, or inorganic, such as particles of earth, or solids thrown out of solution through chemical action.

A Tank.—A basin or reservoir on an elevated structure with the bottom located at a suitable height to deliver all water held in storage at the desired head.

A Tank Capacity.—The number of U. S. gallons of water available above the bottom capacity line of tank.

A Tank Spout.—A movable delivery pipe so fixed to a water tank as to conduct water conveniently into the tanks of locomotive tenders.

M Tank Tower.—A structure which supports an elevated tank.

The term is also generally considered as that part of any tank structure from the top of foundation to the bottom capacity line of the tank.

M Tank Valve.—The valve controlling the delivery of water from the tank to the outlet pipe.

A Track Pan.—A shallow trough located between the rails, from which water is taken by locomotives while in motion by means of a scoop located under the tender.

The troughs are usually from 20 to 30 in. wide by 7 in. deep and 1,900 to 3,000 ft. long.

M Transpiration.—A process of vaporization of water from the breathing pores of leaves and other vegetable surfaces.

MR Turbidity.—A measure of suspended matter in the water due to silt, clay, organic matter, micro-organisms, etc.

It is commonly expressed in terms of the turbidity produced by a given weight of silica.

A Valve Air.—A small valve placed at the summit of pipe lines for the purpose of letting out the air automatically and preventing the pipe line from becoming air bound with a resultant increase of pressure.

M Valve, Float.—A valve which controls the height of water in a tank by the action of the water raising a float.

A Valve, Foot.—A combination check valve and strainer placed at the lower end of a suction line for the purpose of keeping the suction line filled with water to assist the pump in picking up the water.

Centrifugal pumps cannot be operated successfully without a foot valve where the water is below the pump as it is necessary to have the suction line and pump filled with water in starting.

A Valve, Gate.—A device for controlling the openings in pipes, consisting of a body connected in the line of pipe and surmounted by a bonnet or dome generally connected to the body by flanges. The disc or gate is actuated by a threaded stem and rises into the bonnet when the gate is opened.

M Water Column.—A mechanical device consisting of valve, vertical pipe and spout, through which water is controlled and delivered to a locomotive tender.

A Water Hammer.—Excess pressure or other reactions due to sudden decreases in the velocity of water flowing through a pipe line, such as closing a valve quickly or the pulsations of a pump.

A Water Main Cleaner.—A device consisting essentially of a series of scrapers and piloting or propelling discs, flexibly connected, and of a design that will remove debris and incrustation from pipe lines while being forced through under water pressure or pulled through by cable.

A Water Stage Register.—A device for registering the water level in streams or other bodies of water.

MR Water Treatment.—A process whereby water containing ingredients which are chemically or mechanically injurious to boilers is rendered harmless and fit to use in steam boilers.

M Water Table.—The underground water level.

Well, Artesian.—A well in which the water level is raised above the normal ground water level by subterranean pressure.

MR Well, Bored.—A well sunk with an earth auger. This type of well is usually limited to a depth of 40 to 50 ft.

MR Well, Drilled.—A term generally used to designate a well drilled in rock or other hard material by raising and dropping a drill, the drill being rotated to secure a round, straight hole.

MR Well, Rotary Drilled.—A well drilled through sand or other unconsolidated material by means of a drill bit with a hollow stem rotated by power, through which water is forced to assist the bit in cutting and to remove the material. The casing is rotated down in the same manner.

MR Well, Driven.—A well made by driving the casing without a strainer and removing the material inside, or by driving the casing with a well point and strainer, without the necessity of removing the material.

M Well, Flowing.—An artesian well in which the water rises above the surface of the ground.

A Well, Gravel Wall.—A well provided with a double casing from the surface to the top of the strainer. The fine sand is pumped out through a coarse screen and gravel fed into the space between the casing to replace the sand as it is removed, thus forming a gravel wall around the screen.

A Well, Pumping Head.—The level of the water in a well, measured from the surface of the ground while the well is being pumped.

A WELL, STATIC HEAD.—The normal water level in a well, measured from the surface of the ground while the well is not being pumped.

M WELL CASING.—The pipe forming the wall of a drilled or driven well.

While wrought pipe is commonly used for well casing riveted steel, cast-iron and concrete pipe are also used, particularly in the larger wells.

M WELL INTAKE.—A term commonly applied to a well for collecting surface supply in an advantageous position for pumping.

M WELL SCREEN.—A device placed in a well, designed to admit water from the surrounding area and exclude sand and other substances.

It is generally a slotted or perforated pipe, sometimes wound with wire.

A WEIR.—A structure used to determine the flow of water from measurements of its depth on a crest or sill of known length and form.

The notch is generally rectangular or "V" shaped, although other shapes are sometimes used.

A WET STEAM.—Steam containing intermingled moisture, mist or spray. It has the same temperature as dry saturated steam of the same pressure.

A WINDMILL.—A machine consisting of an elevated wood or steel wheel which is driven by the action of the wind.

Commonly used to operate well pumps and to a limited extent for other power purposes.

M WORKING BARREL.—The metal tube or pump cylinder, fastened to the lower end of the drop line, which contains the valves and piston.

It is used in connection with a power head for pumping from deep wells.

A WRENCH, CHAIN PIPE.—A tool designed essentially to turn metal pipe or pipe fittings which cannot be handled effectively with an ordinary wrench.

A chain pipe wrench consists of a bar with a working end terminating between a pair of pivoted V-shaped jaws equipped with lateral wedge-shaped teeth on their top and bottom surfaces and with a chain to embrace the pipe. The chain is wrapped around the pipe to hold the bar in position, while the teeth of the V-shaped jaws grip the pipe and afford a powerful leverage.

A WRENCH, STILLSON PIPE.—A tool designed essentially to turn metal pipe or pipe fittings. The wrench is similar to a monkey wrench except that the jaws are equipped with lateral wedge-shaped teeth to afford a firm grip on the pipe.

A WROUGHT IRON.—Iron which is aggregated from pasty particles without subsequent fusion and contains so little carbon that it does not harden usefully when cooled rapidly.

A ZEOLITE WATER SOFTENER.—A steel shell similar to a pressure sand filter, filled with a silicate material which has the power of absorbing calcium and magnesium from the water.

This material is known as an exchange silicate as the zeolite carries sodium, which is replaced by calcium and magnesium when the water comes in contact with it. When the zeolite becomes saturated with the calcium and magnesium the mineral is revived by means of common salt.

Appendix B

(2) REPORT ON REGULATIONS OF FEDERAL AND STATE AUTHORITIES PERTAINING TO DRINKING WATER SUPPLIES AND SANITARY EXAMINATION OF DRINKING WATER SUPPLIES

S. C. Beach, Chairman, Sub-Committee; H. W. VanHovenberg, C. P. Hoover, A. B. Pierce, O. T. Rees, C. M. Bardwell, C. H. Fox, D. A. Steel.

Reference was made in our last report to new drinking water standards recommended by an Advisory Committee appointed by the Surgeon-General of the United States Public Health Service and composed of representatives from the Government, scientific societies and Sanitarians.

The recommendations were made solely for the regulation of railroad drinking water, and it is to be noted that the Advisory Committee had but one railroad member.

The new standards for Railroad Drinking Water were adopted by the Treasury Department and are now in force, the printed copy of same being obtainable in Public Health Report dated April 10th, 1925.

These new standards are more rigid in general trend and in some respects an improvement over the former standards. The notable differences are (a) the added importance of the survey; (b) the dependence placed upon the presence of gas-forming bacilli in laboratory tests with relegation of gross bacterial count as non-essential, and (c) the defining of a standard sample as consisting of five 10 c.c. tubes.

The following quotation, as showing more breadth of judgment of the water under consideration, is here given: "Supplies which on rigid inspection are found satisfactory in other respects but fail to meet the bacteriological standards may be accepted at the discretion of the certifying authority."

The survey of water source, protection, pumping and delivery to public is stressed and the scope of this survey gone into in detail, it being considered as fundamental and of the utmost importance.

These two points, namely, the presence and percentage of gas-forming bacilli and the added importance of the field survey constitute the basis for acceptance or rejection of the water under consideration.

The chemical and physical characteristics are considered to be of secondary importance, it being judged that if taste, color and odor are acceptable and the water supply satisfactory from the standpoint of safety as determined from the field survey and laboratory tests, it will usually be found satisfactory with respect to physical and chemical characteristics.

It is to be noted that the new standards are for the guidance of the State and Federal authorities recommending or rejecting the water supply, and the report makes clear that a supply will be considered acceptable if certified by the United States Public Health Service, even if it fails to conform to the new standards on bacteriological, chemical or physical characteristics.

Two Supreme Court decisions from Pennsylvania and Wisconsin, respectively, have been made regarding the matter of stream pollution with industrial wastes or other pollution, both being against the right of persons or corporations to contaminate the waters of the stream and thereby place in danger the lives of persons living thereon.

Your Committee regret that the Advisory Committee on Water Standards did not see fit to apprise them regarding the new standard, they being representative of the railroads in this important matter.

Appendix C

(3) PITTING AND CORROSION OF BOILER TUBES AND SHEETS

R. C. Bardwell, Chairman, Sub-Committee; C. M. Bardwell, R. E. Coughlan, W. M. Barr, O. W. Carrick, B. W. DeGeer, C. P. Hoover, C. H. Koyl, P. M. LaBach, T. W. Sedwick, O. T. Rees, H. H. Richardson, C. P. Van Gundy, J. P. Hanley, J. H. Davidson.

The development in the study of Pitting and Corrosion during the past year has not added much information to the reports and conclusions which have already been presented to the Association by your Committee, particularly the able summary which was prepared for the last convention under the direction of Dr. M. E. McDonnell.

Practically every technical society whose work is affected by this subject, including the American Society for Testing Materials, American Chemical Society, and American Electrochemical Society, American Institute of Chemical Engineers, American Society for Mechanical Engineers, American Society of Refrigerating Engineers and American Foundrymen's Association, American Water Works Association, Master Boilermakers Association, and the American Committee on Electrolysis (in conjunction with the Bureau of Standards), all have committees studying this topic, and the National Research Council at Washington has a Corrosion Committee under the direction of W. M. Corse, which does no research work itself but endeavors to coordinate the work of the various committees and avoid overlapping.

The developments to date tend to confirm the theory of corrosion, based on electro-chemical reactions, which was outlined by your Committee in the preliminary report made in 1922 and published in the Proceedings of the Association, Volume 25, pages 493 to 497, inclusive. This is based on the fact that iron is soluble in water to only a very limited extent, forming a ferrous hydroxide. To increase this reaction to the point where practical evidence of pitting is noticed, it is necessary for oxidation to take place and remove that soluble iron so that more can be taken into solution. This oxidation is a chemical term, meaning not only the possible addition of oxygen, but any other reaction which might increase the valency, or power, of combination of the iron and change the balance or equilibrium of the solution. The features affecting this action may be briefly outlined as follows:

(1) Hydrogen-ion Concentration

At the Baltimore meeting of the American Chemical Society in April, 1925, a symposium on "Corrosion" was held at which many papers were presented giving the results of a large amount of experimental work which has been done on the theory of corrosion. Although the discussion included many points in the wide range of this subject, the general conclusion on sub-aqueous corrosion appeared to be that the phenomena was a straight-line function of the hydrogen-ion concentration, and the effect of contributory elements is minimized by increase in temperature. The subject of hydrogen-ionization was explained in the report of your Committee for 1924, and published in the Proceedings of the Association, Volume 25, pages 164 to 166, inclusive. This is essentially, and in substance, the relative acidity of the solution, which is increased by the concentration of common alkali salts, such as sodium sulphate or chloride, in a manner not determinable by the ordinary volumetric tests. The remedy for cases of this trouble appears to be maintaining an excess of hydrate alkalinity in the boiler water, formula for which was presented in the report for 1925 and published in the Proceedings, Volume 26, p. 378. This covers not only the increase in relative acidity caused by increase in alkali salts, but also the cases of direct mineral acidity, including carbon dioxide, such as surface waters occasionally encounter in coal districts polluted by mine drainage.

(2) Carbon Dioxide

The importance and effect of free carbon dioxide inside of locomotive boilers, has not been definitely established. By maintaining the proper relation of hydrogen-ion concentration as outlined above, any possible damage from this feature can be eliminated.

(3) Oxygen

The effect of dissolved oxygen is well known in the stationary boiler field and its elimination has produced successful results at many points. However, in locomotive practice, there is considerable question as to whether such conditions are comparable, as the variable rate of evaporation, together with violent surging, produces conditions which tend to minimize such effects.

(4) Alloys and Coatings

Experiments to date, with alloys and coatings, have not indicated that a commercially adaptable and practical product is available which can be successfully used in boiler construction.

(5) Influence of Suspended Matter, Including Mud and Scale

Instances have developed where pitting and corrosion have taken place under scale, particularly of the calcium sulphate variety around the base of staybolts. Cases of this kind can be readily eliminated by proper addition of soda ash or maintaining a caustic hydrate alkalinity in the boiler.

(6) Counter-Electrical Method

Experiments with the counter-electrical potential method of preventing corrosions are still under way.

(7) Design and Construction of Boilers

The study of the effect of design and construction of boilers is a subject which more logically comes under societies other than the American Railway Engineering Association. However, it has been noted that, in the design of the larger locomotives which are now being placed in railroad service, some trouble is experienced where the large crownsheets and side sheets are not properly stayed, and also the expansion and contraction of the long flues, in some cases, may cause movement in the flue sheets which may result in a change in the crystalline structure of the metal with consequent difference in potential and resultant pitting. Some examples have been noted of serious ring pits around staybolts which can be accounted for either by the sheets not being properly matched, or the cold punching of staybolt holes, either case causing rearrangement of crystallization with resulting difference in potential and pitting of the sheets.

(8) Kind and Care of Material

Your Committee is not in position to question the A. R. A. specifications for materials used in boiler construction and it is felt that the study which has been given to this subject by other committees has been sufficiently thorough to warrant the best results if the specifications are followed. This can only be obtained if the specifications are rigidly adhered to, as the use of non-homogeneous material is known to result in pitting. The care of the material is a feature which is also being given better attention. It is known that when pitting has once started, the action is frequently continuous until failure results, due to the difference in potential and electrolytic action which is set up. Atmospheric corrosion, or rusting, is most common and where boiler material is used on which corrosion has already started, pitting and ultimate failure is most probable. This can be largely prevented by proper storing of materials or coating with rust-proof compounds, several of which are on the market and commercially available.

(9) Recommendation

It is recommended that the study of this subject be continued and that this Association be kept advised of new developments, as well as results of the study of other committees from associations which have this topic under investigation.

Appendix D

(4) COST OF IMPURITIES IN LOCOMOTIVE FEEDWATER AND VALUE OF WATER TREATMENT

C. H. Koyl, Chairman, Sub-Committee; C. M. Bardwell, R. C. Bardwell, W. M. Barr, C. W. Carrick, R. W. Chorley, R. E. Coughlan, J. H. Davidson, B. W. DeGeer, C. H. Fox, E. M. Grime, J. P. Hanley, C. P. Hoover, P. M. LaBach, O. T. Rees, H. H. Richardson, D. A. Steel, C. P. VanGundy.

Last year this Committee reported on the economies resulting from the softening of locomotive feedwater on parts of seven American railways, and reduced the data to "savings per locomotive per year."

In the case of a yard engine working in Minnesota, where the account had been kept for several years both before and after the change from hard and muddy to soft and clean feedwater, the report showed an itemized saving of $4,000 per year in boiler repairs and fuel, with an increase in working ability the value of which was not stated.

In the case of an engine district of 130 miles on the Chicago, Milwaukee & St. Paul Railway in South Dakota, the report on road engines showed a saving of $4,000 per engine per year in boiler maintenance and fuel, and at least an equal saving to the operating department from the avoidance of train delays.

In the case of the classic change on the El Paso & Southwestern, on 128 miles of road, from very hard well water to the best of mountain water, there was shown a total saving, including operation, of $8,000 per locomotive per year.

On other roads where water was not so hard there were reported savings in boiler maintenance and fuel of lesser amount, but averaging roughly $1,000 per locomotive per year for each ten grains per gallon of original water hardness.

In two cases we endeavored to fortify the results by quoting from the official Operating Statistics a comparison of the "cost of maintaining and operating locomotives" on two adjoining divisions, on one of which water had been softened but on the other not. The results were much alike, showing a difference of $3000 per locomotive per year for one pair of divisions and $4000 for the other pair.

In the last meeting of the Committee, it was objected by some members that these Operating Statistics could not be safely used for this purpose without multiplying the results by factors showing the amount of work done in the years under comparison by the engines on each division, thus guarding against the effect of any increase or decrease of business or of number of engines not common to the two divisions.

There was force in the objection, but the report had gone to the printer before the new tables could be computed, and we submit this year a supplementary summary of the result of introducing the additional factor. The computation was made by F. J. Walter, a member of the Committee, utilizing also the data of 1924, and its value is apparent from a consideration of the Sioux City & Davenport and Iowa Divisions of the Chicago, Milwaukee & St. Paul Railway, where the reduction of expense on the softened water Sioux City & Davenport Division remains above $4000 per engine, while on the Iowa Division the influence of the increasing use of soda ash in boiler feedwater from 1922 to 1924 is plainly seen in Mr. Walter's table in the gradual reduction of annual expense from $30,532 in 1921 to $26,494 in 1924, though the official Operating Statistics did not show it. Putting soda in the boiler and in the engine tank is a form of water treating, but the Operating Statistics quoted last year showed so little benefit from it that this use of soda ash was not mentioned in our report.

In the computation of the supplementary tables, inasmuch as in all cases the period 1922 to 1924 is compared with 1921, the year 1921 has been used as a base in equating all work performed. For example: The switch engines on the Iowa Division of the Chicago, Milwaukee & St. Paul Railway made 24,659 miles per engine during 1921 and 27,770 miles per engine during the period 1922-1924. This extra work per engine naturally increased all expenses in the later period and the equated expense represents what we might have expected had they made only 24,659 miles per engine, or the same as during 1921. In the tables, it is assumed that all expenses, except that for coal, vary as the mileage performed.

The first sheet shows the work performed per engine for each class of service on each division. The equated mileage performed per year during 1922-1924 was obtained by multiplying the mileage made in 1921 by the average number of engines in service during 1922-1924. The last column shows the per cent of the equated mileage to the actual, and the corresponding expenses have been equated by multiplying by these percentages.

In determining the equated cost of fuel, the following method was used: First, calculate the tons of coal used per year; then the fuel consumption for each period in pounds per 1000 gross ton mile, or per passenger car mile, or per switching mile, as the case may be; then the gross ton mile, or passenger car miles, or switching miles, made per locomotive in 1921; and multiply by the average number of engines in service during 1922-1924 to determine the equated amount of work during the latter period. Then multiply the equated amount of work by the proper fuel consumption rate per gross ton mile, etc., during 1922-24. This, reduced to tons, gives the equated amount of coal that would have been used had the work per engine been the same each period compared. To determine the cost of fuel, multiply all tonnages by the price paid during the year 1921 to eliminate all differences in the unit price.

For brevity the detailed tables are given only for the Iowa Division of the Chicago, Milwaukee & St. Paul Railway, which is the most interesting case because of its use of soda ash, and merely the summary for the other divisions.

The total amount of scale kept out of the boilers by the water treatment has also been computed, and attention is again called to the fact that the estimate of the Water Service Committee of 1914 of a saving of 7 cents per pound of scale kept out, now estimated at 13 cents because of higher prices, is below the actual savings.

SUPPLEMENTARY STATISTICS

Chicago, Milwaukee & St. Paul Railway—Iowa Division

Service	Year	Mileage Performed	Mileage Per Loco.	Equated Mileage Per Loco.	Equated Mileage Performed Per Year	Per Cent of Equated Mileage to Actual
Switching	1921	443,854	24,659	24,659	443,854	100.00
Switching	1922	502,555	26,450	24,659	468,521	93.22
Switching	1923	592,194	32,900	24,659	443,862	74.95
Switching	1924	571,443	24,845	24,659	567,157	99.25
Passenger	1921	1,465,042	52,323	52,323	1,465,042	100.00
Passenger	1922	1,375,758	42,992	52,323	1,674,336	121.70
Passenger	1923	1,414,724	54,412	52,323	1,360,398	96.16
Passenger	1924	1,409,370	44,043	52,323	1,674,336	118.80
Freight	1921	1,790,730	26,334	26,334	1,790,730	100.00
Freight	1922	1,906,069	27,624	26,334	1,817,046	95.33
Freight	1923	2,179,743	31,590	26,334	1,817,046	83.36
Freight	1924	1,911,959	22,494	26,334	2,238,390	117.07

COMPARISON OF COSTS OF OPERATING AND MAINTAINING LOCOMOTIVES

Chicago, Milwaukee & St. Paul Railway—Iowa Division—1921-1924 —Adjusted for Equal Amounts of Work

Item	Expense 1921	Equated Expense		
		1922	1923	1924
Yard Engine Repairs	$ 140,516.66	$ 141,251.46	$ 122,614.18	$ 156,371.07
Yard Enginemen	108,281.68	108,195.14	102,084.06	135,476.76
Fuel for Yard Engines	112,071.23	87,848.64	81,705.09	134,259.46
Water for Yard Engines	3,850.42	3,902.52	3,909.49	8,475.53
Lubricants for Yard Engines	2,929.61	2,308.29	2,500.97	3,106.73
Other Supplies for Yard Engines	1,576.42	1,995.67	2,095.43	4,482.59
Engine House Expense for Yard Engines	76,298.25	71,450.53	60,094.31	79,079.98
TOTAL—Yard Engines	$ 445,524.27	$ 416,952.25	$ 375,003.53	$ 521,252.12
Average Cost per Engine	24,751.35	21,944.86	20,833.53	22,663.14
Passenger Engine Repairs	374,100.73	474,704.18	376,319.10	344,857.17
Passenger Enginemen	178,397.31	197,441.67	161,193.12	203,084.15
Fuel for Passenger Engines	314,504.76	318,452.74	270,935.55	306,781.12
Water for Passenger Engines	9,804.11	11,401.28	10,492.70	12,087.65
Lubricants for Passenger Engines	8,956.29	13,118.20	7,284.83	7,311.75
Other Supplies for Passenger Engines	3,552.28	4,763.65	3,659 00	5,863.90
Engine House Expense for Passenger Engines	109,466 79	120,611 08	71,936.13	75,929 59
TOTAL—Passenger Engines	$ 998,782.27	$1,140,492.80	$ 901,820.43	$ 955,915.33
Average Cost per Engine	35,670.80	35,640.40	34,685.40	29,872.35
Freight Engine Repairs	604,231.62	591,260.06	574,088.36	661,513 75
Freight Enginemen	332,591.88	341,397.96	327,323.33	418,307.85
Fuel for Freight Engines	845,499.53	762,400 83	763,752.64	910,948.67
Water for Freight Engines	24,318.79	25,669.06	29,323.97	39,010.38
Lubricants for Freight Engines	23,189.80	17,521.02	12,803 09	13,537.55
Other Supplies for Freight Engines	12,427.41	10,290.65	9,845.55	11,906.32
Engine House Expense for Freight Engines	194,131.07	193,231.54	179,416.34	176,916.71
TOTAL—Freight Engines	$2,036,390 10	$1,941,771.12	$1,896,553.28	$2,231,941.23
Average per Engine	29,046 91	28,141.61	27,486.28	26,258.13
TOTAL Cost for All Engines	$3,480,696.64	$3,499,216.17	$3,173,377.24	$3,709,108.68
Average per Engine for All Engines	30,532.43	29,159.96	28,082.98	26,493.63

COMPARISON OF COSTS OF OPERATING AND MAINTAINING ALL LOCOMOTIVES

IOWA AND SIOUX CITY & DAVENPORT DIVISIONS OF THE CHICAGO, MILWAUKEE & ST. PAUL RAILWAY—ADJUSTED FOR EQUAL AMOUNTS OF WORK

Average Cost per Locomotive—Iowa Division

Item	Cost for Year 1921	Equated Cost for Period 1922–1924	Difference in Cost	
			Increase	Decrease
Repairs	$ 9,814.47	$ 9,265.58		$ 543.89
Enginemen	5,432.20	5,342.39		89.81
Fuel	11,158.57	9,753.09		1,405.48
Water	333.10	384.76	$51.66	
Lubricants	307.67	213.89		93.78
Other Supplies	154.00	143.26		10.74
Enginehouse Expense	3,332.42	2,772.14		560.28
TOTALS per Locomotive	$30,532.43	$27,875.11	$51.66	$ 2,708.98
Net Difference in Cost				2,657.32

Average Cost per Locomotive—Sioux City & Davenport Division

Item	Cost for Year 1921	Equated Cost for Period 1922–1924	Difference in Cost	
			Increase	Decrease
Repairs	$10,515.75	$ 7,691.45		$ 2,824.30
Enginemen	4,848.70	4,827.04		21.66
Fuel	7,437.69	6,950.62		487.07
Water	570.50	809.28	$238.78	
Lubricants	227.44	146.96		80.48
Other Supplies	115.29	125.14	9.85	
Enginehouse Expense	3,821.37	2,760.81		1,060.56
TOTALS per Locomotive	$27,536.74	$23,311.30	$248.63	$ 4,474.07
Net Difference in Cost				4,225.44

COMPARISON OF COSTS OF OPERATING AND MAINTAINING ALL LOCOMOTIVES

IOWA AND ST. LOUIS DIVISIONS OF THE ILLINOIS CENTRAL RAILROAD—ADJUSTED FOR EQUAL AMOUNTS OF WORK

Average Cost per Locomotive—Iowa Division

Item	Cost for Year 1921	Equated Cost for Period 1922–1924	Difference in Cost	
			Increase	Decrease
Repairs	$ 8,336.65	$ 8,273.06		$ 63.59
Enginemen	5,559.66	5,389.97		169.69
Fuel	9,762.04	8,880.63		881.41
Water	632.37	784.88	$152.51	
Lubricants	317.81	198.20		119.61
Other Supplies	91.31	86.06		5.25
Enginehouse Expense	3,428.70	2,994.75		433.95
TOTALS per Locomotive	$28,128.54	$26,607.55	$152.51	$ 1,673.50
Net Difference in Cost				1,520.99

Average Cost per Locomotive—St. Louis Division

Item	Cost for Year 1921	Equated Cost for Period 1922–1924	Difference in Cost	
			Increase	Decrease
Repairs	$ 7,545.41	$ 7,749.39	$ 203.98	
Enginemen	5,906.41	6,475.38	568.97	
Fuel	7,595.54	8,203.87	608.33	
Water	609.93	606.78		$ 3.15
Lubricants	186.48	155.53		30.95
Other Supplies	120.89	132.00	11.11	
Enginehouse Expense	2,514.85	2,367.76		147.09
TOTALS per Locomotive	$24,479.51	$25,690.71	$1,392.39	$181.19
Net Difference in Cost			1,211.20	

SUMMARY OF COMPARISON OF EXPENSE OF OPERATING AND MAINTAINING LOCOMOTIVES TO DETERMINE VALUE OF WATER TREATMENT

Adjusted for Equal Amounts of Work

Railway	Division	Expense per Locomotive			Difference in Expense per Locomotive	Decrease in Expense per Locomotive Which May Be Attributed to Water Treatment
		Water Not Treated		Treated Water		
		Year 1921	Period 1922–1924	Period 1922–1924		
I. C.	St. Louis	$24,479.51	$25,690.71	....	+$1,211.20	....
I. C.	Iowa	28,128.54	....	$26,607.55	— 1,520.99	$2,732.19
C. M. & St. P.	Iowa	30,532.43	27,875.11	....	— 2,657.32	....
C. M. & St. P.	S. C. & D.	27,536.74	....	23,311.30	— 4,225.44	1,568.12
					Average	$2,150.16

SUMMARY SAME AS ABOVE BUT OMITTING ALL ENGINEMEN EXPENSE FOR ALL THREE CLASSES OF SERVICE

Railway	Division	Expense per Locomotive			Difference in Expense per Locomotive	Decrease in Expense per Locomotive Which May Be Attributed to Water Treatment
		Water Not Treated		Treated Water		
		Year 1921	Period 1922–1924	Period 1922–1924		
I. C.	St. Louis	$18,573.10	$19,215.33	....	+$ 642.23	....
I. C.	Iowa	22,568.88	....	$21,217.58	— 1,351.30	$1,993.53
C. M. & St. P.	Iowa	25,100.23	22,532.72	....	— 2,567.21	....
C. M. & St. P.	S. C. & D.	22,688.04	....	18,484.26	— 4,203.78	1,636.27
					Average	$1,814.90

Appendix E

(4) COMPARISON OF DIFFERENT METHODS OF WATER TREATMENT

C. H. Koyl, Chairman, Sub-Committee; C. M. Bardwell, R. C. Bardwell, W. M. Barr, O. W. Carrick, R. W. Chorley, R. E. Coughlan, J. H. Davidson, B. W. DeGeer, C. H. Fox, E. M. Grime, J. P. Hanley, C. P. Hoover, P. M. LaBach, O. T. Rees, H. H. Richardson, D. A. Steel, C. P. VanGundy.

The object of treatment for boiler waters is to free the water from substances which produce scale, leaking, foaming and pitting; and because scale wastes fuel, ruins boiler metal, and is a primary cause of leaking and sometimes of foaming, the elimination of scale is of the first importance.

The best natural water is the rain and melted snow of mountain streams, and though this water aways contains oxygen and carbon dioxide from the atmosphere and is continuously rusting the interior of boilers, yet the rusting is slow and uniform and the results are not serious during the ordinary life of a boiler.

Water containing a trace of mud, or carbonate of lime or magnesia up to 5 grains per gallon, deposits a thin scale throughout the boiler, but the deposition is so slow that usually no effort is made to prevent it except that once or twice a month 4 to 8 pounds of soda ash is dissolved in the boiler water of the engine at work, by which means the scale is loosened so that it is easily washed out.

If the water contains more mud or other scale matter than this, say from 5 to 100 grains per gallon, the damage to the boiler is greater in proportion and it is considered wise to apply some form of treatment to any boiler water whose hardness is more than 5 grains per gallon.

Ideal Water Treatment

Perfect water treatment would be some method by which we could extract everything dissolved or suspended in the water, leaving it pure. There is the distillation method by which we can evaporate the water and condense the vapor, leaving everything else behind; but the process is too expensive for non-condensing engines like locomotives, and among the chemical methods which are practicable in cost we can only approximate ideal conditions.

In the great majority of waters, the undesirable substances in solution are the carbonates and sulphates of calcium and magnesium which are scale makers, and the sulphate and chloride of sodium which are factors in pitting and foaming. We can do very little with the sodium salts, but we can always remove the calcium and magnesium carbonates down to 3 grains per gallon by means of fresh lime, and leave nothing in their place; and from waters in which the calcium and magnesium sulphates do not exceed the carbonates, we can also remove the sulphates with barium hydrate, and leave nothing in their place. In waters nearly free from sodium chloride, both carbonates and sulphates of calcium and magnesium can be removed by lime and barium carbonate, leaving nothing in their place; but the soluble barium salts are poisonous as well as rather expensive, and it has been customary to confine our efforts at water softening to the following methods.

Lime-Soda Treatment

The oldest and at the same time the standard and usual method of water softening for locomotives, and most large boiler installations, is by chemical precipitation and settling before the water goes to the boiler. The object of the process is both to precipitate from solution the calcium and magnesium salts and remove the precipitated sludge, so as to deliver boiler water which is not only soft but clean.

In its earliest and simplest form, as used by Dr. Clark of Aberdeen, Scotland, in 1840, the apparatus consisted of two tanks which alternately were filled with hard water, dosed with the proper amount of fresh lime, well stirred, and allowed to settle. The fresh lime destroyed the carbonate hardness of the water by combining with the carbonic acid which holds the carbonates of calcium and magnesium in solution.

Later the treatment was increased by William Porter in England to include the use of soda ash to destroy the sulphate hardness by converting calcium and (by the aid of lime) magnesium sulphate into sodium sulphate. And in course of time this method of softening and cleaning water, long known as the Clark-Porter process, became known as the lime-soda treatment. The two reagents, lime and soda-ash, are still in common use because they are the cheapest for the purpose.

About 1880, with the aim of cheapening the installation by speeding up the process, one small tank was used for continuous mixing of chemicals with a stream of raw water, and one large tank for settling the precipitate from the continuous stream. Thenceforth the first method (with two large tanks) has been known as the "intermittent process" and the other as the "continuous process." Both are satisfactory for the purpose.

While this method continues to be known as the "Lime-Soda Process" because of the common use of these reagents, it will not be forgotten that the equipment is complete for the use of any reagents or any variation of method which the character of the water may demand. If the water is muddy, the mud is carried down by the precipitate. If the water carries very fine clay or for any other reason is difficult to settle, a few grains per gallon of coagulant can be added as part of the process. If the water is heavily charged with sodium sulphate and likely to be a pitting medium, an increase in the charges of lime and soda-ash will provide caustic soda for its amelioration. If the carbonate and sulphate hardness happen to be equal in the water, and it is desired not to increase the sodium sulphate, the treatment may be entirely by barium hydrate (or barium carbonate and lime) which will take out the calcium and magnesium salts and to that extent decrease the mineral matter in solution. There is nothing in the chemical treatment or cleaning of water which cannot be accomplished in one of these plants. Any water can be so treated in them that in a boiler it will cause neither scale nor leaking, and will not cause foaming in a locomotive until the sludge and alkali salts become highly concentrated.

On a railroad it is usually desirable at all water stations except Division points that the water pumping and treating be done during the hours of daylight, and therefore water treating plants for railroads are cited by their hourly, not daily, capacity. Such a plant, of a treating capacity of 15,000 gallons of water per hour, housed and heated, costs nowadays about $16,000; and if it treats 120,000 gallons per day, a 10-per-cent charge for interest and depreciation amounts to 3¾ cents per thousand gallons of water treated. If the plant works 18 hours per day, the depreciation and interest amount to 1¾ cents per thousand gallons.

The advantages of this method of water treatment are (1) its universal adaptability, (2) the excellence of its effluent, (3) the fact that the economies resulting from its use make it a paying investment for any water above 10-grains-per-gallon hardness and for most waters above 5-grains-per-gallon.

Its disadvantages are (1) that, with lime and soda-ash reagents, it can destroy sulphate hardness only by converting calcium and magnesium sulphate into sodium sulphate, thus increasing the alkali salts in the water, and (2) that construction costs are, per thousand-gallon-per-hour capacity, from $600 to $1,600 according to size and north-and-south location.

Soda-Ash Treatment

Years ago, in railroading across the western plains, there was found a class of hard waters which do not scale boilers. These waters all contain carbonate of lime or magnesia *and* carbonate of soda, and in a boiler the limestone precipitates as soft sludge, not as hard scale. Advantage has been taken of this knowledge to prevent the formation of hard scale from the simpler waters by adding enough soda ash to neutralize the sulphate hardness and to leave an excess of two or three grains of sodium carbonate per gallon.

For many years this addition of soda ash has been made to the water in the engine tank, and the results are good when the amount necessary is small and when the engine crew attend to it faithfully as the water is received from the roadside tank. But the boiler will soon commence to foam unless regularly and consistently blown out; and because the crew is more interested in getting over the road than in saving fuel or boiler repairs, it has been found difficult to get soda ash added regularly by this method.

This condition led some years ago to the practice on some roads of blowing dry soda ash into the boilers while in the enginehouse, immediately after washing. Soda ash so blown in covers the boiler interior quite uniformly like whitewash, loosens any old scale and, working in the simpler waters, prevents for a day or two the adherence of new scale, that is, until the soda ash is used up or blown out. During the active life of this soda ash there is little tendency to foam, but the charge of 20 to 30 lb. seldom lasts until the next boiler washing and it is necessary in the interval to add soda ash to the engine tank with its attendant difficulties.

Soda Ash Applied to Water in Roadside Tank

The best and most economical method of utilizing soda ash in boilers consists in adding exact quantities to the water as it is being pumped into the roadside tanks. Because the treatment is exact there is no waste of chemical, and practically no hard scale forms in the boiler. The total amount of sludge deposited in the boiler depends on the hardness of the water, and the total amount of alkali salts in the boiler is the sum of the alkali originally in the water and the soda ash added.

Because of the necessity of keeping the amounts of sludge and alkali salts down to certain limits to prevent foaming, special blowing-out equipment is advisable on the engines and special training of the engine crews in its use; and on the regular and thorough blowing of the boilers to keep the sludge and alkali within the limits set for that kind of sludge, depends the possibility of operating the engines.

It has been determined in practice that with this kind of sludge alkali concentration must be kept down to 125 grains per gallon, and that, when the blowoff is properly arranged, the sludge is kept within necessary limits by the blowing to reduce alkali concentration.

The amount of blowing for any given water is easily calculated if we translate "125 grains per gallon" into "200 parts per 100,000." For water containing 10 parts per 100,000 of alkali (sum of alkali originally in the water and the soda ash added), if the water must not exceed 200 parts per 100,000 then $\frac{200}{10}$, or 20 boilers of water, can be evaporated before water will be at the foaming point, and the blowing out of one boiler in twenty, or 5 per cent of the water, will prevent foaming. At 18,000 gallons water used per hundred freight train miles, this will mean 900 gallons blown out; and, if blowing at 130 gallons per minute, it will mean 7 minutes' blowing. Likewise for waters containing 20 to 120 parts per 100,000 or 12 to 70 grains per gallon of alkali salts, the percentages are from 10 to 60, and the amounts of water to be blown out from 1,800 to 10,800 gallons per hundred miles.

Cost of Blowing Out

It should be remembered that the water blown out is water at 200 lb. pressure, and not steam at 200 lb. One pound of ordinary railroad coal will heat 20 lb. of water from 50° Fahr. to 387°, which is the temperature of water heated to 200 lb. steam pressure; and the final cost of railroad coal may be averaged at $3.00 per ton. On the supposition that the locomotive has no feedwater heater, that the water costs 10 cents per 1,000 gallons for pumping, and that of the total alkali salts in the water half is the result of treatment with soda ash, the following table gives the cost of water, soda ash and heat blown out in 100-mile freight run, under the different water conditions assumed:

Alkali in Water		Water Blown Out		Blown Out, Lb.			Cost				
Grains Per Gallon	Parts Per Hundred Thousand	Per Cent	Gallons	Water	Soda Ash	Coal	Water Cts.	Soda Ash Cts.	Coal $	Total $	Per M Gallons Water Used Cts
6	10	5	900	7,500	.5	375	9	1.0	.56	0.66	3.7
12	20	10	1,800	15,000	1.5	750	18	2.3	1.12	1.32	7.3
18	30	15	2,700	22,500	3.5	1125	27	5.3	1.68	2.00	11.1
24	40	20	3,600	30,000	6.0	1500	36	9.0	2.24	2.69	14.9
29	50	25	4,500	37,500	9.0	1875	45	13.5	2.80	3.38	18.8
35	60	30	5,400	45,000	13.0	2250	54	19.5	3.36	4.09	22.7
41	70	35	6,300	52,500	18.0	2625	63	27.0	3.92	4.82	26.8
47	80	40	7,200	60,000	23.0	3000	72	35.0	4.50	5.57	31.0
53	90	45	8,100	67,500	29.0	3375	81	43.0	5.06	6.30	35.0
58	100	50	9,000	75,000	36.0	3750	90	54.0	5.62	7.06	39.2
64	110	55	9,900	82,500	44.0	4125	99	66.0	6.19	7.84	43.6
70	120	60	10,800	90,000	53.0	4500	108	80.0	6.75	8.63	48.0

It is evident that the class of waters which lend themselves to this kind of treatment are those comparatively free from alkali salts and sulphate hardness and light mud; and that at present prices the cost of blowing out becomes high with treated waters of even 30 grains per gallon alkali salts, which are common all through the West. It is probable that with such amounts of alkali in the water, recourse would be had to anti-foaming compound which would reduce the amount of blowing off, but would also increase the amount of sludge adhering to the flues and sheets.

This method of ameliorating boiler condition was worked out on the Chicago Burlington & Quincy Railroad in the years between 1902 and 1912, then carried in 1912 to the Wabash, where it has been put into general use because of the suitability of the waters to this method of treatment (15 grains per gallon hard, mostly carbonate and nearly free from alkali salts); then in 1922 to the Chicago & Alton, where it is also in general use on still harder waters; and to other roads.

Your Committee spent five days in a study of the condition and operation of the boilers on the Wabash. They found the boilers in good condition and with little evidence of foaming on the road.

The boiler blowoff equipment is of the most effective kind, and its systematic use is assured by the close cooperation of all in authority on the road. Each freight engine has one 1½ inch blowoff cock, which is extended through the back mud-ring by a perforated pipe, and can discharge about 130 gallons per minute. At terminals, each freight engine has at least one full glass of water blown out, and on the road about one minute's blowing per hour, and more if necessary to prevent foaming. Passenger engines have two such blowoff cocks, one of which is used only at terminals to blow off one or two full glasses of water, and the other (reduced to one-quarter inch in a three-quarter pipe) can be used as a continuous blowoff if necessary, delivering between the rails under the engine deck about 600 gallons per hour. Side blowing from passenger engines is not allowed.

Passenger engines using this process, and no anti-foam compound, are run for 15 days between washings, and freight engines for 30 days. There are records, both for this water and for completely treated water, of locomotives run for 4000 to 10,000 miles without washing, and being found almost perfectly clean at the end; but on roads on which previously it was necessary to wash boilers every round trip, it requires gradual education to get a boiler operated more than one week without washing, no matter how good the water.

The advantage of this method of softening water inside the boiler is in the cheapness of the soda ash plants (about $1000 each) as compared with the cost of complete treating plants for the simple kinds of waters to which alone this process is applicable.

The disadvantages of the process are (1) the loss of heat from the additional blowing off required, (2) the loss of water where water is scarce, (3) the objections of people along the road where closely populated, (4) the smearing of equipment, (5) the greater use of engine oil, common to all locomotives treating water within the boiler.

PROPRIETARY BOILER COMPOUNDS

There are also proprietary mixtures of soda ash and vegetable extracts which are dissolved in the water in the engine tank and used to keep the boiler scale somewhat soft so that it can be more easily washed out. It is claimed for the vegetable extract that it has a colloidal effect on the particles of calcium carbonate and sulphate precipitated by the heat, so that these particles do not attach themselves to the heated metal surfaces but remain loose sludge suspended in the water in the boiler. The influence of colloids on both hot and cold suspensions is now under intensive study and agreement has not yet been reached; but experience shows that these boiler compounds do keep boilers reasonably clean when used on waters of low hardness. Next to soda ash these are the cheapest boiler cleaners for simple waters, and, like soda ash, they are better when fed into the roadside tanks in proportion to the character and amount of water pumped.

Zeolite Treatment

About fifteen years ago there was brought to this country from Germany a method of softening water by passing it through a bed of zeolite sand.

Zeolite is the name commonly given to a class of minerals which are double silicates of aluminum or iron with sodium or potassium, and some of which have the remarkable property of giving up their sodium or potassium to hard water poured over them, and taking in exchange the calcium or magnesium from the water. This has been named the property of base exchange, and the result of the operation of passing hard water through this zeolite sand is that the sand becomes silicate of aluminum or iron and calcium or magnesium, while the water exchanges its carbonate or sulphate of calcium or magnesium for carbonate or sulphate of sodium or potassium.

The value of this material for water softening lies in the fact that the process is reversible, and that a solution of sodium chloride (common salt) poured over this changed mineral will take away its calcium and magnesium, replacing it with sodium and restoring the mineral to its original condition.

In practice these zeolites vary from, say, 20 grains to perhaps 200 grains of useful exchange capacity per pound, and the rate at which the exchange can be made also varies with the variety of sand. A gallon of water containing 20 grains of calcium carbonate can be softened to almost zero hardness by passing over one pound of the poorest grade of sand mentioned above, or can be equally softened by one-tenth of a pound of the best sand; and the speed of reaction can be calculated from the statement that a mass of, say, 12,000 lb. of the better grades of zeolite can be regenerated by salt solution in 15 minutes.

For water softening purposes, zeolite sand is arranged in a tank very much as is ordinary sand for filtering purposes. A mass of zeolite rests on a suitable foundation near the bottom of the tank, and water passes through it. When the softening capacity of the zeolite has been exhausted, the hard water stream is shut off and the sand is back-washed, for the purpose of cleansing and loosening the bed. Then a stream of common-salt water is passed through the zeolite for the purpose of restoring its charge of sodium base, the bed of sand is washed with fresh water, and the zeolite is ready for work.

The softening capacity of the mass of zeolite sand in the tank is measured by its weight multiplied by its availability per pound, and this determines how many gallons of water of specified hardness can be run through it before regeneration is necessary.

The treated water carries as much sodium bi-carbonate and sodium sulphate as there was bi-carbonate and sulphate of calcium and magnesium in the hard water, plus any sodium sulphate or chloride originally present, and the sodium carbonate equivalent of the free carbonic acid.

The simplicity of the plant and of its operation make this process very suitable for softening water for dwellings and for many industrial purposes where the use of water containing sodium bi-carbonate is not objectionable. The process has not been extensively used for locomotive boiler waters, presumably because so much loosely-combined carbon di-oxide tends to foaming and because there has been doubt in some quarters of the effect of concentrated sodium carbonate and caustic in boilers. Your Committee is not prepared to confirm either of above reasons and is now awaiting the results of tests being made.

From the constitution of the sand and the use of sodium chloride for regeneration, it is apparent that hard waters available for softening by this process do not include those carrying any considerable charge of iron, alumina or manganese, or of sodium chloride or sulphate, and the less calcium or magnesium bi-carbonate the better. It is evident also that turbid waters from streams, lakes or reservoirs cannot be treated without previous filtering because the zeolite sand would soon be clogged.

Several installations of zeolite softeners for large stationary boilers have lately been made; and the Southern Pacific Company is now testing at

Los Angeles, Cal., the suitability of this method of softening for stationary boilers, switch engines and road engines. By agreement with D. Wood, Engineer of Tests, your Committee has been furnished the result of the preliminary test on stationary boilers and switch engines. In both cases no anti-foam compound was used, and the boilers were not blown out until necessary because of foaming. The stationary boiler, averaging 184 per cent rated capacity and carrying 100 lb. steam pressure, ran 22 days continuously before it was necessary to blow out because foaming began at an alkali concentration of 4000 grains per gallon and sludge accumulation of 400 grains per gallon. The switch engine, evaporating 6000 gallons of water per day, did not require blowing out until the 6th day when alkali concentration amounted to 200 grains per gallon and sludge to 20 grains per gallon. It is evident at once that violent disturbance of the water in the boiler by sudden changes of direction of motion of the engine and by sudden changes of steam pressure incident to the work of switching, are the most important factors in the production of foaming and priming.

The Southern Pacific plant consists of two closed steel tanks, each 7 ft. diameter by 7 ft. high, containing zeolite; an open salt-solution tank 5 ft. diameter by 4 ft. high; necessary piping and valves; all well housed, and costing complete some $10,000.

The water treated is that supplied by the City of Los Angeles, containing about 11 grains per gallon of calcium and magnesium carbonate, nearly 4 grains of calcium and magnesium sulphate, and 5 of alkali sulphate and chloride. Each of the zeolite units can soften 28,000 gallons of this 15-grain water between regenerations, and then uses 7 lb. of salt per thousand gallons of water (or ½-lb. of salt per 1000 grains of hardness) for the regeneration of the mineral. The two units are operated at the same time, the total rate being 25,000 gallons per hour. Harder water would be treated more slowly, and would be less between regenerations. At present, water for flushing and regeneration amounts to 110 gallons per thousand gallons treated.

Salt costs $3.75 per ton in Los Angeles, and the cost of salt for treating this water is stated as 1¾ cents per thousand gallons. The price of salt in Chicago is $7.60 per ton and at least $8.00 per ton in outlying districts. The cost of treating a 15-grain water in this vicinity would be 3.6 cents per thousand gallons for salt.

The advantages of the zeolite method of water-softening are (1) the reduction of hardness to one grain per gallon, (2) the absence of solid sludge, (3) the elimination of after-precipitation, (4) the possibility of using an inclosed pipe system, (5) the small amount of technical attention necessary, (6) the comparative cheapness of the equipment.

The disadvantages are (1) that it substitutes sodium salts for all the calcium and magnesium salts which it removes, and therefore (2) can treat for boiler use only comparatively soft waters, and (3) these waters must be clean, free from acid, iron, aluminum and manganese, and almost free from sodium chloride and sulphate.

Summary

The method of softening by barium hydrate or barium carbonate and lime, leaves certain waters soft and clean, and does not increase the content of sodium salts.

The method of softening by soda ash and lime leaves any water soft and clean, and increases the sodium sulphate by the amount of original sulphate hardness.

The method of softening by zeolite leaves water soft and clean, but increased in sodium salts by the total original hardness, and for locomotive boilers the method can utilize only the simpler natural waters.

The method of treatment by soda ash applied to water in roadside tanks, leaves water which still contains carbonate of lime and magnesia which precipitates as sludge in the boiler; and the method is satisfactorily applicable only to the simpler waters.

The method of treatment by soda ash or any boiler compound applied to water in the engine tank, is always a palliative but is sufficient only in the simple waters.

Foaming and Priming in Boilers

In the matters of foaming and priming in boilers, the experience of members of this Committee and other authenticated records vary over such wide limits that it is not considered safe to make more than a general statement. It is known that the foaming limit of any boiler is affected by the kind and the amount of sludge, the concentration of alkali salts, the steam space in the boiler and the ratio of the rate of dry evaporation to the rate of steam consumption. We have made measurements of these relations on a few waters and boilers and kinds of sludge, and are continuing our investigation in the hope of learning something of general value.

Appendix F

(5) THE RELATIVE MERITS OF THE DIFFERENT METHODS OF DEEP-WELL PUMPING

H. H. Richardson, Chairman, Sub-Committee; R. A. Baldwin, J. M. Fitzgerald, P. M. LaBach, J. H. Knowles, F. J. Walter, F. D. Yeaton, E. M. Grime.

One of the common methods of obtaining suitable water supply for railroad requirements is by means of drilled or artesian deep wells. Surface supplies or shallow well supplies are not always available and in some cases a better quality of water from both sanitary and chemical standpoints can be secured from deep water-bearing strata. On account of the depth to reach these deep-well supplies and the limited space available for pump installation and operation, the surface types of pumps cannot be used and special deep-well pumping equipment must be installed. In general, the most common types of such pumping equipment are the deep-well reciprocating pump, the deep-well centrifugal or turbine pump and the air lift. For complete and detailed information of description and principles of the various types on the market, reference should be made to latest manufacturer's bulletins. The deep-well pumps consist primarily of three parts: the water end, preferably submerged or sufficiently close to water level to avoid loss of prime; the power end above ground or at least readily accessible, and the transmission line or driving mechanism connecting the power end with the water end.

The water end of the deep-well reciprocating pump consists of working barrel or cylinder, plunger and valves. The top of the working barrel is fitted with a coupling and attached to the lower end of the drop line or discharge line from the working barrel to the well head. The plungers are operated from the power end by working rods of wood or steel or a combination of the two. The power end or working head may consist either of a steam cylinder with piston rod direct connected to working rods and plungers or of a crankshaft or cams with connecting rods to working rods and plungers, the latter type driven by motor, steam engine, or internal combustion engine direct connected through reducing gears or belt driven through reducing gears. The deep-well reciprocating pumps are made in (1) single-plunger, single-acting type, (2) single-plunger, double-acting type, (3) double-plunger, single-acting type, and (4) triple-plunger, single-acting type.

The water end of the deep-well centrifugal or turbine pump consists of a horizontal turbine pump with a sufficient number of impellers or stages to deliver water against the required working head. The pump is coupled or flanged to the lower end of the drop line or discharge line to the well head. The impellers are operated from the power end by a steel shaft which passes through a stuffing gland and into the discharge line and extends through the discharge line to the pump. Guides are placed at intervals in the discharge line to keep shaft in proper alignment. The power end or driving head at the ground level supports the shafting to the pump and provides a housing for the thrust bearing and discharge elbow or tee. Driving power may be either vertical electric motor direct connected through a flexible coupling to shaft, or motor, steam or internal combustion engine belted to pulley on pump drive shaft. Where total head above the ground level is very large, a type of deep-well turbine pump can be secured with a built-in "Booster centrifugal pump" at the ground level connected to the vertical drive shaft.

The water end of the deep-well air lift pump consists of a nozzle or foot piece submerged sufficiently deep so that distance from water level in well when pumping to the foot piece is from 30 per cent to 60 per cent of the total distance from foot piece to point of delivery of the water. Compressed air is forced down a smaller vertical pipe inside the well casing and issues from the submerged nozzle or foot piece. Air bubbles are formed in the entire column of water in the well, which lower the specific gravity of the water column and cause it to rise assisted by the upward impulse of the bubbles. At the point of delivery, the air separates from the water and is freed. There are no working or moving parts in the wall. The power end of the air lift pump consists of an air compressor of suitable capacity and type for the services demanded. The compressor may be driven by motor, steam or internal combustion engine.

In considering the relative merits of the different methods of deep-well pumping, consideration should be given to the following features: character of the water; capacity of source of water supply; pumpage required; pumping head; first cost of complete installation of equipment; length of useful life; reliability; flexibility; efficiency, and cost of operation.

At locations where the water to be pumped from deep wells contains an appreciable amount of sand or gritty materials, the air lift pump will give the best and the reciprocating pump the poorest service. The air lift having no working parts is not affected to any large extent by such materials in the water. The leathers and valves in reciprocating pumps quickly require renewal under such conditions. The impellers and bearings of turbine pumps are worn by the gritty material and replacements or repairs are needed at intervals. The aerating effect obtained through use of the air lift pump aids in removal of iron and other impurities in the natural water. "Back-blowing" of wells with air to increase the flow and shut off the sand is also readily accomplished with an air lift pump installation.

Where the yield of a well is relatively small and strata is moderately deep, the reciprocating pump is most desirable. The turbine pumps are primarily large capacity pumps and are not suitable for low yields. If a single well will not furnish the pumpage required, and if wells are widely separated, the air lift is conveniently uesd at each well by piping compressed air from a central compressor station. For a given diameter well, the air lift will produce the largest yield.

If the water strata is capable of delivering large volumes of water, and the depth does not exceed 150 to 200 feet, the turbine pump will most economically produce the largest volume of water. The reciprocating pump will give satisfactory service at depths up to 300-400 feet, although at these depths the weight of rods requires large power heads and the delivery is limited to relatively small amounts. The air lift is limited as to depth only by the limitations of compressor; by installing stage lifts or auxiliary starting jets, the same compressor can be used for considerably greater depths. The air lift, on account of submergence necessary, requires a well hole of greater depth than the water-bearing formation, provided yield is low. The air lift with no working parts can be installed in wells which are considerably out of plumb and in which reciprocating or turbine pumps would not give satisfactory service.

The reciprocating pumps are made to fit in well casings from 5-inch diameter up to 30 inches diameter and are capable of yields from 20 gallons to 2500 gallons per minute. The turbine type pumps are made to fit in well casings from 6-inch diameter up to 24 inches diameter with yields ranging from 100 to 5000 gallons per minute. The air lift pumps are made to fit in well casings from 3 inch to 18 inches diameter with yields from 15 to 3300 gallons per minute.

In general, the first cost of the turbine-type pump is highest and first cost of air-lift pump including compressor but not prime mover is lowest. The direct connected motor driven turbine pump, however, requires less housing than either of the other two types.

As to reliability and length of useful life, the type and fitness of the pump for the service required are large determining factors. The air lift pump with no working parts below the ground is probably the most reliable, although the compressor unit may give occasional trouble. The centrifugal or turbine-type pump has fewer working parts to get out of order than the reciprocating pump. The high speed of turbine-pump shafting, however, demands careful alignment of shaft and attention to bearings. To insure reliability the pump must be of proper type to fit the conditions, must be of ample capacity, must be well designed and of stout construction. When the extra investment is warranted, a reserve unit of wells and pumping equipment should be provided; this is especially applicable to Terminals and other points where continuity of service is of utmost importance.

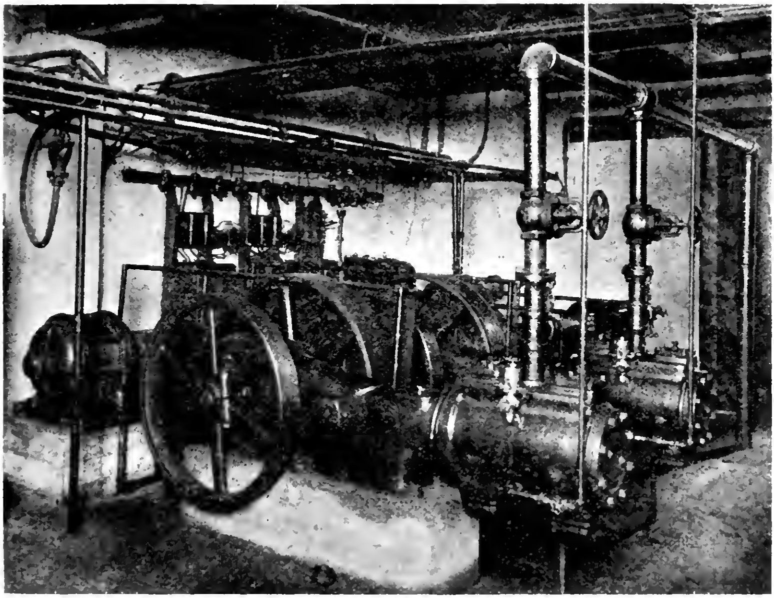
All three types of pumps are flexible to a certain extent. The reciprocating pump is the most flexible over a medium range of pumping yields with the least variation in pumping efficiency. The turbine type is most suitable for constant conditions of head and yields. The air-lift pump is flexible over a great range of heads and yields although the efficiency is altered considerably. The air lift pump can be most easily adjusted for increasing or decreasing the setting. The turbine type pump can be used to deliver direct into supply mains and is not injured by sudden closing of discharge. The air-lift pump cannot be successfully used for discharging into closed piping systems, but by application of booster tank the discharge can be raised to a reasonable elevation, air separated from water, and gravity flow used to mains. For fire protection, the turbine-type pump is most desirable as it furnishes a large quantity of water without pulsations. The air-lift pump alone cannot be used successfully for fire protection.

The reciprocating pumps, being of positive action, will yield a higher efficiency than turbine or air-lift pumps. Losses occur in turbine pumps on account of the high speed "churning" action upon the water while thermodynamic losses from compressed air cut down the efficiency of the air-lift systems. In general, efficiencies of the reciprocating pumps will reach 80 per cent under most favorable conditions, turbine pumps 65 per cent, and air lift pumps 35 per cent. On account of its low efficiency the air-lift pump is seldom used except under specific conditions which would make the other types of pumps unsuitable.

Under average conditions maintenance costs of the air lift systems will be lowest and reciprocating systems highest. Attendance costs are relatively the same. Each of the three systems can be operated automatically, if desired. As the pumping economy depends very largely on suitable pump and power equipment for given conditions, after choice of pump and equipment has been made and pump installed, tests should be run at convenient intervals to develop what changes, if any, have occurred in operating conditions. A record of all inclusive costs of pumping should be kept for ready reference and comparison.

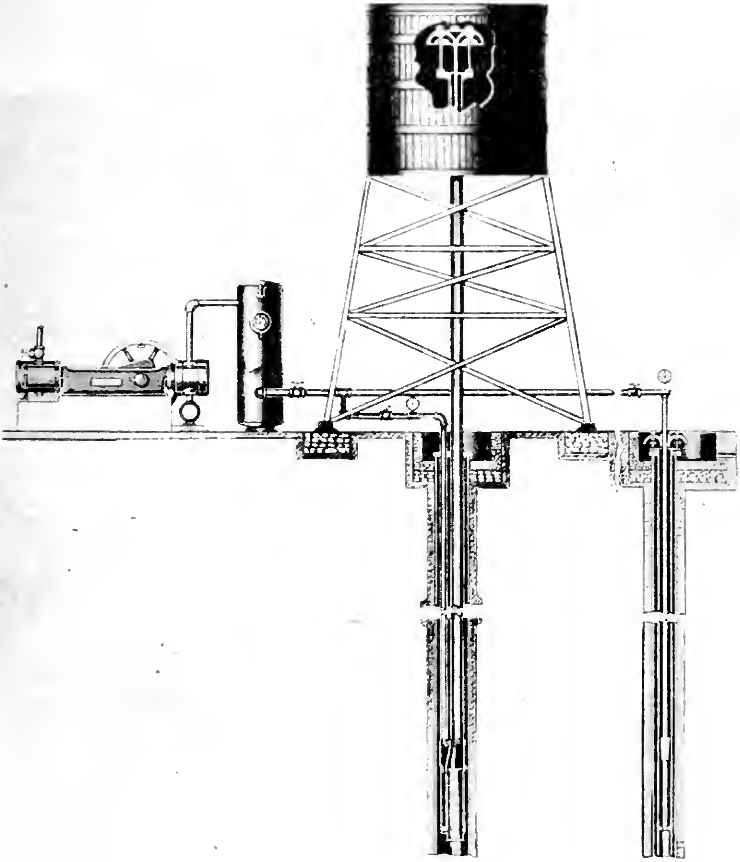
Conclusion

Each type of deep-well pumping equipment has its respective advantages and disadvantages over other types. To insure reliability and greatest over all economy, individual conditions should be thoroughly considered and analyzed before choice of equipment and purchase from reputable manufacturer is made.

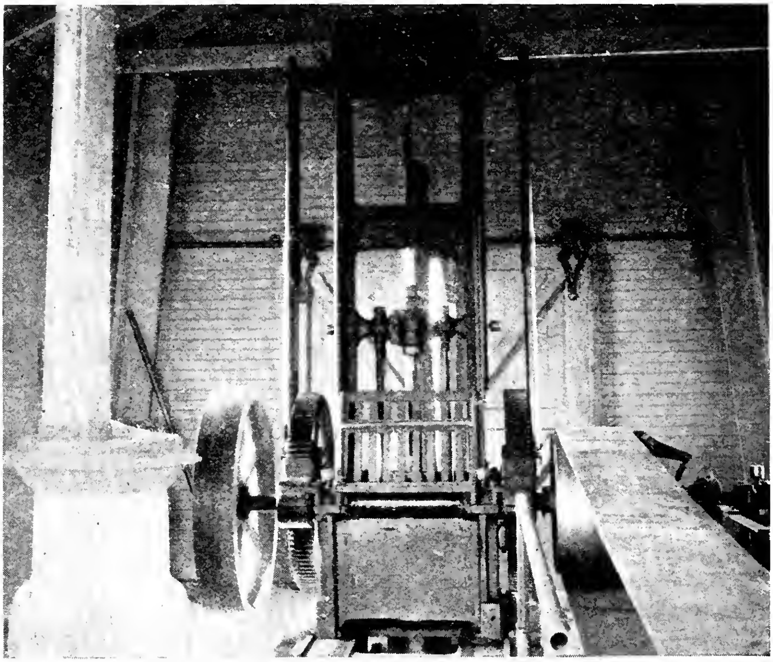


TWO 9 x 8 COMPRESSORS OPERATING DEEP-WELL AIR-LIFT PUMPS

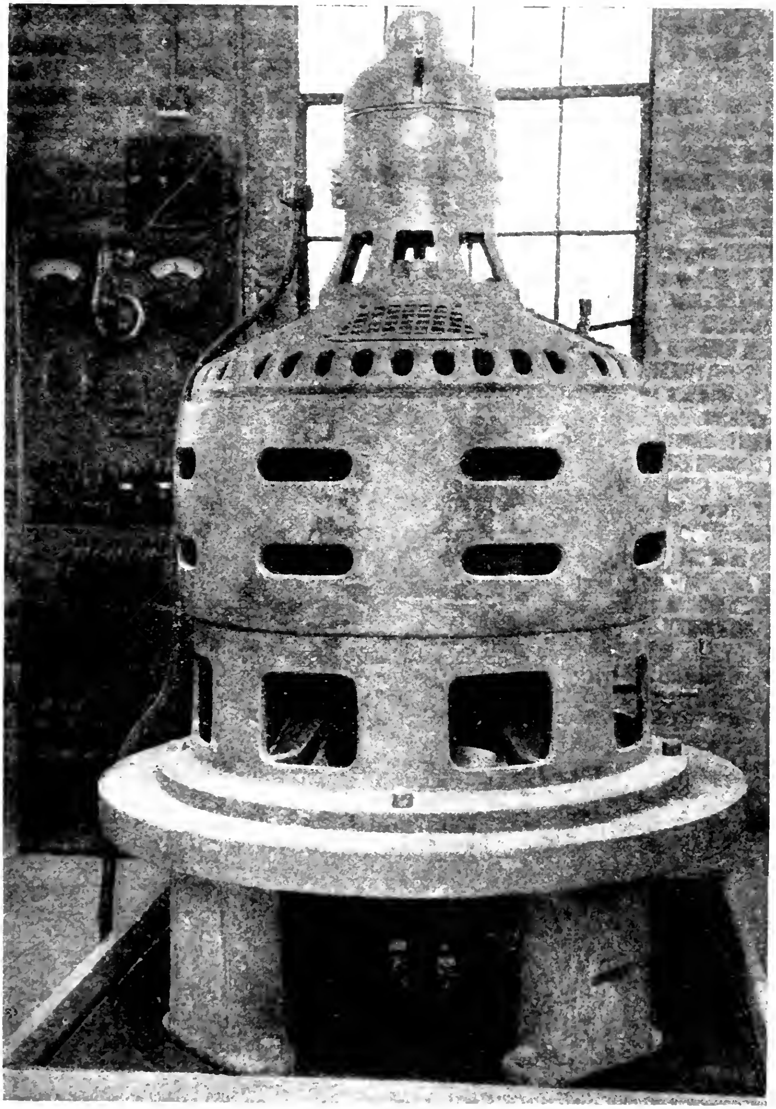
Air-Lift Discharging Into Tank Direct from Umbrella Top



Air-Lift Diagram



Power Head on Deep-Well Reciprocating Pump



Switch-Board and Motor on 750 9 p. m. Centrifugal Deep-Well Pump.

Brick Pump-House and Derrick for Motor-Driven Deep-Well Centrifugal Pump.

Appendix G

(6) THE DESIGN, CONSTRUCTION AND MAINTENANCE OF PIPE LINES

J. P. Hanley, Chairman, Sub-Committee; R. A. Baldwin, J. M. Fitzgerald, C. H. Fox, C. D. Johnson, J. H. Knowles, E. G. Lane, A. B. Pierce, F. J. Walter, F. D. Yeaton.

On page 625 of the 1921 Manual of the American Railway Engineering Association the following pipe lines are defined under water service facilities:

Intake Line.—A line of pipe conveying water by gravity from the source of supply to the intake well.

Suction Line.—A line of pipe through which a pump draws its supply.

Discharge Line.—A line of pipe through which water is forced by action of the pump.

Service Line.—A pipe line through which water is distributed.

Your Sub-Committee has confined their investigation to these four classes of pipe lines and wishes to report on the Design, Construction and Maintenance of each class separately.

The Committee presents, as an Addenda to this report, an interesting monograph, prepared by Mr. F. J. Walter, a member of the Committee, entitled "Flow of Water in Pipes."

Intake Lines—Design

The intake line may be classed as a flow line, as it conveys water by gravity from the source of supply to the well. It operates under a low head and its cross-sectional area should be sufficient to convey the required quantity of water at a velocity not exceeding two feet per second, as an excessive velocity creates currents near the exposed end of the pipe and these currents convey floating débris into the well.

In placing intake lines in rivers it is advisable to turn the pipe slightly down stream or to place a bend on the river end of it to decrease the likelihood of floating débris lodging in the pipe by the force of the river current. In rivers or other waters containing floating débris, some railways use a box screen having an area three to four times greater than the pipe area, and some railways use a round cone-shaped screen of similar ample surface area with satisfactory results. But where the débris is of such character that it may adhere to a screen, no screen should be used on the exposed end of intake or suction pipes unless provision is made for raising or otherwise cleaning this screen. Where possible, the screen should be located in the intake well in such a way as to be accessible for cleaning under high or low water conditions.

It is preferable to lay the intake line in a level position, and this grade should be true and uniform, as sags or traps in the line may collect deposits of sand or muck and allow same to build up to the bottom of the true flow line, thereby decreasing the working area of the pipe. A gate valve should be placed on the well end of the intake pipe with a valve rod extension above high water, for closing the intake line when necessary to clean the screens or foot valves which may be located in the well.

While almost any kind of pipe manufactured may be used for intake lines, we believe that the use of bell and spigot cast-iron pipe with joints of lead or composition or the use of wrought iron pipe with standard joints, is preferable, as such pipe is very durable and heavy enough to resist current and wave action to good advantage.

The design of intake pipes is usually simple for the average railway pumping station, as these intake lines seldom exceed 100 feet in length. The diameter of intakes under these conditions should be 12 to 14 inches for a flow of 500 to 1000 gallons per minute, as these sizes are sufficient to convey these water flows without objectionable currents, even after allowing for incrustations and deposits which may form in the pipe lines.

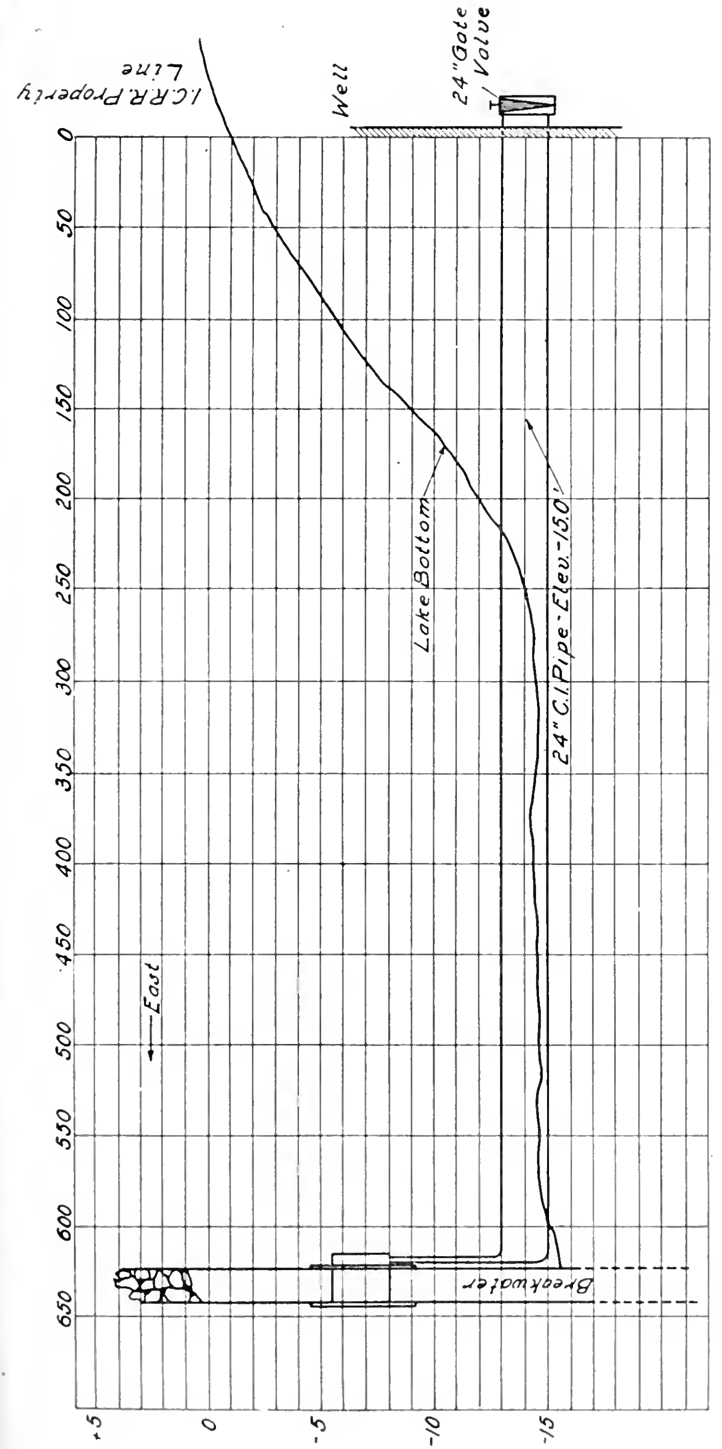
However, there are some intake lines which are more difficult to design. One of these was a 24-inch intake line recently installed by the Illinois Central Railroad at Chicago. This intake pipe is 650 feet long and extends from a well on the old shore line of Lake Michigan to the new shore line recently constructed. It was laid in water 15 feet deep and will be eventually covered by 25 feet of fill when this section of the lake is converted into a park. It is composed of 24-inch diameter Class "B" bell and spigot and ball and spigot cast-iron pipe. A ball joint was placed each 48 feet of length, which allowed for settlement and wave action without damage to the pipe, and also provided sufficient flexibility to allow the end of the last section laid to be raised above the water line for jointing to the next section and the lowering of both sections to the lake bottom, where the pipe was finally inspected and leveled by a submarine diver working from the floating equipment which handled the pipe. Plans and profiles of this intake line are shown.

If the source of supply is in navigable waters in the United States, the approval of the United States Army Engineer in charge of the district in which the work is located should be obtained, and this approval will usually include some regulations as to the depth of the pipe below mean low-water level.

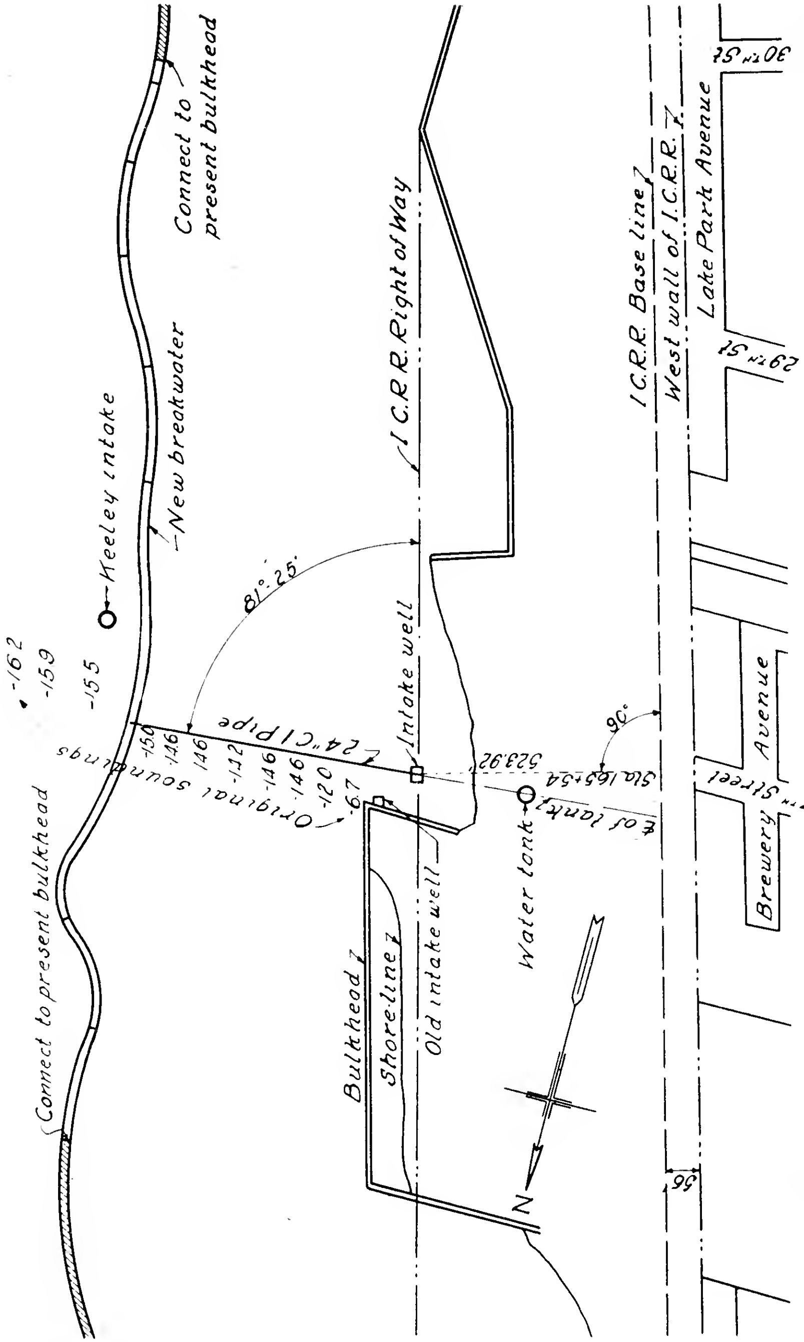
In cases of this kind unusual care should be taken in locating and constructing the line so that it may resist wave action and not be damaged by passing ships. A crib is usually constructed at the end of such intakes and the pipe secured to same by hook bolts and straps. A typical plan and section of an intake in navigable waters is shown.

Intake Lines—Construction

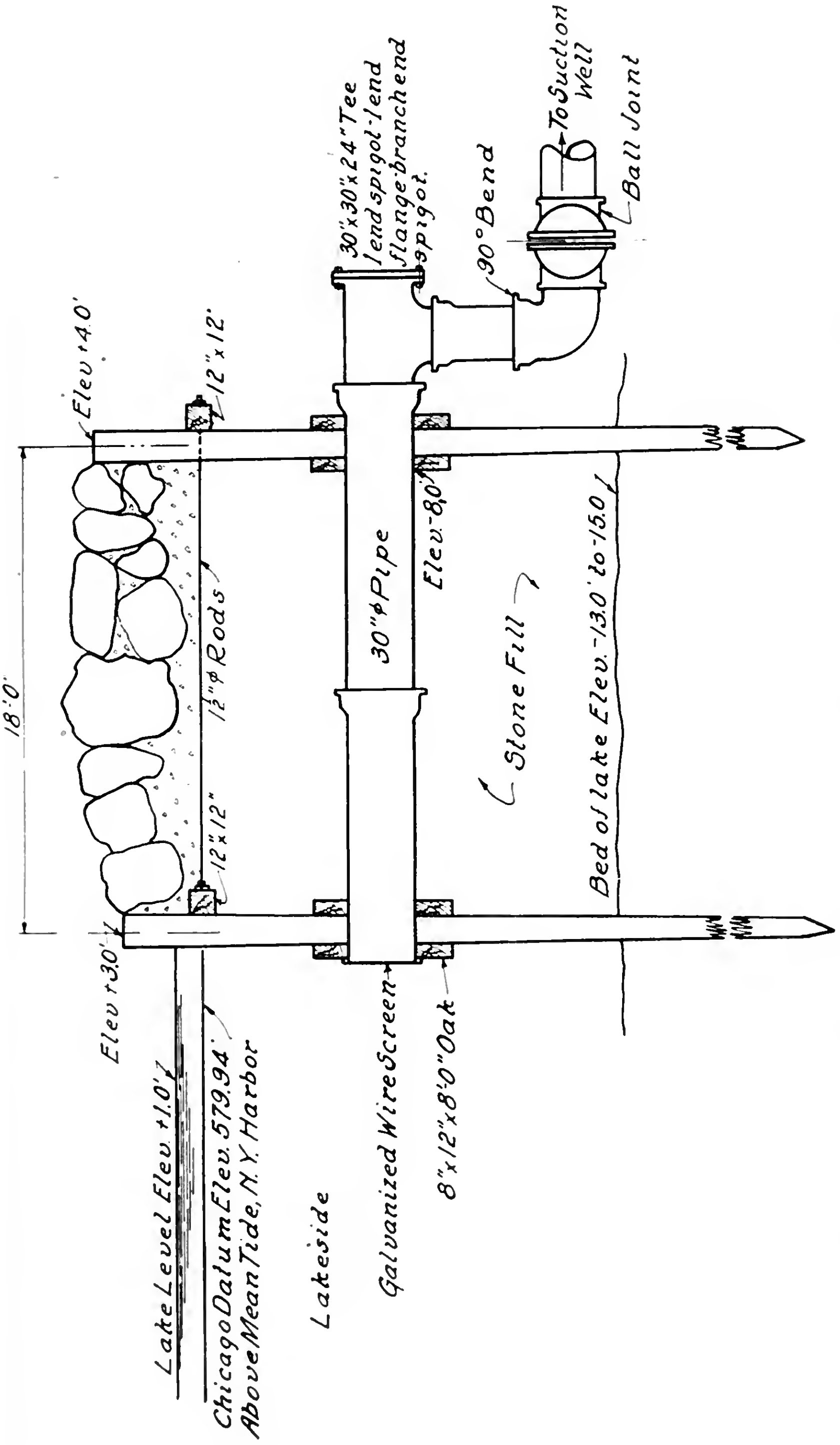
Where the water is shallow, the pipe may be installed by sectional trenching or light cofferdam work. Where the water is deep and the length to be laid considerable, the use of floating barges, derricks and other



Profile Showing Elevations of Illinois Central Railroad Intake at 27th Street, Chicago. Elevations are Expressed in Feet and Represent Chicago City Datum.

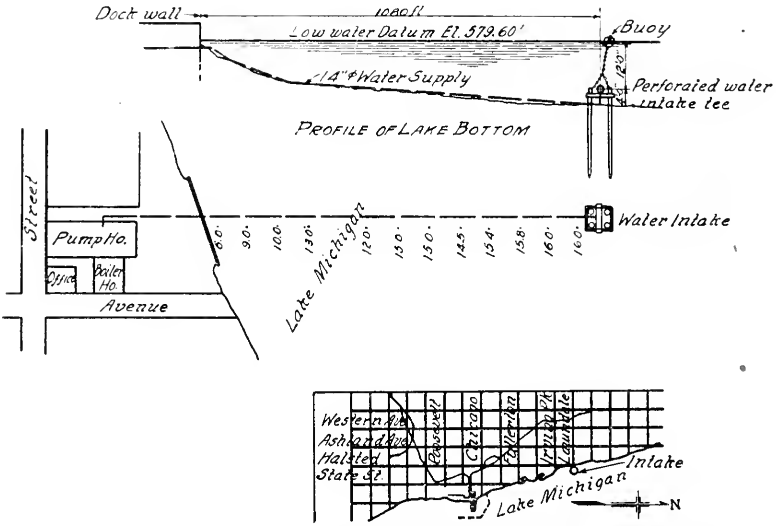


Plan Showing Illinois Central Railroad Intake at 27th Street, Chicago. Elevations are Expressed in Feet and Tenths and Represent Chicago City Datum.



Section Through Breakwater of Illinois Central Railroad Intake Pipe at 27th Street, Chicago. Elevations are Expressed in Feet and Represent Chicago City Datum.

equipment is usually economical or necessary. Some photographs are shown illustrating the latter method of construction which was recently used by the Illinois Central on the installation mentioned above. The joints in the cast-iron intake lines should be constructed of lead, lead wool, or composition in the usual manner of pouring and calking. The design should, wherever possible, provide for these joints being made above the water line or in a water-free trench or cofferdam, as the making of the joints can then be checked more thoroughly than if they are installed under water by a diver.

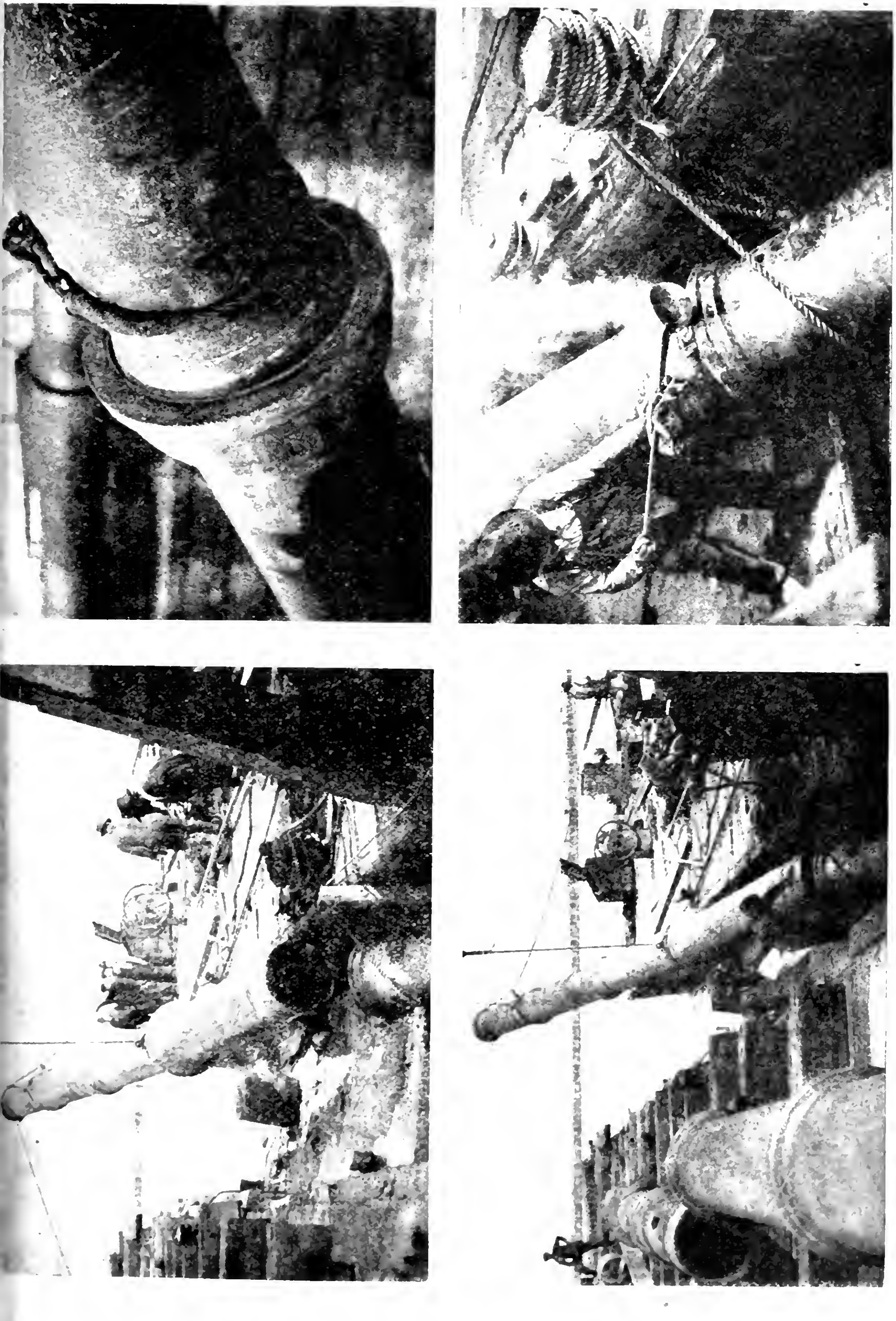


Typical Layout of Intake Line and Crib in Navigable Waters. Elevations and Soundings are Expressed in Feet and Tenths and have Reference to Low Water Datum 579.6 Above Mean Low Tide, New York.

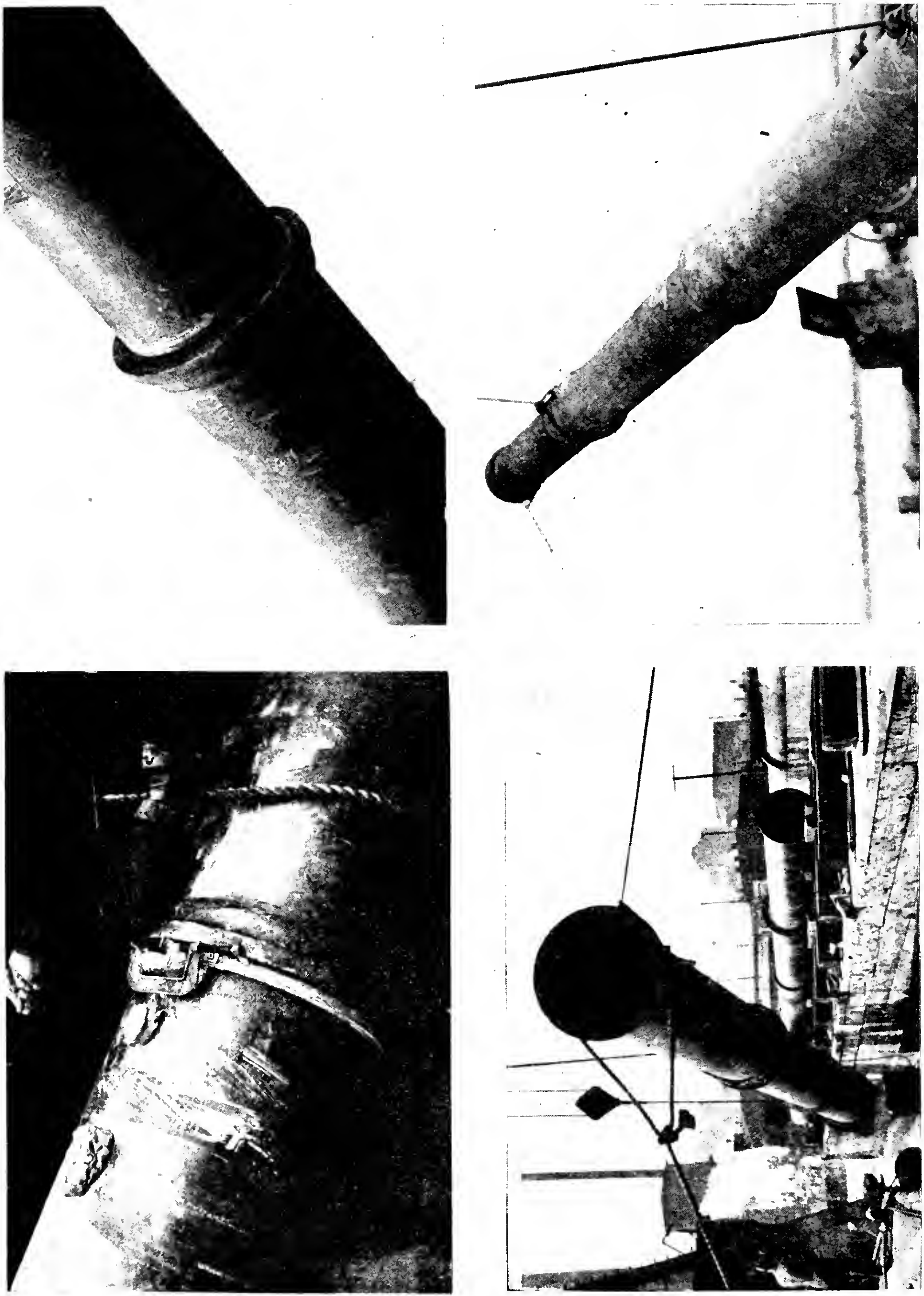
Intake Lines—Maintenance

Intake lines constructed of sound material and in accordance with good design require little maintenance, except where it is necessary to clean sand, ice or débris from them. When this is necessary the conditions requiring attention should be made as accessible and as easily handled as possible.

In some cases it has been found satisfactory to back wash intakes and intake pipe lines with water piped from the pumping station. In this case a head of water is accumulated in the intake well by closing the gate valve on the intake line, then opening the valve quickly and flushing and jetting the material backward to the outlet. In other cases the use of a small dredging bucket with a capacity of 2 to 3 cubic feet operated either by hand or power methods has been found very useful in baling the accumulated material from the intake.



Illustrating Method Used for Pouring Joints on Intake Pipe for Illinois Central Railroad, at 27th Street, Chicago.



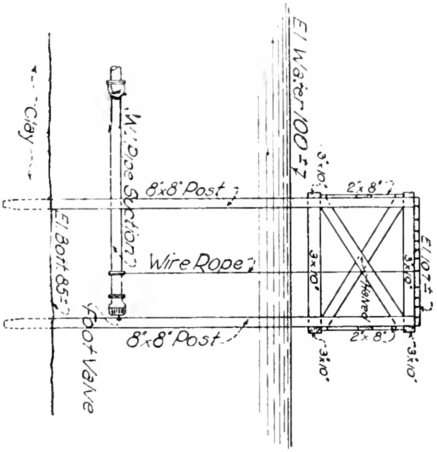
METHOD USED IN INSTALLING 24-INCH INTAKE PIPE FOR ILLINOIS CENTRAL RAILROAD, IN LAKE MICHIGAN, AT 27TH STREET, CHICAGO.

Suction Lines—Design

A suction line is a line through which a pump draws its supply. The suction line may enter the source of supply direct or it may obtain water from an intake well. For reservoirs, or lakes and rivers where there is little wave action and a small amount of floating débris it is satisfactory to have the suction pipe enter the supply direct, but in bodies of water having severe wave action, considerable amounts of floating débris, or as a method of frost protection, the intake well is recommended.

Suction lines should be as short as possible and of such size or cross-sectional area that when the pipe line friction is added to the static suction lift the total of both will be easily within the suction lift capacity of the pump and if possible should not exceed 15 feet.

In centrifugal pump installations it is necessary to install either a foot valve or check valve on the bottom end of the suction line, but in reciprocating pump installations these valves are not usually necessary, except where the suction lift is excessive. Where such valves or where a screen is installed, arrangements should be made for removing the débris which will usually accumulate on them. This can be done by having a flange connection in the pipe above the water line and near the foot valve or by installing a crib or framework near the end of the suction pipe when same enters the water direct; in the latter case a hinge joint should be installed near the end of the suction pipe so that valve and pipe can be lifted above the water line for giving the screen or foot valve necessary attention. A profile of such a crib is shown.



Typical Section Showing Crib and End of Suction Pipe in Reservoirs. This Arrangement is Useful in Clearing Debris from Foot Valve Screens.

In making the connection between suction pipe and pump where the pipe is necessarily one or two sizes larger than the suction opening on the pump, the connection should be made by a reducing elbow or an eccentric tapered reducer with the straight side up or in some other manner that will prevent a depression in the top of the flow line at this point and thus prevent the collection of air in the upper portion of the suction pipe.

Suction Lines—Construction

We believe that genuine wrought iron pipe with screwed joints is the best pipe for suction lines. Flanged wrought iron, flanged cast-iron and bell and spigot cast-iron pipe may be used, but there is less danger of small air leaks in the screwed wrought iron pipe joint than any of the other joints, especially where the pipe is subjected to vibration or settlement after installation. The objection to the use of wrought iron pipe is that it is less durable than cast-iron, but this can be largely overcome by painting the exterior of the pipe with a coating of hot pitch and tar and wrapping with burlap after the manner of gas pipe services where the soil conditions warrant this treatment.

Special care should be taken in making all screwed and flanged joints. Threads, bolts and gaskets should be carefully placed and fully and uniformly wrenched and drawn together. Red lead should be used on the male threads and all exposed threads painted with it after the joint is screwed together.

All horizontal sections of suction lines should be laid with a slight grade (about three inches per 100 feet) toward the source of supply. This grade should be true and uniform and the earth rammed underneath the pipe to prevent local settlements after backfilling, as sags in the line will allow air to collect and thus impair the efficiency of the suction line and pump.

Suction Lines—Maintenance

If suction lines are laid of screwed wrought iron pipe on a true grade there will be little maintenance on them. If bell and spigot cast-iron pipe is used, there may be some maintenance required in calking leaks. Suspected air leaks may be located by by-passing water pressure from the discharge side of the pump into the suction. Most of the maintenance will occur on the foot valves in cleaning debris from same and in applying new valve leathers.

Discharge Lines—Design

As this is the pipe through which water is forced by the pump, it is not necessary to lay it at as true a grade as is desirable in intake and suction lines, but it may follow the grade of the land. However, it is best to lay the pipe on as straight a line and on as easy a grade as cost conditions permit and to eliminate as many bends and fittings as possible. The use of 22½-degree bends should be given preference over 45-degree bends, and 45-degree bends used if possible instead of 90-degree bends, and where a slight turn is required and conditions permit, the line should be changed by slightly cramping one or more joints instead of using any bends. Each twelve-foot length of cast-iron pipe can be offset not to exceed four inches from a straight line without impairing the joint, and this method should be used where slight changes of line or grade are required in the pipe line instead of using fittings. The pipe line should be laid close to the right-of-way line so as to clear as far as possible all future track and building construction.

At the point where the pipe connects to the pump a swing check valve and gate valve should be installed and another gate valve placed near the roadside tank or discharge end of pipe. If the pipe line is laid in hilly or rolling country, air valves to relieve air-binding should be installed at the summits and blowoff valves to discharge sediment located in the valleys. These valves should be inspected, maintained and operated on a regular schedule and not neglected.

The use of gate valves in the discharge line at one-half mile intervals or other suitable locations is advisable if sectional control of the line is desired.

The relative merits of cast-iron, steel, wood and other materials for pipe lines have been reported by this Committee in a report appearing in Volume 24, 1923, and railways interested in such materials for special locations can refer to that report for detailed information. The economical size of the discharge line will be such that the interest on the first cost, plus depreciation and plus cost of pumping against the friction head, will be a minimum. The cost of pumping against the friction head should be determined upon the basis of the water horsepower hours required per year to overcome the loss in friction and the approximate cost of pumping per water horsepower hour was reported by this Committee last year in a report dealing with the relative economy of pumping water by steam, oil and electricity. This report appears in Volume 26 of the Proceedings.

Discharge Lines—Construction

We find that this part of our subject has been covered by the following reports of this Committee to the Association, the reports appearing in the Proceedings as follows:

Volume 24, 1923.—Specifications for contracting railway water facilities, in which recommendations are made for trenching, laying and calking cast-iron pipe.

Volume 23, 1922.—Specifications for cast-iron pipe and special castings, in which recommendations are made that the A.R.E.A. adopt the specifications of the American Water Works Association on this subject.

Volumes 25 and 26, 1924 and 1925.—The use of lead as compared to substitutes for joints in cast-iron pipe lines.

Discharge Lines—Maintenance

If discharge lines are laid of the proper class and grade of pipe with good joints and protected from vibration and water hammer, there will be very little maintenance on them, as the material itself is durable and depreciates slowly.

The maintenance expense will be greatest in repairing leaks which usually occur under tracks, and we believe that it is advisable to protect pipe lines by a conduit when such lines pass under switches or tracks which make repairs frequent and expensive. This conduit may be composed of concrete or cast-iron culvert pipe through which the water line is laid, or may be composed of timber or masonry. The conduit should be of such design and of sufficient size and inside clearance to permit the calking of leaks, which may occur even under the best conditions.

After repairing leaks the cleaning of the interior of the pipe is of considerable importance and we find that this item has been investigated and reported by this Committee to the Association in a report appearing in Volume 22, 1921, of the Proceedings, entitled "The Extent and Effect of Incrustation in Pipe Lines," "Cleaning Water Mains at Belle Plaine, Iowa," and "After Precipitation from Treated Water—Its Causes and Prevention." We would also like to call attention to the report of Mr. Charles Haydock on the "Cleaning of Cast-Iron Water Pipe Lines," which report appears in Volume 11, No. 3, May, 1924, of the Journal of the American Water Works Association, and describes the benefits derived from such cleaning by the City of Philadelphia on sections of their municipal watermains. The delivery was increased 30 to 40 per cent and the pressure at the point of delivery also increased.

Gravity Lines

Where favorable conditions exist, it is often found desirable and economical to secure a satisfactory water supply by gravity from an impounding reservoir at a sufficient elevation above the point of use. In all such cases care must be exercised in locating and laying the pipe line to see that no portion of it lies above the hydraulic gradient. If any portion of the pipe line lies above the hydraulic gradient, the pressure at this point will be less than atmospheric, with the consequence that air may accumulate in the line and affect the quantity of water delivered and may even result in a complete stoppage of the flow.

Service Lines

The design, construction and maintenance of service lines is similar to discharge lines. We have found, however, that cast-iron service pipe in sizes 1½ inches, 2 inches and 3 inches is being placed on the market. This pipe is made with screwed, calked and flexible bolted joints, and we believe that the use of this pipe for service lines of these sizes will give a cheaper and more durable installation than wrought steel or wrought iron standard screwed pipe, especially where the soil contains pitting or corrosive elements.

Pipe Coatings and Linings

The standard specifications for cast iron pipe and special castings of the American Water Works Association specify that cast-iron pipe shall be coated inside and out with coal tar pitch varnish, in which the pipes and castings shall be immersed at a temperature of 300 degrees Fahr.

This coating is satisfactory except in regions having corrosive water such as is sometimes found in the New England states. For waters of this kind cement-lined pipe is beginning to be used in municipal water service and your attention is called to an article entitled "The Development and Manufacture of the Modern Cement-Lined Service Pipe," by Reeves J. Newson, Commissioner of Water Supply, Lynn, Mass., appearing in the February, 1925, Journal of the American Water Works Association. This article indicates that the cement lining for pipes and fittings is better and more economical than lead or tin lining for conveying corrosive waters.

The use of a protective coating for small wrought iron service lines is sometimes necessary where the soil contains pitting or corrosive elements and a very good coating can be made by painting the outside of the pipe with a pitch and tar paint heated to 300 degrees Fahr., then wrapping with burlap strips and coating the outside of the burlap with the same paint, after the manner that gas companies use in protecting their gas services in streets.

General

On account of the extent of the subject, the variations in local conditions, financial ability of the roads and personal ideas of the Engineer, we have tried to make our report expressive of sound practice rather than complete detail, but we would like to refer any members of the Association interested in more detail to the following list of articles and reports dealing with pipe lines, which have appeared in various issues of *Railway Engineering and Maintenance.*

1921

Patching Leaks in Water Mains.—A description of approved methods. January. Page 28.

A Time Saving Pipe Chart.—A description of a short cut method of determining cost. April. Page 147.

Rebuilding an Unusual Wood Stave Pipe.—A description of the El Paso's method. August. Page 277.

Laying Cast-Iron Pipe.—A debate on best practice. August. Page 305.

Incrusted Pipe Lines Cause Heavy Losses.—A description of this condition and relief work on the Illinois Central. May. Page 175.

The Proper Size of Pump Suctions.—A development of the relation between suction and discharge sizes. October. Page 363.

The Detection and Repair of Leaks in Water Mains.—An abstract of a special Committee's studies with discussion. November. Page 410.

1922

The Effect of Air on Pump Suctions.—An explanation from a technical standpoint. June. Page 215.

Water Works Intakes.—A discussion on the methods of protection. July. Page 248.

Testing Pipe Lines.—A discussion of problem and practice. November. Page 399.

1923

Air Relief Valves on Water Lines.—A discussion of best practice in design. January. Page 33.

The Protection of Pipes Penetrating Walls.—A discussion of prevailing practice. February. Page 75.

Laying Pipe Underground.—A discussion of preferred methods from the viewpoint of several engineers. March. Page 132.

The Proper Arrangement of the Supply Line on Water Tanks.—A discussion of preferred practice under various conditions. March. Page 164.

Flanged Pipe for Pump Suctions.—A discussion of conditions for which such material is suited. June. Page 247.

Cost of Digging Pipe Line Trenches.—A determination of value for various depths and sizes. June. Page 249.

Laying Pipe to Curves.—A determination of the maximum curves for various pipes. July. Page 285.

A Double Purpose Pipe Line for Water Tanks.—A discussion on recommended practice. December. Page 499.

1924

Two Railroads Find Water Main Cleaning Profitable.—A description of recent work on Northern Pacific and Rock Island Railways. February. Page 64.

Locating Obstructions in Water Lines.—A description of proved methods for various conditions. May. Page 199.

Cleaning Water Mains Yields Large Returns.—Methods used by the Pennsylvania System. September. Page 359.

Thawing Pipe Lines with Electricity. A discussion of conditions under which such work can be done. December. Page 501.

Conclusions

(1) We consider cast-iron pipe to be generally preferable to other classes of material for pipe lines except suction lines.

(2) We consider genuine wrought iron pipe with screwed joints generally preferable for suction lines.

(3) We recommend the use of air valves on summits and blowoff valves in the valleys, for discharge and service lines laid through a rolling country.

(4) We recommend the encasing of important water mains in larger pipes or conduits where such mains are laid in congested railway yards or at locations where it is impossible to space the pipe joints clear of the tracks. This conduit should be of such design and have sufficient clearance to allow calking of possible leaks in the main.

(5) We recommend that cast-iron pipe be given consideration for service lines in sizes 1½ inches to 3 inches, which sizes are now usually laid with screwed wrought steel or wrought iron pipe.

(6) We recommend the specifications of the American Water Works Association for the manufacture of cast-iron pipe and special castings.

(7) We recommend piping water from the pumping station to the intake for flushing it or the use of a small dredging bucket operated by hand or power methods for baling débris from it, as good methods for keeping intakes cleaned.

FLOW OF WATER IN PIPES

By F. J. Walter, Assistant Engineer, Nashville, Chattanooga & St. Louis Railway.

The determination of the proper and economical size of pipe lines in connection with railway water supply facilities is dependent very largely upon the frictional losses. A number of formulæ for the calculation of these losses have been advanced by various experimenters; however, these formulæ are practically all of the same general form and differ only in the exponents used. As the calculation of these losses is often quite laborious, charts have been prepared from which they can be readily determined, both for straight pipe and standard elbows and tees. The charts cover only those sizes of pipe which are usually encountered in railway water service work.

The chart showing the friction loss in new cast-iron pipe is based upon the Hazen and Williams formulæ and assumes average water conditions, and that the pipe line is well laid. On the righthand side of this chart another series of curves have been plotted showing age factors to determine the loss in pipe lines of any size. This factor is simply a multiplier to be used with the loss for new pipe. For example, the frictional loss in 8-inch pipe 15 years old is 1.6 times that shown for new pipe. These age factors have been determined upon the assumption that the increase in loss of head on account of tuberculation amounts to three per cent per year, and that this tuberculation decreases the diameter of the pipe at the rate of one-hundredth of an inch per year.

The Hazen and Williams formulæ is a modification of the well-known Chezy formula. It is believed that it gives values which more nearly represent average conditions than do the earlier formulæ. With any of these formulæ, it must be remembered that the results are approximations only, based upon the results of a vast number of experiments and represent average conditions. Individual cases may be encountered which differ from these calculated results.

In the construction of new pumping facilities, we are principally concerned with the determination of the pumping head at some future date, so that ample power may be provided to take care of future operating conditions. In such cases, it is the usual practice to determine the frictional losses for a pipe line from 15 to 20 years old. In using the charts in such instances, it will be found that an age factor multiplier of 1.63 will give the losses for pipe lines varying in age from 13 to 20 years, depending upon the size of the pipe used.

In certain instances it will be found advisable to make further allowances for the character of water to be handled. Experience has demonstrated that with waters of low alkalinity, tuberculation increases at a much more rapid rate than the average and in such cases the age factor must be increased. On the other hand, where cement-lined cast-iron pipe is used, it has been found that the rate of tuberculation is very materially retarded.

On the chart showing age factors, lines have been drawn for various values of the coefficient "C" in the formula used. These charts are thus applicable to pipe lines of other material, such as wood stave, or riveted steel, as well as uncoated cast-iron and centrifugal cement-line cast-iron pipe, by using the multiplier corresponding to the proper value of "C" for the particular material. These values of "C" may be considered as follows:

For cement-lined cast-iron pipe, "C" = 135 to 140.
For wood pipe, "C" = 130.
For riveted steel pipe, "C" = 110 to 120.
For uncoated cast-iron pipe, "C" = 120.

Unfortunately a comparatively small number of experiments have been made in the past to determine the loss of head through bends and fittings and of these by far the greater number have been made using small malleable iron, short radius, screw-end elbows and tees, so that the results are not strictly applicable to standard cast-iron fittings of the larger sizes and greater radius as used in present-day pipe line construction.

Graphs have been prepared showing the losses through standard elbows and tees. These graphs are based upon experiments made by Alexander, Williams and Brightmore, using cast-iron fittings ranging in size from three inches to thirty inches, and give results which probably more nearly approximate the actual losses through this class of fittings than do the results obtained through the use of formulæ based upon experiments made on small size fittings of extremely short radius.

Appendix H

(7) DESIGN AND CONSTRUCTION OF WATER STATION BUILDINGS

E. M. Grime, Chairman, Sub-Committee; R. A. Baldwin, J. M. Fitzgerald, J. P. Hanley, C. D. Johnson, J. H. Knowles, A. B. Pierce, F. J. Walter, F. D. Yeaton.

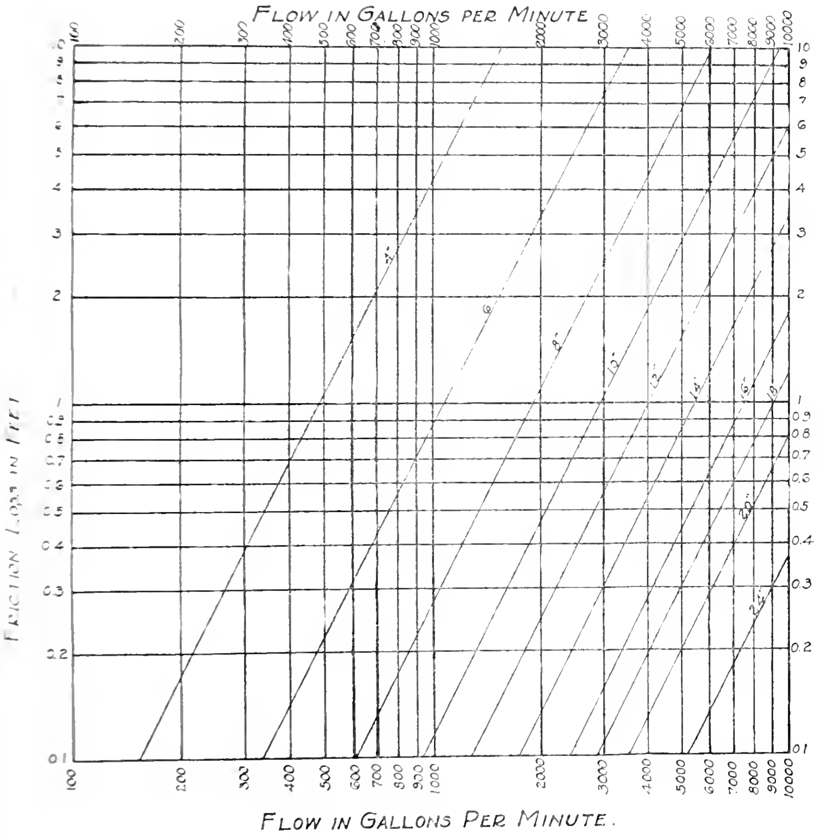
The water supply of a railroad is such an important facility that it is usually desirable to house the mechanical equipment required for this service in substantial buildings. Any interruption to the continuous supply of suitable boiler water is a serious matter as regards efficient operation, and as machinery in duplicate is often considered necessary in order to avoid possible delays, as a general rule it seems equally desirable to house this equipment in buildings of fireproof construction.

The equipment in general use consists of:

1. Pumping plants operated by steam.
2. Pumping plants operated by internal combustion engines.
3. Pumping plants operated by electric motor.
4. Pumping plants at deep wells and operated by steam, oil engines, electric power, or compressed air.
5. Water treating plants.
6. Suction and intake wells.
7. Pumpers' cottages.

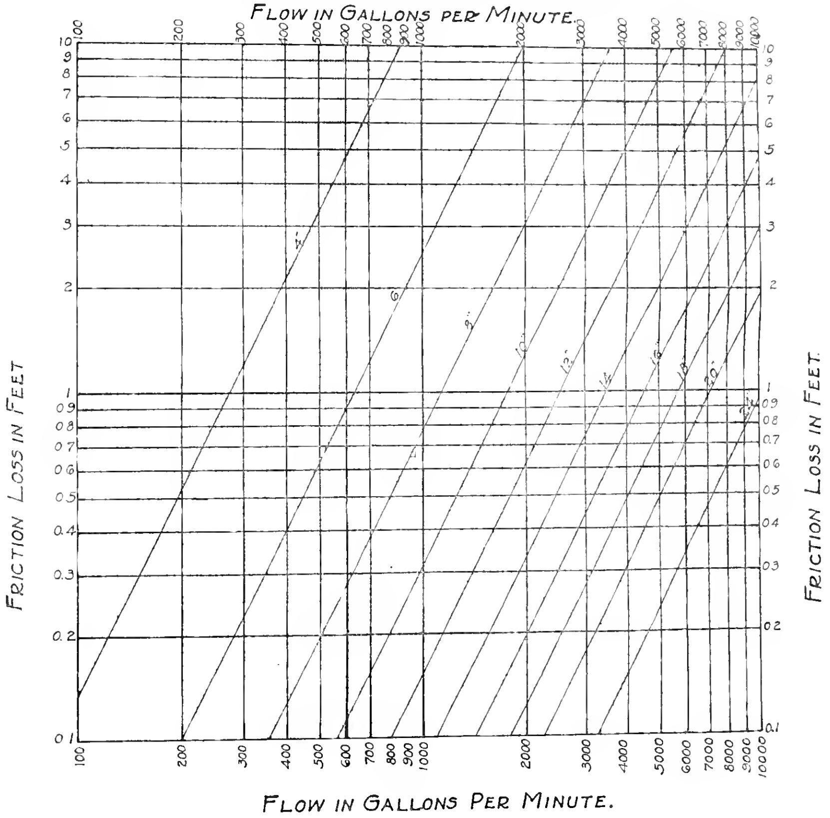
Friction Loss in Cast Iron Tees and 90 degree Elbows.

90 degree Cast Iron Elbows.– (A.W.W.A Standard)



Cast Iron Tees–(A.W.W.A. Standard).

Also Standard Screwed and Flange 90 degree Elbows



FRICTION LOSS IN NEW CAST IRON PIPE SHOWN IN FEET PER 1000 FEET OF PIPE

BASED UPON FORMULA $V = C r^{0.63} S^{0.54} 0.001^{-0.04}$ AND $C = 130$

TO DETERMINE FR[illegible] FOR PIPE OF ANY AGE, MULTIPLY VALUE GIVEN ON CHART BELOW BY PROPER FACTOR SHOWN ON CHART ON THE RIGHT

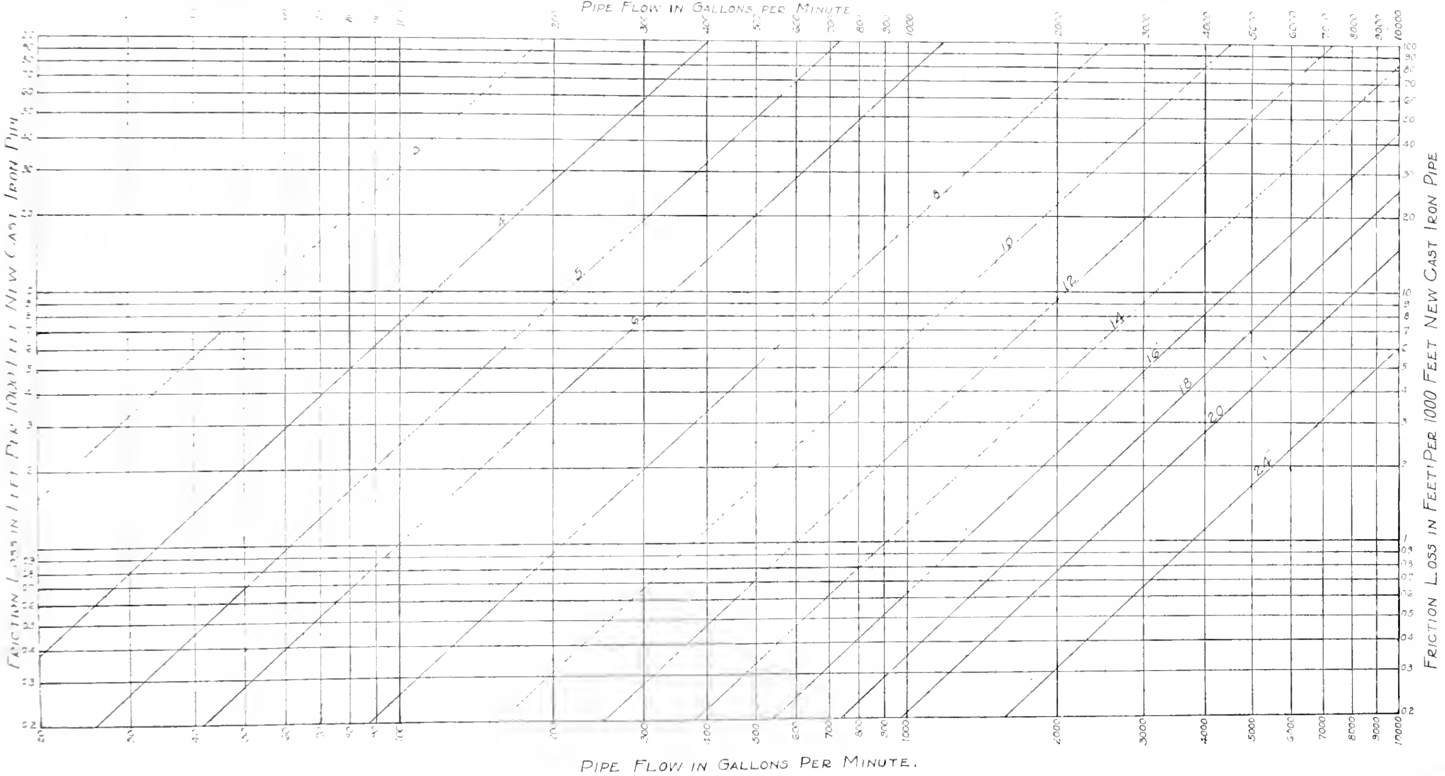
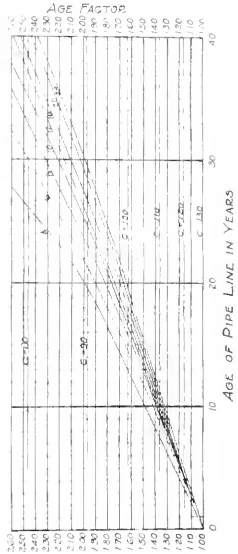


CHART TO DETERMINE FRICTION LOSS IN PIPE LINES OF VARIOUS AGES



FACTOR TO BE USED AS MULTIPLIER WITH FRICTION LOSS IN NEW PIPE TO DETERMINE LOSS FOR PIPE OF ANY AGE SHOWN

VERTICAL LINES SHOW VARIOUS VALUES OF "C" IN FORMULA $V = C r^{0.63} S^{0.054} 0.001^{-0.04}$

STEAM PLANTS

While steam plants as a rule are being displaced by internal combustion engines or electric motors, their use in some locations is still desirable. It usually is most convenient to store the fuel supply in a room partitioned off adjacent to the boiler, and where this is done the total size of the structure required for the ordinary installation may be about 16 ft. by 28 ft. with side walls 8 to 10 ft. high, and a gable roof. Usually steam plants are installed at outlying points where steam is needed for other purposes, such as for heating coaches or buildings or where little water is required, and being considered somewhat of a temporary expedient, are housed in frame buildings. A concrete foundation and a brick or concrete floor is necessary and the roof should be covered with asbestos shingles or corrugated iron in order to reduce the fire risk to the minimum. In the colder climates it is desirable to ceil the interior of the building and provide storm windows, but in the South this is unnecessary and an ideal form of construction is a timber framework covered with corrugated, galvanized iron. At least two full-size check rail windows should be provided in the boiler and pump room.

INTERNAL COMBUSTION ENGINE PLANTS—SMALL UNITS

The ordinary small wayside plant usually consists of an engine from 5 to 15 horsepower, either directly connected to the pump or having a comparatively short belt connection. The size of the pumphouse is determined by the equipment required, but usually either a brick building or a hollow tile building, sometimes covered with stucco, varying in size from 12 ft. by 16 ft. to 12 ft. by 24 ft., and with walls 8 to 9 ft. high, is sufficient. If a vertical type oil engine is used, a ceiling height of 12 to 16 ft. may be necessary. As pumphouses are usually near the shore of a lake or river where the ground is liable to be unstable, and are also subject to the jar of machinery, particular care should be given to provide a secure foundation. This should be of concrete and should extend up to a point at least six inches above the floor line. A concrete floor should be provided and it should drain to a sump connected with the sewer. The walls of these small brick buildings may be only eight inches in thickness. The roof should preferably be of concrete. In the cold climates, to avoid condensation from the ceiling, the under side of the concrete should be insulated with a layer of flaxlinum one-half inch thick, or similar insulating material. A coating of tar or heavy asphalt paint should be used on the roof. At least two full-size check rail windows should be provided. Frames and sash may be of wood or steel, the latter being preferred. Storm doors and storm windows are needed in the northern climate and for these small buildings stove heat is sufficient. A suitable ventilator should be provided in the ceiling or the upper part of the window sash should have a sliding ventilator. In the South where cold weather is not a factor, for wayside stations of lesser importance frame pumphouses covered with galvanized iron are frequently used. By providing a concrete floor and asbestos wainscoting five-eighths inch thick for a height of five feet on the side walls, the fire risk is minimized to a large extent.

LARGE UNITS

There is a wide range in the size of buildings required for the larger pumping units which are located at terminals and important intermediate points, and where machinery is usually provided in duplicate. Local conditions will determine what must be provided. In general the building should be of brick with walls not less than thirteen inches thick, and should have a concrete foundation and preferably a concrete roof. In cold climates, insulation for the under side of the concrete roof is necessary. The window sash and frames should be of steel. The floor may be of brick or concrete with adequate provision for good drainage. Electric light should be provided with outlets adjacent to each machine. In the northern climate, if steam from other facilities is not available, a small hot-water heating plant is desirable, and this will serve to maintain an even temperature throughout the period when the pumpers are not on duty. Suitable ventilators, either in the ceiling or in the upper part of the window sash, must be provided.

Frequently conditions are such that it is necessary to set the engines or motors above the high-water level and the pumps at a lower level in order to decrease the suction lift. Where high water creates considerable static head, the pit or lower section of the pumphouse must be carefully designed with suitable reinforcement. It is usually necessary to waterproof this concrete, and this has been successfully done in many cases by the use of hydrated lime in the mixture. In some cases a double wall is used with the waterproofing membrane between.

ELECTRICALLY OPERATED PLANTS

Where electricity is available at a suitable rate, this type of power is often desirable and since the electric motor may usually be directly connected to the pumping machinery, a smaller size of building is sufficient. The building should be of substantial, fireproof construction, as previously described for internal combustion units, and usually the pump may be located below the frost-line so that provision for heating the building is not always necessary.

DEEP WELL PUMPING UNITS

The size of building required will depend entirely on the type of equipment used. A small building not over 10 ft. by 10 ft. is often all that is necessary where an electric motor may be directly connected with the pump head. A building 10 ft. by 20 ft., or larger, may be necessary where an oil engine is used for power. The building may be of frame construction or else of the same general type as that described for internal combustion units, except that it may be better to use frame construction for the roof and a prepared or built-up roof covering. A derrick frame extending 20 to 35 ft. above the roof of the building is essential, and this frame should rest directly on the building foundation.

WATER TREATING PLANTS

On account of the widely differing conditions in the quality of locomotive water supplies, as well as differing climatic conditions, there is at this time no one type of plant that can be considered standard. A method of treatment for one water will not give the desired results with another and the means adopted for treatment must be adapted to the local conditions. In a cold climate it is usually desirable to have the settling and chemical tanks in a substantial two-story, well-insulated building where an even temperature may be maintained. With few exceptions these treating plant buildings are of frame construction, resting on a concrete foundation. Since economy seems to dictate this type of construction for the large building required for this purpose, it is essential that the fire-fighting apparatus be of the best. A concrete floor should be provided in the engine-room, the heating should be by means of a hot-water plant, if steam is not available from outside sources, and the roof-covering should be of asbestos or other fire-resistant material. Electric light wiring should be in conduit. If the chemical storage room is on the ground floor, a raised or false floor should be provided to prevent absorption of moisture and give proper ventilation. All piping and valves should be either above ground or in trenches where they will be readily accessible in case of trouble. The sewer for drainage should lie as far as practicable in a straight line, have the best grade possible and have no manholes between the plant and the outlet.

In the warmer climates it is not necessary to house in settling tanks and the buildings need only be as large as necessary to enclose the pumping and chemical handling machinery, as well as to provide for sufficient storage of chemicals. Usually a one-story frame structure with concrete floor and asbestos shingle roof is sufficient.

SUCTION OR PUMP WELLS

At many locations it has been found desirable to build a suction or pump well to serve as a reservoir from which the pump will draw its supply direct. Frequently these wells are located directly beneath the pump-house and are a part of the structure. Occasionally in order to decrease the suction lift, the pump is placed at some distance down in the well. By means of baffle plates, screens or other devices, these wells serve to eliminate trouble from sand and leaves or other floating debris which might otherwise be drawn directly into the pump. They should be built of brick or concrete and have a watertight bottom. The pipe arrangement should be such that the supply from the river, lake or other source can be cut off while the well is being cleaned. A by-pass connection from the pump discharge pipe line to the intake line is also desirable, as frequently it may be possible to flush out or open up a clogged line by means of static water pressure from the tank or pressure from the pump.

PUMPERS' COTTAGES

Many water stations are located at outlying points, making it necessary to provide living quarters for the pumpers. In general these consist of frame buildings of five or six rooms and of the same type as provided for sectionmen. In all cases concrete footings or foundation should be provided. In the colder climates the house should be well built and a concrete cellar under at least part of the house is desirable. The use of asbestos shingles is recommended, as they cost little more than other roof-covering and largely decrease the fire risk.

Appendix I

(8) REPORT OF BOILER WASHING PLANTS AS AFFECTING WATER SUPPLY

F. D. Yeaton, Chairman, Sub-Committee; W. M. Barr, J. H. Davidson, O. W. Carrick, R. W. Chorley, R. E. Coughlan, J. P. Hanley, J. H. Knowles, T. D. Sedwick, O. T. Rees, H. H. Richardson, C. H. Koyl, B. W. DeGeer.

In the early days of railroading locomotive boilers which required washing were brought into the engine house, emptied of water and steam and allowed to cool so that the cold water which was then used for washing would not damage the side sheets, flues and staybolts. This method required considerable water, time and delay to locomotives. Later the washout water was heated with live steam to about 80 deg. Fahr., which required the use of much steam, and did not give efficient results.

A method in use at present at some terminals is to blow the water into hot water sumps, where it is cooled to about 125 deg. Fahr., and then used for washing.

Hot water boiler washing plants have come into general use in recent years. Many of the modern terminals are now using boiler washing plants which separate the hot water and steam. The hot water is used for washing and the steam for heating clean refilling water.

The use of hot water boiler washing plants has resulted in large savings in operating costs. The economies effected by these plants include savings in time, water, coal and boiler repairs.

Time of the men and of the locomotive is saved because (1) with wash water at a temperature of about 120 deg. Fahr., which is as hot as men can handle, it is not necessary to wait until the boiler is cool before washing; (2) under these conditions a boiler can be cleaned more quickly, and (3) after washing and refilling steam can be raised to working pressure in the boiler more quickly.

Less water is used because (1) none is required to cool the boiler, and (2) the water blown off from one boiler (with a small percentage of fresh water to cool it down to handling temperature) is utilized to wash the next boiler. Economy in the use of water is effected only where boiler plants are of proper design with ample storage and properly operated.

Coal is saved at the powerhouse because it is no longer necessary to pre-heat the washing or refilling water, and at the locomotive because the refilling water is used at a temperature of 190 deg. Fahr., instead of 90 deg. Fahr.

Because of less variation in temperature of the boiler at washing time there is a marked decrease in repairs required by side sheets, flues and staybolts.

Insufficient study seems to have been given to the conservation and reclamation of the water. The present-day washout plants seem to be designed to give the hottest usable temperature for the water used through them, and the amount of water used, and its possible reclamation has been given only minor consideration.

In reducing the temperature of the washout and refilling water from 175 to 125 deg. Fahr. a large amount of fresh water is required. This inflow of fresh water is sometimes more than sufficient for makeup purposes, with the result that the surplus is wasted when it might be used at the cinder pit.

The waste would be stopped and the operation of the tempering devices and entire washout plants would be improved if the refill and washout storage tanks were of sufficient capacity to receive the maximum peak blowoff. Two 50,000-gallon capacity tanks could be used to good advantage where two 10,000-gallon tanks are now sometimes used. One large railway system reports that they design their blowoff piping for a maximum use of five engines at the same time and that they are considering the installation of 50,000-gallon tanks to save water when such peak blowoff occurs.

These tanks should be equipped with a sludge removal system and a lattice work cooling device for cooling the water and removing the steam. This lattice work could be somewhat similar to the cooling arrangement in use by ice manufacturing plants. Plants equipped with condensers, separators and mechanical tempering valves are sometimes rather complicated and unless given close supervision waste a large amount of water.

One western railroad reports that most of their plants are constructed with only one tank into which the steam from the blowdown engines and exhaust steam from the pumps and power plants are emptied for heating either raw or treated water to bring the temperatures up to approximately 140 deg. Fahr. This water is then used for both washout and fill up purposes. Only at two of their twenty-four plants is the blowdown water saved, and this because of the scarcity of water.

The water at one plant is so scarce that all water of any kind is used several times. At this particular plant there is a two-tank system, one is for washout purposes and one for fill up. The water from the boilers is emptied into the washout tank and saved, and the water used for washout purpose, together with all drainage from the engine house, goes to a sump which is used as an auxiliary supply to the well production. This is an unusual condition, however, on account of the shortage of water.

Another large southwestern railroad reports that they design their boiler washing plants. They utilize the steam only from the blowdown and recover from each locomotive approximately 1000 gallons of water that comes over with the blowdown as re-evaporation upon reduction of pressure, or roughly, one-third of the water in the boiler. The remaining 1500 or 2000 gallons in the boiler, when the blowdown operation is completed to a point where no more steam can be removed within a reasonable time, is wasted into the sewer.

The following information has been obtained from a modern boiler washing plant located at a large terminal:

The plant is in the immediate vicinity of the engine house, and consists of a steel separator tank (for separating boiler blowoff into steam, water, and sludge) ; a wooden washwater tank, 24 ft. diameter by 14 ft. high, which receives the hot water from the separator tank; a wooden refilling-water tank, also 24 ft. by 14 ft., which receives the steam from the separator tank as it is condensed by a spray of cold, fresh water so that the temperature of the resulting refilling water is about 200 deg. Fahr.; and three 600-gallon-per-minute steam pumps, one for wash water to the engine house, one for refilling water, and one in reserve for either purpose; the housing for tanks and pumps; and the three lines of 6 in. pipe for blowoff from, and wash water and refilling water to the engine house.

The blowoff sludge which settles to the bottom of the separator tank is discharged to the sewer at intervals of two or three hours; the blowoff water passes by gravity from the separator tank to the washout tank, whence it is forced to the engine house stalls at a pressure of 120 lb. per sq. in. and a temperature of 120 deg. Fahr., having been reduced to this temperature by a small stream of cold water which is regulated by a thermostatic valve attached to the washout pump; the steam from the separator tank passes overhead to the refill tank, being condensed en route, and is forced to the engine house stalls by the refilling pump at a pressure of 120 lb. and a temperature of about 200 deg. Fahr.

The washout and the refill tanks are both provided with overflow to the sewer, and each has a float valve to govern the admission of fresh, cold water when necessary to maintain a certain level in the tank.

The pumps are supplied with steam from the central power plant, and exhaust steam from the pumps is conducted to the refill tank.

The engine house handles approximately 110 engines per day, with 15 washouts, and 40 water changes. At an average of 5000 gallons per boiler washed there is a saving of 75,000 gallons of wash water per day. This saving is partly due to sufficient storage capacity and the use of hot blowoff water.

The use of this plant has made a force reduction and a fuel saving possible. Fifteen boiler washers and helpers, working in three shifts of five men each, formerly washed 12 boilers per day, while now, on account of the hotter water and higher pressure, they wash 15 per day.

The coal saved in the power house and in heating the refilled boiler to working pressure averages approximately 500 lb. per boiler washed or having water changed.

The time saved in washing averages two hours, and in water changing one hour.

Five men were formerly employed in flue work, but only two are employed now. New sheets put into the boilers since the use of hot water for washing show no cracks, and the old cracked sheets are not getting worse. Arch tubes replaced the year before hot water were 52 and the year later only 14. There is a noticeable improvement in the spirit of the men from having always available a dependable supply of hot water under sufficient pressure. It is too early to attempt to determine the value to the boiler of the lesser wear and tear in the engine house.

An evaluation of the average saving per boiler washed, of the items which we can measure, is approximately as follows:

5000 gallons of water at 8 cents per 1000 gallons	$0.40
500 lb. coal at $4.00 per ton	1.00
1½ engine hours at $2.50 per hour	3.75
20 minutes for 2 boiler washers at 45 cents per hour	.30
1 hour 10 minutes for fire builder at 45 cents	.53
	$5.98

For a water change, we estimate the saving at $4.03.

It should be noted that the principal item in the above list—1½ engine hours at $2.50 per hour = $3.75—can be included only when the engine is not held for machinery repairs; but that the omission of this item will probably be more than balanced by the lesser repairs and wear and tear on the boiler, the value of which we have not endeavored to estimate.

Conclusions and Recommendations

(1) Storage tanks should be of sufficient capacity to take care of the maximum number of boiler washouts without waste of water or heat.

(2) Lattice work cooling devices may be provided for the blowoff tank to cool the water as much as possible by exposure to the atmosphere instead of cooling it by adding fresh water. Fresh water should be used only for makeup purpose.

(3) A sludge collecting system might be installed in the tank bottom for discharging accumulated sludge. This will avoid emptying tank of water and taking it out of service.

(4) Blowoff water not needed for washout purposes may be utilized at the cinder pit and for other purposes for which the water is suitable.

REPORT OF COMMITTEE XI—RECORDS AND ACCOUNTS

H. M. Stout, *Chairman;*	V. R. Walling, *Vice-Chairman;*
E. G. Allen,	W. J. Kelly,
A. M. Blanchard,	Henry Lehn,
L. H. Bond,	J. R. Leighty,
Z. M. Briggs,	H. T. Livingston,
A. C. Copland,	E. W. Metcalf,
E. B. Crane,	R. E. Patterson,
H. C. Crowell,	H. J. Sargent,
C. C. Haire,	H. F. Sharpley,
H. E. Hale,	C. K. Smith,
J. H. Hande,	H. M. Tremaine,
W. A. Hill,	W. A. VanHook,
F. W. Hillman,	G. R. Walsh,
T. J. Irving,	H. R. Westcott,

Committee.

To the American Railway Engineering Association:

Your Committee on Records and Accounts respectfully submits herewith its annual report to the Association covering the following assigned subjects:

(1) Revision of the Manual.

No revisions are offered for the consideration of the Association this year.

(2) Methods and forms for gathering and recording data for keeping up to date the physical and valuation records of the property of railways.

The first progress report on this subject was presented to the Association last year (see Bulletin 274, February, 1925, and Volume 26, Proceedings of the American Railway Engineering Association).

The second progress report is herewith presented (Appendix A). It is expected that the final report will be submitted next year.

(3) Feasibility of reducing the number of forms used in the Engineering and Maintenance of Way Department, combining forms and simplifying those retained.

Report on this subject is presented herewith (Appendix B).

(4) Methods for recording and accounting for the determination of proper allowances for Maintenance of Way expenses due to increased use and increased investment, collaborating with the Committee on Economics of Railway Operation.

Committee XXI, Economics of Railway Operation, presented their report last year on the corresponding subject, which was approved by the Association. While a beginning has been made in the study of our branch of the subject, the matter has not progressed far enough to offer even a preliminary report this year.

Bulletin 281, November, 1925.

(5) Revision of the I. C. C. Classification of Accounts.

No constructive work has been done on this subject during the past year by the Committee. Our activities have been limited to an attitude of watchfulness. We have been informed that the Interstate Commerce Commission has completed the preparation of the tentative draft for the revision of the Classification of Income, Profit and Loss, and General Balance Sheet Accounts. Also, revision of the text for Operating Expense Account has been begun, but that the revision of the Classification of Investment in Road and Equipment has not been commenced.

(6) Comparison of daily and monthly time and material reports.

The first progress report on this subject was presented last year (see Bulletin 274, February, 1925, and Volume 26, Proceedings of the American Railway Engineering Association).

The second progress report is herewith submitted (Appendix C). It is expected that in the final report recommendations of the forms and the specifications and directions for their use will be presented for publication in the Manual.

(7) Outline of work for ensuing year.

See "Recommendations for future work" below.

Action Recommended

Your Committee's recommendations are as follows:

1. That the report on subject No. 2, Physical and Valuation Records of Railways, given in Appendix A, be received as a progress report.
2. That the report on subject No. 3, given in Appendix B, be received as a final report and the subject discontinued.
3. That the report on subject No. 6, given in Appendix C, be received as a progress report.

Recommendations for Future Work

1. Revision of the Manual.
2. Methods and forms for gathering and recording data for keeping up to date the physical and valuation records of the property of railways.
3. Methods for recording and accounting for the determination of proper allowances of Maintenance of Way expenses due to increased use and increased investment, collaborating with the Committee on Economics of Railway Operation.
4. Revision of the I.C.C.. Classifications of Accounts.
5. Comparison of daily and monthly time and material reports.
6. Aerial surveys and maps.
7. Outline of work for ensuing year.

Respectfully submitted,

THE COMMITTEE ON RECORDS AND ACCOUNTS,
H. M. STOUT, *Chairman.*

Appendix A

(2) METHODS AND FORMS FOR GATHERING AND RECORDING DATA FOR KEEPING UP TO DATE THE PHYSICAL AND VALUATION RECORDS OF THE PROPERTY OF RAILWAYS.

C. C. Haire, Chairman, Sub-Committee; A. M. Blanchard, A. C. Copland, H. E. Hale, W. J. Kelly, E. W. Metcalf, H. M. Tremaine, G. R. Walsh, H. R. Westcott.

There is presented by the Sub-Committee a second progress report on this subject.

For several sub-divisions of the subject, this Sub-Committee made a report last year that appeared in the 1925 Proceedings of the Association, and that report is therefore not repeated this year as no revisions have been made.

The subjects upon which the Sub-Committee submits a report this year are as follows:

1. Definitions of Terms.
2. Organization for Collecting, Compiling, Recording and Filing.
3. Forms for Recording Changes in Physical Property.
   - (d) Record of Side Tracks.
   - (e) Structural Record—Buildings.
   - (f) Roadway Machine Record.
   - (g) Shop Machine Record.
   - (h) Equipment Index—Record of Equipment Changes.
5. Mandatory Forms Required by Federal Regulations.
   - (c) Record of Property Changes.

(1) DEFINITIONS OF TERMS

Addition.—A structure, facility, equipment or other property unit added to those in service.

Betterment.—Improvement of an existing facility through the substitution of superior parts for inferior parts retired.

Charge.—An entry in accounting; setting down or debiting an item or sum to some account.

Gross Charge.—A sum on the debit side, representing the entire amount or total of the charges resulting from any transactions before credits are deducted.

Net Charge.—A sum on the debit side, representing the entire amount or total of the charges resulting from any transactions after credits are deducted.

Credit.—A negative charge.

Gross Credit.—A sum representing the entire amount or total of credits resulting from any transactions before debits are deducted.

Net Credit.—A sum representing the entire amount or total of the credits resulting from any transactions after debits are deducted.

Chart.—A delineation or statement in graphical form.

Cost.—The outlay incurred in acquiring, creating, operating or maintaining a property, including the money value of the services rendered and other considerations involved.

Gross Cost.—The total outlay incurred in any transaction, including the money value of services rendered and other considerations involved, before credits are deducted.

Original Cost to Date.—Cost of original construction, plus all charges against Capital, under proper accounting principles, for expenditures incurred thereafter, and minus all proper credits to Capital for the cost of property which has been disposed of, or otherwise retired.

Unit Cost.—The cost of any selected unit of property.

Depreciation.—Loss of physical worth, due to age, use, inadequacy, obsolescence, depletion and other similar causes.

Facility.—A portion of the property capable of rendering a specific service.

Labor—Cost of.—The amount paid for labor performed by the carrier's own employees.

Material—Cost of.—The amount paid for the purchase, inspection, transportation and loading of material, plus a proportion of the store expense.

Fixed Property.—Property of immovable nature or incapable of a change in location without reconstruction, either in whole or in part; property which may not be used except in a fixed location.

Equipment.—Rolling stock, floating equipment and highway vehicles devoted to common carrier's service.

Plat.—A portion of a map designed to show some part with particularity.

Profile.—A longitudinal section through a work or section of country to show the elevations and depressions.

Property Change.—Any change in the physical property.

Project.—A scheme or plan for creating or changing physical property.

Replacement.—Property put in place of some previously existing facility, to serve a like purpose.

Retirement.—Property which for any reason is taken out of the service for which it was created or installed; fixed property moved from one valuation section to another.

Salvage.—Material or value recovered from property retired or from property after use as a construction aid.

Unit of Property.—The amount or quantity of any class of physical property adopted as a standard of measurement for other amounts or quantities of the same kind.

Ledger Value.—The value at which the property is carried in the Property Investment Account of the carrier.

(2) ORGANIZATION FOR COLLECTING, COMPILING, RECORDING AND FILING

In recommending an organization for collecting, compiling, recording and filing, consideration has been given to the carriers' own requirements and to the regulations of the Interstate Commerce Commission's Valuation Order No. 3 and the regulations of various states.

The collecting, compiling and recording and filing of data for keeping up to date the physical and valuation records is so closely allied to the railways' accounting methods that it is considered in the interest of efficiency and economy that all the requirements can well be combined.

For years many carriers maintained some form of organization which recorded currently and reported to the Interstate Commerce Commission annual expenditures to Investment in Road and Equipment, and requirements of some few states necessitated reports from a few carriers as to changes in physical property, so that many railroads had some scheme to collect and record information for all accounting purposes and for their own internal needs.

The issuance of Valuation Order No. 3 has brought to the front the need of greater refinement and elaboration of accounting for Investment in Road and Equipment expenditures, as it is mandatory to set up property changes in detail on prescribed form and to submit summaries of the result, annually and semi-annually.

The procurement of information as to physical changes to the property of railways naturally requires an orderly and systematic method of procedure. The mandatory requirements outlined briefly certain procedure, but it is insufficient to meet all the needs of the carriers for their physical records and accounting work.

The methods that are considered best by the Sub-Committee for gathering and recording data can be summarized as follows:

(1) All physical changes to property to be included in an annual budget, excepting special and emergency cases, which it may be necessary to handle, or the condition of expenditures and revenue may permit of subsequent changes to the budget, which can be added thereto.

(2) All changes in physical property, except ordinary repairs, to be carried out under an "Authority for Expenditure."

(3) "Authority for Expenditure" estimates should be prepared in the same general form as required to record the expenditures on roadway completion reports, so that direct comparison can be made and so that the estimates may serve as a guide to those who handle construction accounting.

(4) Expenditures to be recorded, tentatively distributed and summarized under the direction of the organization responsible for collecting, compiling, recording and filing physical data, and the system of records and accounts required for Investment in Road and Equipment and other mandatory regulations of states and the Interstate Commerce Commission.

(5) Physical changes to be inventoried and recorded by proper units under the direction of the organization mentioned immediately above.

(6) The analysis of charges and comparison of inventory of physical property, perpetuated to compile final accounting records and records of physical changes required for carriers' internal use and mandatory regulations to be handled under the direction of the organization mentioned above.

The record of physical changes to property is needed in the operation and maintenance of the carriers and it is important to keep up to date maps and profiles and to have complete records of this nature to show what changes were made. In the administration and handling of an Engineering Department, correct station maps, profiles, right-of-way and alinement maps and records, etc., are of importance and these records must be maintained to a high state of perfection at all times.

The Engineering Department is required to continually originate estimates for the purpose of improving and maintaining the property. Estimates cannot be made intelligently and correctly unless there are physical data in some form to show the characteristics of the property. This must be complete information of all local conditions, costs, topography of country, construction difficulties encountered, geological conditions, etc. Much of this information is interwoven with accounting records, such as the cost of performing work, but the majority of it should come from the construction engineers who should record currently, by diaries and other records, in an historical manner, the progress of the work and all difficulties and conditions encountered.

After original construction of a railroad, all the records in connection therewith should be carefully preserved, but it is evidently of greater importance, as improvements are made in a plant, that each engineer who handles any construction or changes in connection with maintenance, should make a record of changes, giving a complete outline in the nature of an engineering report of the new units added and their cost and those units that are retired. Such an engineering report should be profusely illustrated with drawings, plans, sketches, photographs, etc.

In constructing new lines and extensions, or additions to existing property, engineers ordinarily keep notes and memoranda of a varied nature; they must, of necessity, prepare progress profiles, cross-section sheets, sketches, field notes, make working drawings of any changes and, in a varied way, a complete history of the project reported, and it is obvious that the scattered notes, memoranda and data be collected in a uniform manner, in one record, so that this information can be conveniently reported and filed.

This Sub-Committee is of the opinion that ordinarily no more time or work is required to record all notes and construction data of physical changes in one set of records of uniform size and manner than to prepare the data in any other form.

It is considered that information of this kind can be easily collected and filed so that for all future time it will be readily accessible as a history and as a record of any construction work or physical change in the property.

The collecting, compiling, recording and filing of the physical data is further made necessary by the present-day refinement of accounting and the needs of reporting cost of construction in a uniform manner. Roadway Completion Reports require that the cost of construction be reported by using standardized units and reporting the cost of units of property added and property retired. It is only from the correct record of physical changes that this information can be collected; therefore the Sub-Committee calls attention to the obvious necessity of combining the two functions under one organization and one head.

All other records in connection with the State and mandatory regulations of the Interstate Commerce Commission revolve around a physical record as described above and cost reported on Roadway Completion Reports, and the collection of the information in a summary that is required either semi-annually or annually is a mere matter of detail and office routine.

The accounting requirements, as promulgated in the Classification of Investment in Road and Equipment, has stipulated, for many years, certain procedure in recording cost of construction work, but no method is specified in detail as to how to arrive at the information; consequently the accounting for the cost of construction by railways has not been uniform nor regular.

The cost of construction work cannot be correctly recorded and the requirements of the Classification of Investment in Road and Equipment cannot be carried out correctly unless based upon the construction data outlined in the foregoing. This is obvious in connection with the separation between the various primary accounts of Investment, Operating Expenses, Income, etc., as unit quantities are frequently the only basis of making a separation. Much could be said and there could be much argument as to why this is a fact.

The keeping up to date of the valuation records of railroad property, aside from the physical records, involves the question of amounts added to and retired from the Investment Account of the carriers and as such amounts are based upon construction costs and information originating with engineers and their subordinates, the Sub-Committee is of the opinion that construction cost accounting is a joint accounting and engineering function, for the following reasons:

(1) The accounting and engineering work involved in handling the collecting, compiling, recording and filing of data for the physical changes to property, as is required for carriers' own use and in the mandatory form, and the accounting for Investment in Road and Equipment projects, are inseparable.

(2) The handling of accounting in connection with construction cost and the engineering work in connection with collecting, compiling, recording and filing the physical changes to property, requires specialized employees of both engineering and accounting experience.

(3) The control of Capital Expenditures and those expenditures chargable to Operating Expenses or Other Accounts, in connection with construction work, is a responsibility of the engineers who are in charge of the execution of work and the inseparable engineering and accounting work required, for construction expenditures must be coordinated with such control of expenditures.

In considering the mandatory requirements of the various regulatory bodies, both federal and state, and the carriers' own needs, it is obvious that it is both efficiency and economy to organize so as to satisfy all the following purposes simultaneously:

(1) Collect, compile, record and file data for carriers' own use, such as:
  (a) Construction cost data and physical records.
  (b) Investment in plant for tax return purposes.
  (c) Investment in plant for insurance schedule purposes.
  (d) Participation in joint ownership.
  (e) Investment in joint facilities.
  (f) Compile indices of price trend for equating original cost to date, to cost of reproduction for rate purposes.

(2) Accounting for Investment in Road and Equipment expenditures.

(3) Records and accounts prescribed by Valuation Order No. 3 and Supplements No. 1 and No. 2 thereto.

(4) To comply with the requirements of Valuation Order No. 23, which requires the maintaining up to date of certain valuation maps.

(5) To comply with State laws and requirements of Public Service Commissions.

To comply with governmental regulations it is necessary to carry out the suggestions made in the preceding paragraph. It is necessary, further, that the data be compiled concurrently with the progress of the work; therefore the carriers' own interests will also be served by making the reports within the time limits prescribed by the legal requirements.

The failure of many railways to meet the time limit imposed on them in the submission of their reports to Governmental bodies can be traced directly to division of responsibility existing between various departments and the fact that the engineering work and the accounting work is not combined in handling the various features directly or indirectly connected with the real objective of preparing final returns for the reports.

The most feasible and proper organization to function so as to obtain all the results can best be secured by a separate bureau or department, properly correlated to the Accounting, Operating and Engineering Departments. A separate bureau or department, functioning in a dual manner, eliminates any division of responsibility and duplication of work performed, with its consequent heavy cost to the railway. Duplication of work often exists in railway organizations, instituted under the cloak of department needs and so-called departmental responsibility. However, from the standpoint of efficiency and economy, such duplication is in the last analysis superfluous.

Centralization of authority, including centralization of working forces, answers the requirements of expediency and economy as a close cooperation between a bureau and other departments that can be maintained. Efficiency is, however, a direct contribution of the personnel.

A single acting department or bureau to handle all functions is required to efficiently administer to the handling of the mandatory regulations and to maintain correct accounting. The interest of any department should not dominate nor influence the proper handling of the various records and accounts, and the mandatory system of records and accounts cannot be successfully maintained unless handled in an independent manner from other organizations, not prejudiced in any way by other department needs.

The handling of this branch of engineering and accounting work being a specialized field and having important functions should, therefore, in the opinion of the Sub-Committee, be an independent department or bureau under the direction of an experienced engineer or accounting officer. The importance of reliable accounting and the interest engineers should have in cost data, accounting records and accounts in general was called forcibly to the attention of the members of the American Railway Engineering Association by Past-President Lee, in his address before the March, 1924, Convention, as follows:

> "Railroad Accounts are valuable as a record of past performance and existing status, but a more important element of their value is in the use of these records as a basis for decisions as to future practice and performance. Necessarily these accounts are kept so as in a way to resemble a code. All railroad officers should have some general knowledge of railroad accounts. Many of the members of our Association have such a knowledge, but every member of the Association should make it his business to familiarize himself thoroughly with railroad accounting, both in principle and practice, in order to be able to decide for himself information constantly necessary.
>
> "If I may hand on a word of advice to our younger members, so full of brains and ambition and enthusiasm, I would be inclined to say, as everyday work, do the job in hand to the best of your ability; as special work, master railroad accounting in principle and practice; and, as a general interest, study the psychology of your fellowmen."

The Sub-Committee's recommendations for a separate bureau or department form of organization for collecting, compiling, recording and filing department data are based upon the following conclusions:

(1) The collecting, recording, compiling and filing data and keeping up to date the physical and valuation records of the property of railways is essentially the responsibility of both accounting and engineering organizations, and,

(2) Some one individual should be made responsible for the handling of the mandatory regulations of the Federal and State Commissions and for collecting and compiling physical data, as well as to handle all accounting features.

(3) Accounting features should be inclusive of accounting for Investment in Road and Equipment.

(4) That with such departmental or bureau organization, all requirements to State Commissions, Federal Commissions, tax bodies, etc., can be combined and one set of records and accounts used for all purposes.

(5) That the proper control of Capital Expenditures and construction costs is essential to scientific management, and this can be best effected by a joint bureau or departmental form of organization, removed from influences or prejudices of any other department's own needs.

(3) FORMS FOR RECORDING CHANGES IN PHYSICAL PROPERTY*

(d) RECORD OF SIDETRACKS—(EXHIBIT 11) (PRESENT FORM 1106)

One of the auxiliary records that is needed by carriers for recording changes in physical property is a record of sidetrack mileage, as well as main track mileage, changes; such a record as this is also necessary in connection with the mandatory records as are required by Federal regulations.

In connection with the Federal inventory of carriers, there were established definite side and main track lengths and a number for each sidetrack was assigned for each valuation section. Accordingly, a perpetuation of such a record is of value for main and sidetrack mileage statistics that are required annually by the Bureau of Statistics of the Interstate Commerce Commission, and for a carrier's own internal needs.

It is only by reconciling annual sidetrack mileage and the Investment Account records by "Authorities for Expenditure" that the changes in track lengths can be properly maintained; therefore the advisability, as well as the necessity, of a record of all sidetrack changes, are obvious, and the Sub-Committee's recommendations are as shown by the attached Exhibit 11, in lieu of Form 1106, that is shown on insert between pages 510-511 of the 1921 Edition of the Manual.

There is no real reason that requires the maintenance of Form 1106, whereas there are definite reasons for the use of the form recommended by the Sub-Committee; also, the Sub-Committee has been in consultation with representatives of the Bureau of Valuation of the Interstate Commerce Commission who advocate a record along the lines of the Sub-Committee's proposed form.

(3) FORMS FOR RECORDING CHANGES IN PHYSICAL PROPERTY

(e) STRUCTURAL RECORD—BUILDINGS (EXHIBITS 12, 13 AND 14)

The Sub-Committee, in its study of general subject No. 3, "Forms for Recording Changes in Physical Property," considers that a detailed record of

---

*See Vol. 26, Proceedings of 1925, pp. 809-826, for **Exhibits 1 to 10, inclusive.**

all buildings is essential and that all structures of this character should be numbered and changes to each building recorded by "Authorities for Expenditure."

Accordingly, the Sub-Committee recommends two forms, similar to the Exhibits 12, 13 and 14, 8½ by 11 inches in size, to be used as a card file.

(3) FORMS FOR RECORDING CHANGES IN PHYSICAL PROPERTY

(f) Roadway Machine Record (Exhibit 15)

Within the last seven or eight years the general use of motor cars and improved roadway machines of various kinds has come into vogue on steam railroads. The investment in this class of property has grown immensely and the value of each individual unit is sufficient to require an individual record of the Investment, performance and ultimate life of the unit; furthermore, this class of property depreciates rapidly, i. e., is worn out, destroyed in accidents, or otherwise, and to properly maintain the Investment Account an individual record should be kept for each unit and the Sub-Committee suggests Exhibit 15, 8½ by 14 inches in size, to be used as a loose-leaf book record.

(3) FORMS FOR RECORDING CHANGES IN PHYSICAL PROPERTY

(g) Shop Machine Record (Exhibit 16)

This class of property requires some detail to record its individuality and owing to the machines being moved with some frequency from one shop location to another, the advantage of having an individual record, from an operating and engineering point of view, is obvious.

The identity of each machine must be maintained by numbers, and as they are moved or retired a record of each change should be established with definiteness.

Accordingly, the Sub-Committee recommends that a record be maintained for each machine, in accordance with Exhibit 16, 8½ by 11 inches in size, to be used as a card record.

(3) FORMS FOR RECORDING CHANGES IN PHYSICAL PROPERTY

(h) Equipment Index—Record of Equipment Changes (Exhibits 17, 18, 19 and 20)

In connection with other records for recording changes in physical property, the Sub-Committee has designed four forms for equipment changes, as follows:

Exhibit 17—Record of Equipment Changes, for
Account No. 53—Freight Train Cars
Account No. 54—Passenger Train Cars
Account No. 57—Work Equipment.

Exhibit 18—Record of Equipment Changes, for
Account No. 51—Steam Locomotives
Account No. 52—Other Locomotives.
Exhibit 19—Record of Equipment Changes, for
Account No. 56—Floating Equipment.
Exhibit 20—Record of Equipment Changes, for
Account No. 58—Miscellaneous Equipment.

It is considered unnecessary to use a "Record of Property Changes" for equipment, as Equipment Completion Reports contain the detail of all equipment changes in essential form, and to record these changes in any other form than the "Record of Property Changes" is an unnecessary duplication.

Exhibit 17 is an index of all items owned by a carrier of "Freight Train Cars," "Passenger Train Cars" and "Work Equipment" and the index is the equipment unit number. The index gives the original cost and the "Authorities for Expenditure" for various changes for any one unit of equipment subsequent to original acquisition.

In a manner similar to Exhibit 17, Exhibits 18, 19 and 20 are to be used for "Steam Locomotives," "Other Locomotives," "Floating Equipment" and "Miscellaneous Equipment."

The general scheme of maintaining a "Record of Property Changes" for equipment in the above described manner, has been approved in principle by the Bureau of Valuation of the Interstate Commerce Commission and the Sub-Committee recommends its use, in the interest of simplicity in handling Valuation Order No. 3, Second Revised Issue, and records of physical changes to equipment needed by the railways for their own purposes.

(5) MANDATORY FORMS REQUIRED BY FEDERAL REGULATIONS

(c) Record of Property Changes (Exhibits 21, 22 and 23)

The "Record of Property Changes," generally spoken of as Exhibit "E" of Valuation Order No. 3, Second Revised Issue, is a record that was originally designed for the dual purpose of recording and consolidating units of a like kind that are added and deducted periodically from the property of the carrier, and, also, to record and accumulate expenditures by debits and credits periodically. The record is primarily to perpetuate the Federal Valuation by units and by money.

As a record of expenditures it differs from the usual railway accounting procedure in recording the Investment charges currently, in that Exhibit "E" requires a record of final or total expenditures only when the project is in transportation service, whereas the accounting method is to report chronologically the debits and credits as they originate from any source.

There is a growing thought in connection with this record, which is tending towards the abolition of the method of showing units and it may be that in the future the only record that will be required will be one to

Y&S - Yard Tracks & Siding
Ind. - Industry Tracks, Co.
I.&C.- Industry Tracks, Private
Jt. - Jointly Owned Tracks

NORTH & SOUTH RAILROAD

RECORD OF SIDE TRACKS

Exhibit 11

Operating Division..................
Valuation Section..................

Line	Track No.	Description	Length or date of Valuation..........				Changes In Lengths																				
							A.F.E.	Add.	Retire	Length Dec. 31st 19......				A.F.E.	Add.	Retire	Length Dec. 31st 19......				A.F.E.	Add.	Retire	Length Dec. 31st 19......			
			Y&S.	Ind.	I&C.	Jt.				Y&S.	Ind.	I&C	Jt.				Y&S.	Ind.	I.&C.	Jt.				Y&S.	Ind.	I.&C.	Jt.
1																											
2																											
3																											
4																											
5																											
6																											
7																											
8																											
9																											
10																											
11																											
12																											
13																											
14																											
15																											
16																											
17																											
18																											
19																											
20																											
21																											
22																											
23																											
24																											
25																											
26																											
27																											
28																											
29																											

Binding Margin

Size of form 11" × 17"

Size of form 8½"×11"

BUILDING RECORD

Exhibit 12

Owning Co.______ R. & E. Account No.______ Used For______

State______ Val. Sec.______ County______ Division______ Town______

AFE No's.______ ______ Date Placed in Service______ Map Ref.______ Building No.______

Present Dimensions______

Note: Sketch Showing Floor Plan To be Shown On Reverse Side

DESCRIPTION	COST				
	Original ※		........Repr. New **	I. C. C. Eng. Report	
				Repr. New	Less Depr.
Original Construction* Contract* or Company*					
Construction as of..............*					
File Reference:— Plan______ Inventory Book______ Page______					
Bill of Material______ Contract______					
Superstructure Complete______					
Kind______ Dimensions______					
Roof:— Type______ Covering______ Proj.______					
Walls:—______					
Floor:—______					
Foundation______					
Platform & Curb______					
Heating______					
Lighting______					
Plumbing______					
Furniture and Fixtures______					
Water Lines Outside______					
Sewer Lines Outside______					
Accessories:—					
Coal and Oil Boxes______					
Well or Cistern______					
Toilets______					
TOTALS					

Insurance Schedule No.______ Year______ Bldg.______ Furniture______ Other Contents______

Insurance Schedule No.______ Year______ Bldg.______ Furniture______ Other Contents______

* Strike out one which does not apply. ※ Indicate estimated cost by letter "E". ** Estimate based on 1910-1914 Prices.

Size of form 8½" × 11"

BUILDING RECORD

Exhibit 13

Owning Co. ______ R. & E. Account No. ______ Used For ______

State ______ Val. Sec. ______ County ______ Division ______ Town ______

AFE No's. ______ ______ Date Placed in Service ______ Map Ref. ______ Building No. ______

Present Dimensions ______

Note:- Sketch Showing Floor Plan To be Shown On Reverse Side

DESCRIPTION	COST				
	Original $		......Repr. New **	I. C. C. Eng. Report Repr. New	 Less Depr.
Original Construction* Contract* or Company* Construction as of .... ♦ File Reference:— Plan ______ Inventory Book ______ Page ______ Bill of Material ______ Contract ______		•			
TOTALS					

Insurance Schedule No. ______ Year ______ Bldg. ______ Furniture ______ Other Contents ______

Insurance Schedule No. ______ Year ______ Bldg. ______ Furniture ______ Other Contents ______

* Strike out one which does not apply. ♦ Indicate estimated cost by letter "E". ** Estimate based on 1910-1914 Prices.

Size of form 8½" × 11"

Exhibit 14

ADDITIONS, BETTERMENTS and RETIREMENTS

AFE No.	Date Placed In Or Retired From Service	Plan File	DESCRIPTION OF PROPERTY CHANGE	ORIGINAL COST	
				Added	Retired
			Reverse Side of Exhibits 12 and 13		

Exhibit 15

NORTH & SOUTH RAILROAD
ROADWAY MACHINE RECORD

Owning Company..................
Division..................

						Acquired					Changes By Years							
Number of Car or Machine	Name of Manufact-urer.	Builder Number	Engine Number	Description	Valuation Section	A.F.E.	Date In Service	Purchase Price	Other Costs	Total Cost								

Binding Margin

Size of form 8½" × 14"

Size of form 8½" × 11"

Exhibit 16

NORTH AND SOUTH RAILROAD

SHOP MACHINERY AND TOOLS

Name of Owning Company ____ Val. Sec. ____

Name of Machine ____ Shop No. ____

Builder ____

Builder's No. ____ Type No. ____

Seller ____

Cost ____ F. O. B. ____

Req'n. No. ____ Date ____

Order No. ____

Installed At ____ Date ____

Installation Cost - $ ____

Transf. To ____ Date ____ A.F.E. ____

" " ____ " ____ " ____

Retired Value ____ " ____ " ____

Scrap Value ____

Rated Size ____

____

R.P.M. of Ctrshaft ____

Driven Pulley on Ctrsh. ____

Kind of Drive ____

H.P. Required to Drive ____

Shipping Wt. Lbs. ____

Net " " ____

Bldrs.' D'wg. No. ____

Fdtn. " " ____ Cost of ____

" Size ____

Total Cost of M'ch. & Fdtn. - A.F.E.No. ____ Cost ____

REMARKS: ____

____

____

Exhibit 17

of Equipment Changes

SIZE

Exhibit 17

OWNED BY

OPERATED BY

NORTH & SOUTH RAILROAD

RECORD OF EQUIPMENT CHANGES

SERIES

CLASS

DESCRIPTION

UNIT NUMBER	COST AS OF	EQUIPMENT ACQUIRED SUBSEQUENT TO			ADDITIONS AND BETTERMENTS															RETIREMENTS			REMARKS
		A.F.E. NO	DATE	AMOUNT	A.F.E. NO	DATE	AMOUNT	A.F.E. NO	DATE	AMOUNT	A.F.E. NO	DATE	AMOUNT	A.F.E. NO	DATE	AMOUNT	A.F.E. NO	DATE	AMOUNT	A.F.E. NO.	DATE	AMOUNT	
51																							
52																							
53																							
54																							
55																							
56																							
57																							
58																							
59																							
60																							
61																							
62																							
63																							
64																							
65																							
66																							
67																							
68																							
69																							
70																							
71																							
72																							
73																							
74																							
75																							
76																							
77																							
78																							
79																							
80																							
81																							
82																							
83																							
84																							
85																							
86																							
87																							
88																							
89																							
90																							
91																							
92																							
93																							
94																							
95																							
96																							
97																							
98																							
99																							
100																							

Binding Margin

Exhibit 17

RECORD OF EQUIPMENT CHANGES

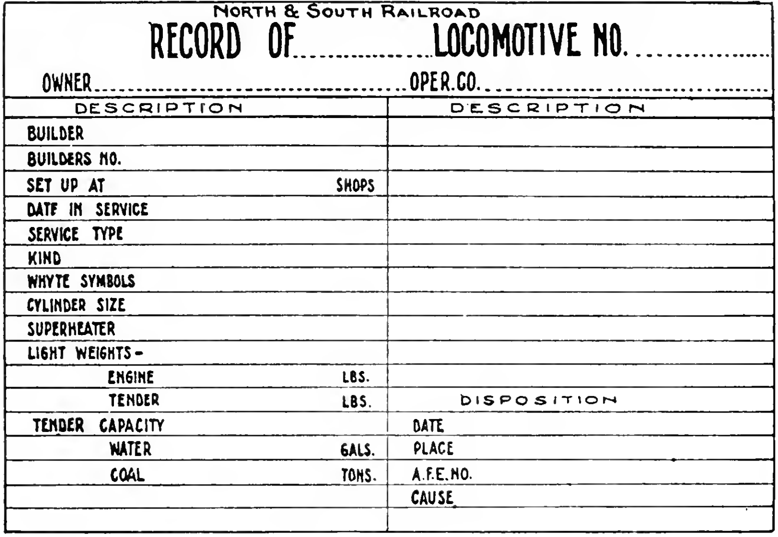
Size of form 8½" × 11"

NORTH AND SOUTH RAILROAD

Exhibit 16

Size of form 4"×6"

Exhibit 18



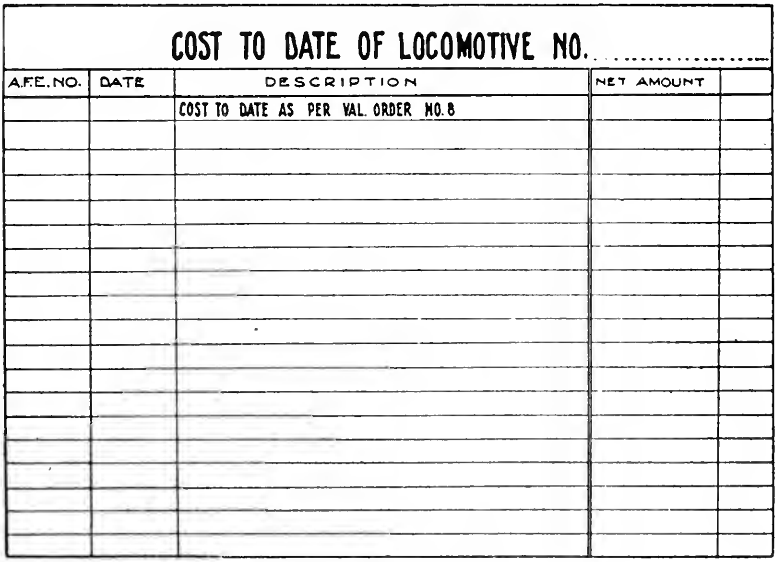
NORTH & SOUTH RAILROAD

RECORD OF .... LOCOMOTIVE NO. ....

OWNER .... OPER.CO. ....

DESCRIPTION		DESCRIPTION
BUILDER		
BUILDERS NO.		
SET UP AT	SHOPS	
DATE IN SERVICE		
SERVICE TYPE		
KIND		
WHYTE SYMBOLS		
CYLINDER SIZE		
SUPERHEATER		
LIGHT WEIGHTS -		
ENGINE	LBS.	
TENDER	LBS.	DISPOSITION
TENDER CAPACITY		DATE
WATER	GALS.	PLACE
COAL	TONS.	A.F.E. NO.
		CAUSE

FRONT OF CARD



COST TO DATE OF LOCOMOTIVE NO. ....

A.F.E. NO.	DATE	DESCRIPTION	NET AMOUNT	
		COST TO DATE AS PER VAL. ORDER NO. 8		

REVERSE SIDE OF CARD

This is a form to be used as a record of changes for each unit of Account No. 51, "Steam Locomotives" and Account No. 52, "Other Locomotives."

It is an index filed by unit numbers and summarizes by A.F.E's all completion reports affecting each unit.

Size of form 4"× 6"

Exhibit 19

NORTH & SOUTH RAILROAD

FLOATING EQUIPMENT

RECORD OF EQUIPMENT CHANGES No.............

OWNER.. OPER.CO. ....

DESCRIPTION	DESCRIPTION
	REMARKS

FRONT OF CARD

A.F.E. No.	DATE	DESCRIPTION	NET AMOUNT	

REVERSE SIDE OF CARD

This is a form to be used as a record for each unit of Account No. 56, "Floating Equipment." It is an index filed by unit numbers and summarizes by A.F.E's all completion reports affecting each unit.

Size of Form 4"x6" Exhibit 20

NORTH & SOUTH RAILROAD

MISCELLANEOUS EQUIPMENT

RECORD OF EQUIPMENT CHANGES No.............

OWNER ....OPER. CO. ....

DESCRIPTION	DESCRIPTION
	REMARKS

FRONT OF CARD

A.F.E. No	DATE	DESCRIPTION	NET AMOUNT	

REVERSE SIDE OF CARD

This is a form to be used as a record for each unit of Account No. 58, "Miscellaneous Equipment." It is an index filed by unit numbers and summarizes by A.F.E's all completion reports affecting each unit.

Size of form 11"×17"

Binding Margin ↗

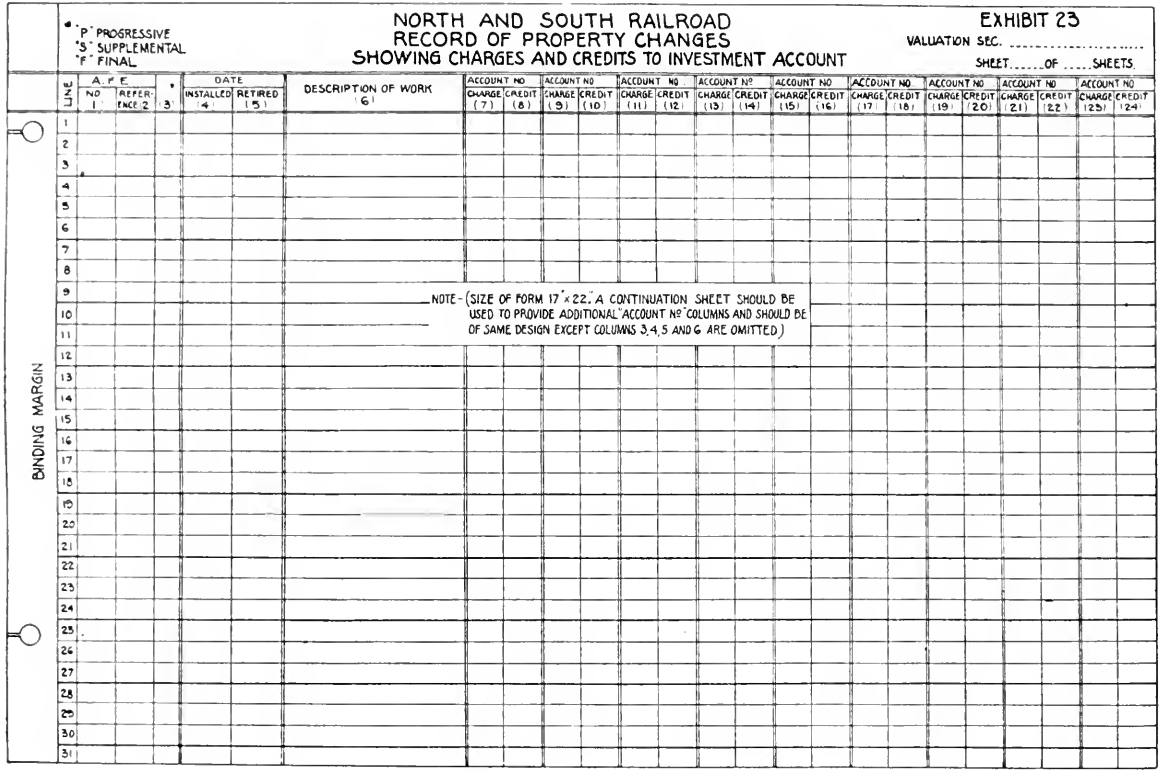
Exhibit 22

North & South Railroad
RECORD OF PROPERTY CHANGES

Description of item ……………………………………

Unit ……………
Account No. ……………
Valuation Section ……………

AFE No or Reference (1)	Date Completed or Retired (2)	Location & Description (3)	Added		Retired		Remarks (8)
			Number of Units (4)	Cost (5)	Number of Units (6)	Cost (7)	



* "P" PROGRESSIVE
"S" SUPPLEMENTAL
"F" FINAL

NORTH AND SOUTH RAILROAD
RECORD OF PROPERTY CHANGES
SHOWING CHARGES AND CREDITS TO INVESTMENT ACCOUNT

EXHIBIT 23

VALUATION SEC. ....

SHEET...... OF ...... SHEETS.

BINDING MARGIN

LINE	A.F.E.		*	DATE		DESCRIPTION OF WORK (6)	ACCOUNT NO		ACCOUNT NO		ACCOUNT NO		ACCOUNT Nº		ACCOUNT NO		ACCOUNT NO		ACCOUNT NO		ACCOUNT NO		ACCOUNT NO	
	NO (1)	REFERENCE (2)	(3)	INSTALLED (4)	RETIRED (5)		CHARGE (7)	CREDIT (8)	CHARGE (9)	CREDIT (10)	CHARGE (11)	CREDIT (12)	CHARGE (13)	CREDIT (14)	CHARGE (15)	CREDIT (16)	CHARGE (17)	CREDIT (18)	CHARGE (19)	CREDIT (20)	CHARGE (21)	CREDIT (22)	CHARGE (23)	CREDIT (24)
1																								
2																								
3																								
4																								
5																								
6																								
7																								
8																								
9																								
10																								
11																								
12																								
13																								
14																								
15																								
16																								
17																								
18																								
19																								
20																								
21																								
22																								
23																								
24																								
25																								
26																								
27																								
28																								
29																								
30																								
31																								

NOTE—(SIZE OF FORM 17" × 22." A CONTINUATION SHEET SHOULD BE USED TO PROVIDE ADDITIONAL "ACCOUNT Nº" COLUMNS AND SHOULD BE OF SAME DESIGN EXCEPT COLUMNS 3, 4, 5 AND 6 ARE OMITTED.)

record only gross charges and gross credits, by valuation sections, by primary Investment accounts.

The Sub-Committee, in its investigation of the entire subject, is of the opinion that this record serves no useful purpose to carriers and that as years go by the immense volume of the record will be such as to preclude any possible use. It has been found that those carriers who have attempted to use the record, after a lapse of some years from the date they were valued, found it necessary to seek recourse in the basic record, the Roadway Completion Report, in order to bring the valuation down to date on any basis.

So long as carriers are required to maintain a "Record of Property Changes," the Sub-Committee recommends two methods as follows:

Roadway Changes

(1) Exhibit 21 has been designed for the use of the larger carriers and it permits of recording the units added and the units retired with the attendant costs of such units. It is similar to the mandatory form in Valuation Order No. 3, Second Revised Issue, except that several additional columns have been provided so as to allocate the cost to units added and retired.

(2) For the smaller carriers, Exhibits 22 and 23 have been designed for recording property changes. Exhibit 22 requires a separate sheet for each unit; accordingly there will be a number of sheets for each primary account.

The record is to be maintained separately by valuation sections and is of some advantage over Exhibit 21 as it permits of accumulating the expenditures, year after year, for any group of units, particularly by individual structures.

Each year the gross charges and gross credits recorded on Exhibit 22 should be summarized on Exhibit 23 for the purpose of preparing the annual returns to the Investment Account as required by Valuation Order No. 3, Second Revised Issue, on B.V. Form No. 589.

Equipment Changes

The subject of recording equipment changes has been covered under Subject No. 3, "Forms for Recording Changes in Physical Property," (h) "Equipment Index—Record of Property Changes," and the recommendations are that the method outlined should be followed, in lieu of using the same "Record of Property Changes" as for roadway work.

Exhibit 21

RD OF PROPERTY CHANGES

Exhibit 21

State of
Valuation Section

NORTH & SOUTH RAILROAD
RECORD OF PROPERTY CHANGES

Account No. ....

Sheet No. of .... Sheets
Year Ended December 31, 192....

Binding Margin

	A.F.E. Number and Reference (1)	DATES Installed (2)	DATES Retired (3)	Charges for Property Installed (4)	Credits for Property Retired (5)	Remarks (6)	Added (7) Cost	Retired (8) Cost	Added (9) Cost	Retired (10) Cost	Added (11) Cost	Retired (12) Cost	Added (13) Cost	Retired (14) Cost	
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

Note:- Columns should be printed on reverse side. A continuation sheet should be used the same as this form but omitting columns 2, 3, 4, 5 and 6. To indicate quickly to the eye, the continuation sheet should be printed in a different color. Size of form 11"×22"

Exhibit *21*

Record of Property Changes

recoı
Inve

opin
year
poss
use ·
foun
pleti

Chaı

Appendix B

(3) THE FEASIBILITY OF REDUCING THE NUMBER OF FORMS IN MAINTENANCE OF WAY AND ENGINEERING DEPARTMENTS, COMBINING FORMS AND SIMPLIFYING THOSE RETAINED

E. B. Crane, Chairman, Sub-Committee; A. C. Copland, W. A. Hill, T. J. Irving, H. T. Livingston, H. F. Sharpley, W. A. Van Hook.

This subject when assigned was considered by the Committee to require the preparation of a catalog of all maintenance of way and engineering department forms of a number of different railroads; the preparation of a table showing the number of roads using each form; the pointing out of duplication, useless or obsolete forms, those aiming at results given on other forms, and finally to draw up an essential list of forms with recommended designs.

Accordingly, such forms were obtained from twenty different railroads. From a study of these it was apparent that because of the varied types of organizations disclosed, a full and complete understanding of all the organizations as well as a full knowledge of the operations directed and ends sought would be necessary.

This Committee heretofore has encountered difficulties in its consideration of forms because of the variety of organizations and in its report to the Eleventh Annual Convention gave as its conclusions that a definite kind of organization would have to be adopted before it was practicable to either approve or disapprove certain forms in any department.

Many railroads have form committees, and it is thought that the work suggested by the subject assigned may best be done by such committees, or by specialists retained for this specific purpose. A study by a committee, or by specialists, in cooperation with heads of departments will, by bringing under consideration all forms in use, develop obsolete and unnecessary forms and some that may be combined, and others that may be reduced in size or otherwise revised. It has been pointed out to the Sub-Committee that savings of 10 per cent to 25 per cent in the cost of forms have been secured on some railroads where such studies have been made.

In 1917 a committee, known as the "Forms Standardizing Committee," was organized on the Southern Pacific Lines to make a special investigation of the forms in use and to carry out for those lines practically the same ideas as the subject assigned to this Committee contemplates, excepting that the Southern Pacific committee considered all forms for all departments. As a result of this committee's work 44 per cent of forms considered were discontinued, as is shown in a paper prepared and read by E. B. Stewart, Chairman of the Forms Standardizing Committee of the Southern Pacific Lines, before the Pacific Railway Club and appearing in the September, 1918, issue of the Proceedings of that Club, and here reprinted as a supplement to this report.

Another company reports the examination of over 2500 forms, resulting in the abandonment of 25 per cent and the revision of 32 per cent—the remaining 43 per cent being either approved without change or with sufficient stock on hand to last for some time, it being the intention to either revise or abandon the latter when the present supply is exhausted.

The report of the Interstate Commerce Commission, Bureau of Statistics, for the year ending December 31, 1924, shows that for Class I roads there was charged under Railway Operating Expenses, Maintenance of Way and Structures, to the Account, Stationery and Printing, $1,340,236, or .17 of 1 per cent of the total charge to Maintenance of Way and Structures for that year. The total charge for Stationery and Printing, for all accounts, for that year amounted at $32,320,987, or .72 of 1 per cent of the total charge to Railway Operating Expense.

The Stationery and Printing Account includes cost of items other than forms, but from the best information obtainable the cost of forms represents one-third of such expense. It is quite apparent, therefore, that if the work done on some roads may be taken as a criterion such studies will result in a very considerable saving.

The adoption of various forms by the Association, and their publication in the Manual, constitute recommended practice and this section of the Manual should be consulted when engineering and maintenance of way department forms are being revised.

Conclusions

This Sub-Committee is of the opinion that the task imposed by the subject assigned is too great for it to handle in detail.

Because of the different organizations of maintenance of way and engineering departments, of changing general conditions, and of the varied practices, operating conditions and requirements of officers, it is considered impracticable for this Committee to devise a complete set of standard forms for all railroads for the maintenance of way or engineering departments, but from the experience of those railroads who have made a study of this subject it has been proven feasible to reduce the number of forms, combining others and simplifying those retained, resulting in a very material saving of money.

This report is submitted as information with the recommendation that the subject be discontinued.

THE WORK OF THE FORMS STANDARDIZING COMMITTEE

By E. B. Stewart

Chairman, Forms Standardizing Committee, Southern Pacific Company.

The opportunity for standardization of Stationery Forms on the Southern Pacific Lines was possibly greater than on many other lines, due to the fact that there were four separately operated companies, namely: Southern Pacific Company, Pacific System; Southern Pacific Lines in Texas and Louisiana; Arizona Eastern Railroad, and Southern Pacific Railroad Company of Mexico—each under the jurisdiction of a president reporting to the chairman of executive committee and each company being operated along similar lines. Economy in stationery is largely governed by the quantities in which it can be purchased and it was therefore apparent that forms which could be used by all four companies and the annual requirements of each line printed at the same time, would result in considerable saving, and with this in view the Southern Pacific Company adopted the following methods and classes of forms:

(1) Common Standard Forms:

(a) Forms used by two or more lines and of which a single stock can be printed, including those bound into books not lettered for any particular line.

(b) Book forms used by two or more lines, lettered on the back or side for the road by which used.

(2) Standard Forms:

(a) Forms of which a single stock can be printed for one or more lines, and other lines using corresponding forms which differ in some respects.

(b) Forms which are similar for all lines except in the name of the road, titles of officers and location printed thereon.

(c) Forms giving similar information for all lines, but showing same by roads, divisions or districts.

(d) Forms bearing the same general title and used by one or more lines for the same general purpose, but differing in some respects account special requirements of each line.

Forms (a) and (b) include books of permanent record, which, although similar in other respects for all lines, have the name of road printed on each page as well as on the back of book.

(3) Local Forms:

Forms used by one line only, to meet local conditions.

(4) Temporary Forms:

Temporary forms deemed necessary to facilitate the handling of the work when common standard, standard or local forms have not been prescribed.

While this method of handling stationery forms was in effect for a number of years, conditions changed somewhat and the various lines drifted away to a certain extent from prescribed methods and established many local forms. Not only were such local forms established by different lines, but this policy was followed by various departments of each line, and, as a consequence, different departments and lines each had a separate form designed for the same purpose, resulting in a large number of local forms in use, which are the most expensive because they are usually printed in small quantities. Therefore, a committee was formed to make a special investigation of the forms in use and to substitute, wherever practicable, common standard forms uniform for all lines, or to discontinue the use of a number of such blanks. Accordingly a sample of every form in existence on the four lines was obtained and the committee, a representative from each of the Accounting and Operating Departments of the various lines, convened in San Francisco, California, May 21, 1917, to make an examination of such forms.

The forms were assembled and assorted by subject, using the Williams Decimal Filing System, and each subject subdivided so as to make an appropriate subject for the various kinds of forms accumulated under the primary subject.

Each form, regardless of its origin or series, was reviewed as to the following general points:

(1) Necessity for its continuance.
(2) Its relation to similar forms of the same and other departments.
(3) Its color, size and kind of ink.
(4) Grade and weight of paper.
(5) Standardization of methods to the end that the same form could be used by other departments or other offices of the same department.

In making this review and considering each individual form, the committee called in and obtained the advice of the expert in the department in which the form was used before recording its recommendations, with the result that both committee and expert were able to offer suggestions advantageous to each other and therefore avoided recommendations that could not be placed in effect due to peculiar conditions prevailing.

After this examination was completed the committee proceeded to place their recommendations in effect, through medium of correspondence. First, the approval of the officer in charge of the department in which the proposed change was to be made, was obtained. Second, the approval of the chairman of the executive committee was obtained. Third, the proposed change was made effective by communicating with the department using form, General Stationer and Stationery Storekeeper.

Results of the investigation were that:

6,959 forms were considered.
3,080 forms, or 44.2 per cent, were discontinued.
848 forms, or 12.1 per cent, were revised.
3,031 forms, or 43.7 per cent, were approved without change.

Forms were discontinued by following methods:

(a) Assignment of standard form numbers to local forms used by different lines for the same purpose, methods or conditions differing somewhat.

(b) Local forms were discontinued by the establishment of Common Standard Forms.

(c) Forms of all kinds were discontinued which had been established for the exclusive use of one department without first ascertaining what forms were being used for a similar purpose by other departments.

(d) Hundreds of locally prepared forms were discontinued because:

(1) Information not necessary.
(2) Special form not necessary.
(3) They were used to supplement existing forms, instead of revising existing forms to meet requirements.
(4) User failed to consult other offices as to their needs, and
(5) Lack of knowledge of other forms in existence.

(e) Self-addressed envelopes and letterheads of minor officials were discontinued.

(f) Distinctive colored envelopes were discontinued where plain re-use envelopes would serve as well.

Forms were revised to produce economy and to standardize their preparation as follows:

(a) Reduced in size.

(b) Eliminating instruction from form. Usually such instructions can be given through the medium of a circular letter, making them unnecessary on the form. Such elimination permitted reduction in size of forms or increasing writing space.

(c) Some forms were reduced to single typewriter space instead of double, thereby reducing their size.

(d) Post cards were established instead of postal cards. In large cities mail delivery is made by messengers, making postage stamps unnecessary.

(e) Post cards were established in place of form letters for tracers, acknowledgments, advices, etc., to eliminate use of envelopes.

(f) Cheaper grades of paper were established for various forms.

(g) Colored papers were eliminated where possible.

(h) Expensive binders, perforations, crimping of binding margins, numbering forms consecutively, the printing of the words "Original," "Duplicate," "Triplicate" have been eliminated where possible.

(i) Books bound with stubs and perforated were discontinued and in place thereof gummed pads without stubs have been established.

(j) Use of caption "Southern Pacific Lines" was inaugurated on standard forms which do not require the name of the corporate properties so that entire stock of such forms for Pacific System and lines in Texas and Louisiana, where they are similar in all other respects, may be printed at the same time.

(k) Blue cobweb bond letterheads have been changed to white onion skin of the same grade, which is cheaper.

(1) The suffix "B" has been added to white onion skin letterheads, suffix "C" to note size and suffix "D" to mimeograph letterheads to better identify them.

(m) Copying ink has been eliminated where not necessary and black non-copying ink, which is cheaper, used in its stead.

(n) Titles have been assigned to forms which have heretofore not borne a title.

(o) Titles of forms have been changed to more appropriate and concise wording.

(p) Card indexes have been established in place of more expensive book records.

(q) Printing has been eliminated from file backs and plain file backs established in their stead.

(r) Bound book records have been supplanted with loose-leaf records, which are cheaper.

(s) Printing of forms when they can be secured free or cheaper from American Railway Association, Interstate Commerce Commission, Bureau of Explosives, Manufacturers, etc., has been discontinued.

(t) A number of forms have been printed on both sides where heretofore they were printed on but one side.

(u) Some forms which have been prepared on blue print papers have been supplanted by printed or process forms, which are cheaper.

(v) Fold-over forms have been discontinued where possible, as they are expensive, and in place thereof padded forms substituted.

(w) Printed forms used as working sheets have been discontinued and statement papers or working sheets without headings substituted.

(x) Re-use envelopes have been established where possible.

(y) Colored rulings of statements have been eliminated where possible to permit their preparation by the wax plate process, which is cheaper.

It was found that many forms required by the different offices were being rendered daily, weekly and monthly by agents, trainmen and others, with the notation "Blank," "Nothing," etc., which meant that a large blank was practically wasted, probably costing several dollars per thousand. The committee, therefore, designed a special form entitled "Nothing to Report," size 5 x 3 inches, to be printed on cheap paper costing less than one dollar per thousand, and arranged for its use by all offices. The estimated annual requirements of this form being over one hundred thousand, the saving effected by its use is therefore apparent.

In days gone by it was the custom to print thousands of forms in copying ink so that impression copies could be made. When the press copy went out of date to a large extent the copying ink was still used, though not necessary. Inks of all kinds cost money these days, but copying ink costs by far the most, and the substitution of black non-copying ink for copying ink means substantial economy.

The following are a few examples showing the results obtained by the review of and standardization of stationery forms.

(1) Transmittals:

Almost every department had in use various kinds of forms for the purpose of transmitting documents between departments, etc. The committee took one form and by a slight revision in title, make-up and size, permitted its use by all departments of the various roads, thereby discontinuing the use of nineteen separate forms.

(2) Acknowledgments:

A standard post card acknowledgment was used by one department and by a slight revision as to form it was made common standard and adopted for use of all departments, thus permitting the discontinuance of ten distinct forms.

(3) Request for Replies:

A standard post card tracer for reply was revised and adopted as common standard for use of all departments, this permitting discontinuance of twenty-three separate forms.

(4) Tracer for Delayed Reports:

A post card tracer for delayed reports form was established by the committee, which permitted discontinuance of thirty-three separate forms.

(5) Envelopes:

A number of re-use envelopes already in use provided for addresses on the front side only. The committee decided they could increase the efficiency of such envelopes and had space provided on back for as many addresses as were shown on front, thereby increasing the use of envelope just one hundred per cent.

The economies derived from the discontinuance of certain forms and substituting others in their place was obvious. First, it increases the requirements of the form substituted, permitting the printing in large quantities, which from an economical standpoint is one of the greatest factors in purchasing stationery.

Second, it decreases the amount of capital necessary to keep your stock of stationery on hand.

Third, it reduces the amount of space necessary to properly store the stock, as well as decreases the amount of labor and clerical cost in handling and accounting.

That economies effected by the work of the committee might be maintained and supervision exercised over the printing and establishment of new forms, a permanent Forms Standardizing Committee was established. The Sub-Committee and General Chairman are to be guided in their work substantially by rules embodied in the following working memorandum:

Working Memorandum for Guidance of Permanent Committee on Standardization of Forms

(1) Recommended changes, elimination or establishment will be referred by the office originating, through proper channel, to the chairman of the sub-committee of the lines on which the recommendation originates.

(2) Local members of the sub-committee will conduct necessary investigation as to the necessity and desirability of the proposed change on their lines.

(3) To be then referred to the chairman of the sub-committee on the other lines for their investigation and recommendation.

(4) If not desired on other lines, chairman of the sub-committee of the lines with whom the recommendation originates, may place the change in effect locally.

(5) Emergency local forms may be authorized by chairman of sub-committees and investigation with other lines conducted as early as practicable.

(6) If standard or common standard form and change meets with approval of all of the lines concerned, the general chairman of the committee on Standardization of Forms will prepare the recommendation for submission to the chairman of the executive committee through proper channels.

(7) No process forms to be established, changed or discontinued by an office without reference to the chairman of the sub-committee of the lines on which the blank is used.

(8) No process forms to be established by an office until a form number has been assigned thereto by the chairman of the sub-committee.

(9) A complete file of all forms of all lines to be maintained by the sub-chairman of the committee of each line.

Contrary to the expectations of the committee, absolutely no difficulty was experienced in convincing department heads of the advisability of changes recommended. Usually it can be assumed that those responsible for a department feel that they know more about their own reports than anyone else, but no such attitude was evident during our investigation. The plan of a well organized committee systematically investigating forms, reports and office methods, and handling their work in a helpful manner without the spirit of criticism, can produce well worth-while results, if properly supported by department heads.

Appendix C

(6) COMPARISON OF DAILY AND MONTHLY TIME AND MATERIAL REPORTS

J. H. Hande, Chairman, Sub-Committee; Z. M. Briggs, H. C. Crowell, F. W. Hillman, H. T. Livingston, R. E. Patterson, C. K. Smith.

Introduction

In its report to the 1925 convention, Committee XI—Records and Accounts, presented as Appendix "C" its arguments for the use of daily time reports, and developed a form for such a report which it considered as fulfilling all of the essential requirements.

In making its presentation, the Committeee stated that the assigned subject "could be considered sufficiently broad to permit of an examination of all reports concerning maintenance of labor and material." The Committee further stated that "In addition to the basic forms for use of the foreman in reporting time and material consumed, forms should be provided for assembling this information promptly and economically; that is, in a manner that will give the greatest benefit to the Maintenance Engineer, consistent with the cost of assembling it. These consolidating or condensing forms will be the subject of subsequent reports."

Work Remaining to be Done Under This Assignment

In continuing the study under this assignment, there remains, therefore, the development of a daily material report and the outlining of a procedure, and forms for condensing and classifying the data that would be collected on these daily labor and material report forms. In carrying out this work, two objectives must be kept constantly in mind: First, that the design of each step in the routine be made with a clear conception of the requirement of the Maintenance Engineer, and second, that the clerical operations above those made mandatory by the Interstate Commerce Commission accounting instructions be kept to a minimum.

Cost and Statistical Data Required by Maintenance Engineer

The statistics which it is considered essential that the Maintenance Engineer be furnished were outlined in the report of the Sub-Committee on "Cost-Keeping Methods, Statistical Records and Forms for Analyzing Expenditures for Assistance in Controlling Expenditures." The recommendations on that subject are shown on the forms facing page 780 of Proceedings for 1925.

The two conclusions enunciated in that report (see page 789, Proceedings for 1925) may well be repeated here. They are (Italics ours):

> "1. The Classification of Operating Expenses as prescribed by the Interstate Commerce Commission, is not formulated to show directly unit costs of any item of Maintenance of Way and Structures, *but these data may be compiled to show unit cost of maintenance per Equated Track Mile or similar unit.*

> "2. Unit costs of the main items of maintenance, particularly those pertaining to Roadway and Track, may be determined by sub-division of the primary accounts in such manner that the charges are allocated to those items. *This sub-division of primary accounts involves some additional expense, which is well justified when the information thus obtained is used in determining and comparing unit costs, and is recommended as good practice.*"

The system designed for gathering these data should be aimed, therefore, at obtaining:

(1) Cost of maintenance per equated track mile or similar unit.
(2) Unit costs of main items of maintenance by sub-divisions of primary accounts.

Classification of Expenditures for Construction Necessary

Incidental to gathering this maintenance unit cost data, consideration must be given to accumulating and classifying the expenditures made by maintenance forces engaged in capital account work. The outlining of the method and forms necessary thereto will be made in cooperation with Sub-Committee No. 2, "Methods and Forms for Gathering and Recording Data for Keeping Up-to-Date the Physical and Valuation Records of the Property of Railways."

Outline of a Typical Reporting System (Exhibit 1)

To show the essential steps in assembling maintenance data and for classification of capital account expenditures, and to show how the work of this Sub-Committee is coordinated with that of the two Sub-Committees previously mentioned, a chart is appended as Exhibit 1.

On this chart, which is to be read from top to bottom, the forms which this Sub-Committee will undertake to develop are shown in heavy full lines. The Unit Cost forms, already designed by the Sub-Committee on "Cost-Keeping Methods, etc.," are shown in heavy dotted lines. Other forms essential to the accounting for labor and material expenditures, and essential as statistical information, but which will not be touched upon by this Sub-Committee, are shown in light full lines. It is evident that many of these forms so indicated are of a purely accounting nature, and still others, while essential, are not within the scope of this Sub-Committee's assignment. All are shown on this chart, however, as parts of a typical plan, and in order that the entire reporting procedure may be visualized.

Operations Involved in Complete Report Procedure (Exhibit 1)

From an inspection of the chart of typical report procedure, it will be seen that the operations involved may be considered in distinct groups:

(A) *Field Reports by Foremen, Blocks 1 to 6.*—These reports are the foundation for all further accounting and statistical operations.

EXHIBIT I

NORTH AND SOUTH RAILROAD
CHART
OF
ACCOUNTING AND STATISTICAL REPORT PROCEDURE
IN
MAINTENANCE OF WAY DEPARTMENT

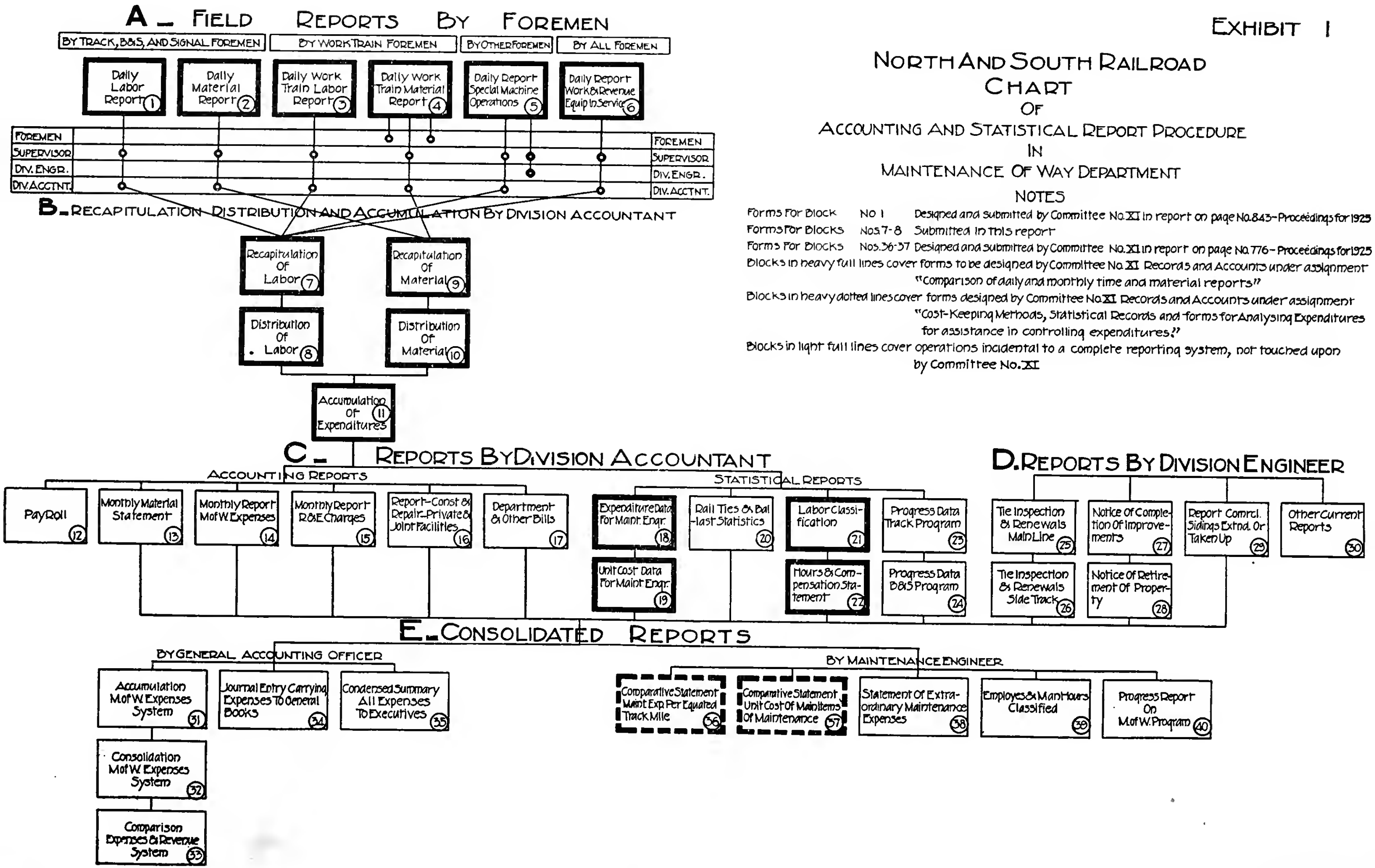
NOTES

Forms For Block	No 1	Designed and submitted by Committee No. XI in report on page No. 843—Proceedings for 1925
Forms For Blocks	Nos. 7-8	Submitted in this report
Forms For Blocks	Nos. 36-37	Designed and submitted by Committee No. XI in report on page No. 776—Proceedings for 1925

Blocks in heavy full lines cover forms to be designed by Committee No. XI Records and Accounts under assignment "Comparison of daily and monthly time and material reports"

Blocks in heavy dotted lines cover forms designed by Committee No. XI Records and Accounts under assignment "Cost-Keeping Methods, Statistical Records and forms for Analysing Expenditures for assistance in controlling expenditures."

Blocks in light full lines cover operations incidental to a complete reporting system, not touched upon by Committee No. XI



(B) *Recapitulation, Distribution and Accumulation by Division Accountant, Blocks 7 to 11.*—In the operations represented by these blocks, the Division Accountant collects and distributes the items of labor and material shown on the foremen's reports, and from a classified accumulation prepares a statement of charges to the appropriate accounts.

(C) *Reports by Division Accountant.*—These are divided into blocks 12 to 17, accounting reports, and blocks 18 to 24, statistical reports.

(D) *Reports by Division Engineer, Blocks 25 to 30.*—A few reports are shown under this caption. Practices vary so widely in this group that it should be viewed as only generally typical.

(E) *Consolidated Reports, Blocks 31 to 35,* are made by the general accounting officer, and *blocks 36 to 40* by the Maintenance Engineer.

We are particularly interested in showing in this chart the steps by which unit costs of doing work are developed from the foreman's daily reports.

Forms and Operations Covered in This Report

Of the work still to be done by this Sub-Committee, it has been thought most expedient to consider this year the recapitulation and distribution of labor, leaving the development of a daily material form and further accumulation studies for subsequent years' work.

The forms to be developed this year are those covered by blocks 7 and 8 on chart of procedure, Exhibit 1. These are:

1. *Recapitulation of Labor* (block 7), so that there may be developed, (a) the amount due each employee for labor performed; (b) the average rate of pay, and (c) the total expenditures for each gang.
2. *Distribution of Labor* (block 8), to primary and sub-primary accounts, and to other than maintenance work.

Form for Recapitulation of Labor (Exhibit 2)

In developing a form for making recapitulation of labor, the first consideration becomes that of providing the most efficient means of transcribing on to a record sheet the details from the foreman's report of time worked by each employee, with the necessary information as to rate of pay, kind of time, gross amount due, deductions and net amount due.

There is almost an unlimited variety of choice as to size and arrangement for such a recapitulation sheet. The Sub-Commitee submits as Exhibit 2, a form which it believes fulfills the essential requirements, and which is readily adaptable to different standards and practices.

The principal features of this form are as follows:

> The size of sheet recommended is 17 by 28 inches, with spaces on each sheet for recording 19 employees. The sheets are arranged for binding on the right-hand margin instead of the left. It has been found that under practical working conditions, the clerk making the entries usually transcribes from the daily reports held at his

> left hand. With the sheets bound at the right, the pages from and to which the transcription is being made are closer together.
>
> Four lines are allowed for each name to show the kinds of time worked, each of which carries a specified rate. The symbols for these kinds of time agree with the captions used in the forms prescribed by United States Railroad Labor Board for reporting service and compensation of railroad employees.
>
> The sheet permits entering both halves of the month on the line for each employee whose name and number is entered only once at the left-hand side of the sheet. This gives the entire month's record on one page, which is important, as statistics are prepared on a monthly basis, although the showing of each half is essential for payroll purposes. An examination of the forms used by 12 representative roads shows that 9 of these roads followed the above system, only 3 showing each half separately, making the same form usable for each half by giving the date columns double headings.
>
> The column "Total Actual Hours" would show the total actual hours for each kind of time carrying different rates. These actual hours are equated by the appropriate factor, and the equated total hours is placed in the "Sub-Total Hours" column, which, added together in Total Hours column, is to be multiplied by the fixed rate, giving the amount earned.
>
> The columns for various deductions may be captioned to fit the plan of organization prevailing on each system, to take care of pensions, savings, sick benefits, commissary, etc. Those cited on the form are for illustrative purposes.

As stated in this Sub-Committee's previous progress report, foremen enter on their daily time report actual hours worked. They are not permitted to equate these by the factors stipulated for various kinds of time. As shown above, actual hours are to be entered on Exhibit 2 each day, the equation by the stipulated factors being done only at the end of each payroll period, in the office of the Division Accountant.

In transcribing the daily report onto this time sheet, foremen and timekeepers are to be listed first on the sheet, grouping the laborers following. In accordance with the system outlined in the previous report of this Sub-Committee, laborers' hours only are to be totaled and applied against the aggregate earnings of the gang, developing an average labor cost which includes a proportionate share of the supervision represented by the earnings of the foreman and timekeeper. The laborers' time each day should be totaled at the bottom of the sheet to check against the total of laborers' time on the foreman's daily report, and on the distribution sheet to be discussed later.

The question next arises as to the necessity of periodical totals for time worked with the consequent total expenditures. The only occasion for taking off totals at other than at the end of semi-monthly payroll periods is to note the amount of earnings accrued as against allotments, in order that arrangements may be made not to exceed such allotments.

Provision is made on the distribution form, next to be discussed, for taking off totals of actual hours worked, by classes of work, after the 7th, 15th and 22nd of each month. This is done primarily to note progress on classified track and program work. This periodical totaling on the distribu-

ngs
urs
ich

for
ces.
avy
any
.

m-
er-
his
ual

ing
ibit
ore-
unt
to
erce
.
d to
nary
tion
has
data
ains
erve
tion.
rms
are
d at
.
rack

S.,
as to
sion

ittee
r of
the
ifica-
r by

xhibit 2

APITULATION OF LABOR

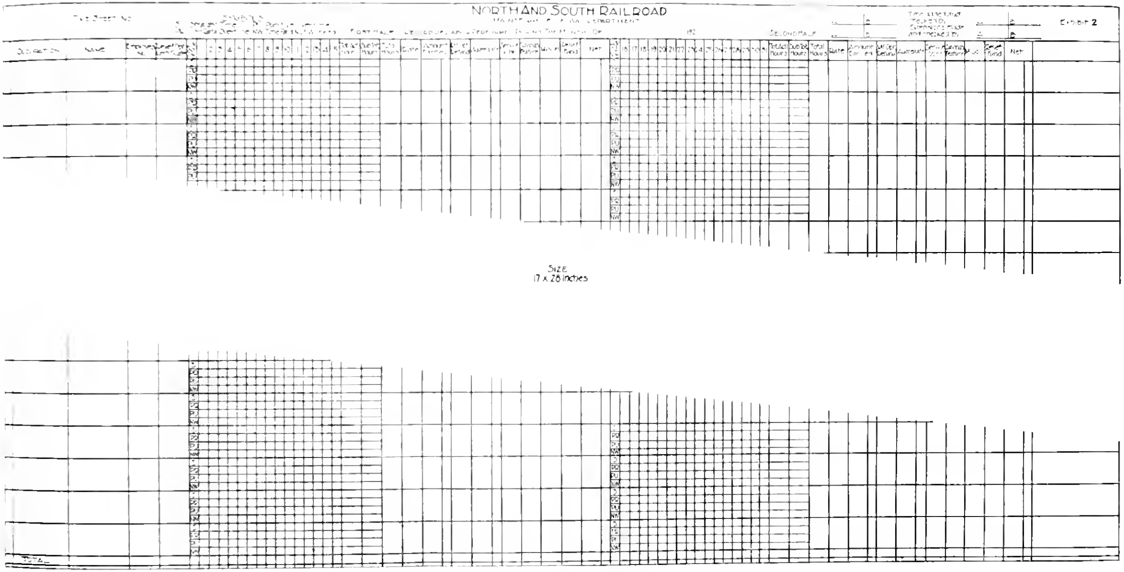


Exhibit 2

NORTH AND SOUTH RAILROAD

192

SECOND HALF

Occupation	Name	Employee No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Tot. Act. Hours	Sub Tot. Hours	Total Hours	Rate	Amount Earned	Net	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Tot. Act. Hours	Sub Tot. Hours	Total Hours	Rate	Amount Earned	Relief Fund	Net
TOTAL																																														

SIZE
17 x 28 Inches

Exhibit 2

FORM FOR RECAPITULATION OF LABOR

l
t

w
t
s
a

li
at
r
o
f
r
s
u

h
h
h
g
gi

th
p
th

A
enter
mitted
As sh
the eq
payrol
In
keeper
In acc
Comm
aggreg
includ
of the
totaled
time
discuss
T
time
for ta
periods
in ord
Pr
taking
15th a
classifi

tion sheet may be made to serve the purpose of a check of accrued earnings against allotment by applying against such periodical total of actual hours worked, an average rate developed from the last payroll period, which should be close enough for that purpose.

As far as this Sub-Committee is concerned, it can see no necessity for making a daily accumulation of earnings accrued by maintenance forces. Such daily accumulation would serve no useful purpose and involves a heavy burden of clerical work. If each day's hours are totaled as reported, any special request for status can be developed from these totals.

Consideration has been given to furnishing a form whereon to summarize the total hours worked and amount carried by sub-divisions, supervisors' districts, or other groupings for each payroll period or month. This can be done on the form, Exhibit 2, using gang numbers in place of individual employees' names.

Forms for Distributing Labor (Exhibits 3 and 4)

As previously stated, the labor distribution form is used in carrying out the operation covered by block number 8 on chart of procedure, Exhibit 1. The different classes of work done by the gangs as detailed in the foreman's daily report are to be grouped under primary or sub-primary account classification in order (a) that expenditures for labor may be charged to the proper maintenance account, as prescribed by the Interstate Commerce Commission, and (b) that unit costs of doing work may be determined.

It is mandatory that the operation of distributing labor be performed to the extent of obtaining a basis for making the proper charges to the primary maintenance accounts of the Interstate Commerce Commission Classification of Operating Revenues and Operating Expenses of Steam Roads. It has been shown that distribution to that extent only does not give enough data to determine unit costs of doing the principal items of work. It remains to be shown how additional data can be gathered in this operation to serve that purpose without material increase in the cost of making such distribution.

Exhibits 3 and 4, appended hereto, are submitted as distribution forms that will accomplish the purpose with the greatest facility. These forms are to be printed on one sheet, Exhibit 3 being printed on one side to bind at right-hand margin, and Exhibit 4 on reverse to bind at left-hand margin.

Exhibit 3 is designed for distributing the maintenance items of track labor.

Exhibit 4 is designed to distribute labor of other gangs, B. & S., Signal, Extra, etc., to classified structures and program work, as well as to furnish an extension to Exhibit 3, to which it is opposite. This extension will carry items of section labor other than maintenance.

As shown on the daily report form designed by this Sub-Committee last year, the foreman has instructions as to the amount and character of detail to be reported. The distribution sheets herein designed set up the sub-primary classifications to which labor is to be distributed, these classifications and groupings being carried to the point recommended last year by

Size 11x17 Inches

Exhibit 3

NORTH AND SOUTH RAILROAD

Distribution Of Time Made By Gang Sub-Division No. 192

Date	202 Roadway Maintenance									218 Ballast			220 Track Laying And Surfacing																				221	225	272						
	A	B	C	D									A-Applying Ballast				B-Applying Ties					C-Applying Rail					D-Ap. O.T.M.		E-Tr. Mts.												
	Ditching	Care Of Roadbed	General Cleaning	Track Walking	Road Watchmen					1st Unloading Stone	1st Unloading Gravel	1st Unloading Other	Stone	Gravel	Other	Cleaning Stone	Unloading & Distributing Ties	Renewing Switch Ties	Renewing M.T. Cross Ties	Renewing S.T. Cross Ties	Respacing	Laying New Rail	Handling New Rail	Laying Repair Rail-Main	Laying Repair Rail-Side	Handling Repair Rail	Applying O.T.M. Main Trk	Applying O.T.M. Side Trk.	Line & Surface Main Trk	Line & Surface Side Track			Right of Way Fences	Crossings & Signs	Removing Sand Snow-Ice					Total Hours	
1																																									
2																																									
3																																									
4																																									
5																																									
6																																									
7																																									
8																																									
9																																									
10																																									
11																																									
12																																									
13																																									
14																																									
15																																									
16																																									
17																																									
18																																									
19																																									
20																																									
21																																									
22																																									
23																																									
24																																									
25																																									
26																																									
27																																									
28																																									
29																																									
30																																									
31																																									
TOTAL HRS.																																									
AVG. RATE																																									
AMT.																																									

Size 11x17 Inches

Distribution Of Time Made By Extra Or Section Gang
On A.F.E.-I.&C.-Other Dpts. Etc.
Distribution Of Time Made By Carpenters, Signalmen Etc.

NORTH AND SOUTH RAILROAD

Exhibit 4

_______________FOREMEN_______192

	Date	Description Of Work																			
	1																				
	2																				
	3																				
	4																				
	5																				
	6																				
	7																				
	8																				
	9																				
	10																				
	11																				
	12																				
	13																				
	14																				
	15																				
	16																				
	17																				
	18																				
	19																				
	20																				
	21																				
	22																				
	23																				
	24																				
	25																				
	26																				
	27																				
	28																				
	29																				
	30																				
	31																				
	Tot. Hrs.																				
	Av. Rate																				
	Amt.																				

the Sub-Committee on "Cost-Keeping Methods, Statistical Records, etc." (page 780, Proceedings for 1925).

An adequate size for these distribution sheets is 11 by 17 inches, which fits a stock size loose-leaf binder. Captions at the top of the sheet provide for name of gang, foreman, month and year. Dates are placed at the left-hand side of the sheets. Blank lines are allowed after the 7th, 15th and 22nd for sub-totals. This is essential in order that from such sub-totals progress on allotments and programs may be noted. Entries on each day must cross-add into a total for that day in the right-hand column of the exhibit, which total must check with the total actual hours worked, as developed in the recapitulation of labor sheet.

On the "front" sheet, or left-hand sheet, Exhibit 3, are placed the sub-primary distribution columns covering maintenance items of Roadway and Track labor. The sub-primary lettering under Accounts 202 and 220 agree with the sub-primary designations on the unit cost sheet already designed. On the "back" sheet, or right-hand sheet, Exhibit 4, the column headings are left blank to permit writing in the appropriate captions, such as "Renewing Frame Bents, Bridge 89," "Painting Home Signal 45," "Repairs, Jones Siding," etc. Above these blank column headings, a blank space is allowed wherein to enter the account number to which each column designation is properly chargeable.

On the forms submitted will be entered the data from individual gang reports. As with the recapitulation forms, the question next arises as to whether forms should be designed to summarize these gang figures into totals for districts and divisions. Form shown as Exhibits 3 and 4 can be used for this purpose, placing gang designation in the space adjoining the binding margin.

Conclusions

The Sub-Committee feels that the following should be clear from the preceding demonstrations:

(1) The cost of the few additional clerical operations shown herein, over and above the cost of those made mandatory by the Commission's accounting instructions, is small in comparison with the benefits to be obtained from the resulting unit cost data.

(2) The statistical control of maintenance expenditures is desirable and is possible through cooperation of the accounting and maintenance engineering organizations in establishing a simple chain of reporting operations.

(3) As the Maintenance Engineer receives the most benefit, the burden of urging the adoption of a comprehensive reporting system falls upon him and his organization. Persistent effort is necessary to overcome the inertia of the established accounting systems.

REPORT OF COMMITTEE XXIII—SHOPS AND LOCOMOTIVE TERMINALS

F. E. Morrow, *Chairman;*	A. T. Hawk, *Vice-Chairman;*
J. B. Akers,	H. M. Lull,
C. I. Anderson,	R. A. Marshall,
A. Lee Atwill,	J. S. McBride,
C. N. Bainbridge,	J. M. Metcalf,
Leland Clapper,	G. A. Noren,
J. W. Dansey,	D. A. Porter,
K. B. Duncan,	V. B. W. Poulson,
R. J. Hammond,	J. W. Raitt,
George W. Hand,	L. K. Sillcox,
G. W. Harris,	John Schofield,
J. L. Haugh,	B. S. Voorhees,
L. P. Kimball,	H. W. Williams,
W. H. Kirkbride,	A. M. Zabriskie,
W. T. Krausch,	

Committee.

To the American Railway Engineering Association:

Your Committee respectfully presents herewith report covering the following subjects:

(1) General Layouts of Engine Terminals (Appendix "A").

(2) General Layouts and Designs of Passenger Car Repair Shops (Appendix "B").

(3) Ventilation of Engine Houses (Appendix "C").

(4) Storehouses for Shops and Locomotive Terminals (Appendix "D").

Action Recommended

1. That the conclusions in Appendix "A," relating to General Layouts of Engine Terminals, be approved for publication in the Manual.

2. That the conclusions in Appendix "B," relating to General Layouts and Designs of Passenger Car Repair Shops, be approved for publication in the Manual.

3. That the conclusions in Appendix "C," relating to Ventilation of Engine Houses, be approved for publication in the Manual.

4. That the report in Appendix "D," relating to Storehouses for Shops and Locomotive Terminals, be received as information.

Recommendations for Future Work

1. Revision of Manual.

2. General Layouts and Designs of Coaling Stations.

3. Typical Layouts for Storage and Distribution of Fuel Oil, including Fuel Oil Stations between Terminals.

4. General Layouts and Designs of Typical Locomotive Repair Shops.

5. Storehouses for Shops and Locomotive Terminals.

Respectfully submitted,

The Committee on Shops and Locomotive Terminals,
F. E. Morrow, *Chairman.*

Bulletin 281, November, 1925.

Appendix A

(1) ENGINE TERMINAL LAYOUT

for Steam Locomotives

R. J. Hammond, Chairman, Sub-Committee; J. B. Akers, C. I. Anderson, A. Lee Atwill, K. B. Duncan, J. S. McBride, G. W. Harris, G. A. Noren, B. S. Voorhees, A. M. Zabriskie, V. B. W. Poulson.

Engine Terminals are provided so that the Mechanical Forces may care for and repair engines and furnish the Transportation Forces a supply of engines in good condition. To maintain the supply, engines must be handled through the terminal in the shortest possible time, or additional engines assigned to the district.

The development of steam locomotives in weight and tractive power has been so rapid during the past ten or fifteen years as to make the engine terminal a particularly important field for investigation looking toward the effecting of economies. The rapid advance in locomotive design is evidenced by the increase in revenue tons hauled per train mile from 380 in 1910 to 632 in 1923, or about 66 per cent.

The Engine Terminal is one of the most important facilities of a railroad today. Therefore, in order to provide a terminal at a reasonable cost which can be economically and efficiently operated a careful coordinated study by all interested departments is necessary.

While the greater proportion of the time an engine is at a locomotive terminal is due to the time necessary in making repairs or waiting for trains or crews, an improperly laid out terminal will not only retard the movement of engines at all times, but will increase the cost of hostling, and in times of peak business may become the controlling factor in the amount of business which can be handled.

In order that the time locomotives are held at a terminal may be reduced to a minimum the locomotive terminal itself must be coordinated with all other facilities so that the movement of engines may be orderly and expeditiously made from the time engine is detached from its train in the yard or at the station until it is again attached to a train, its fires cleaned, coal, water and sand taken, oiled, wiped, and any needed repairs made, ready in first-class condition, to haul its full tonnage rating to the next terminal.

While an engine terminal designed for the orderly and expeditious movement of engines should reduce the time required by the Mechanical Forces to a minimum, it should be also borne in mind that unless traffic conditions are such that the engines can be used as soon as available, no saving will be accomplished by shortening the terminal time, and that the layover of assigned engines is fixed by schedules.

In order that the engine terminal design may meet all the requirements of a particular location, the cooperation of the operating personnel is necessary.

In order that facilities for proper capacity and spacing may be provided, a thorough study of the traffic to be handled, both for the present and in the future, must be made, for which the following information is necessary:

(a) Type and size of engines to be handled.
(b) Number of locomotives handled in each direction daily by classes.
(c) Schedule of arrival and departure of locomotives by classes.
(d) Number arriving during peak period.
(e) Time within which engines arriving must be hostled by classes.
(f) Maximum number of engines on terminal at one time.
(g) Number engines repaired daily by classes of work.
(h) Number engines under repair at one time by classes of work.
(i) Amount of fuel (coal or oil) issued daily.
(j) Amount of water consumed daily.
(k) Amount of sand consumed daily.
(l) Number of men required to operate the terminal.

While the time required for the movement of an engine from the terminal entrance to the engine house will vary greatly, depending upon the climatic conditions, fuel used, the size of the engine, length of run, class of service and amount of work done at the particular terminal, and this must be determined for each specific location, an average for all will be approximately—

From Terminal Entrance to First Facility..........	5 min.
Outside Inspection................................	30 min.
Cleaning Fires....................................	45 min.
Taking Coal, Sand and Water......................	15 min.
Outside Washing	15 min.
Onto Table—Turning and Into House.............	4 min.
	1 hr. 54 min.

The movement between facilities depends upon capacity of facility, number of men, etc.

With the above information, after making allowances for the probable increase in traffic, changes in operating conditions and methods, etc., a diagram can be drawn for each engine movement, and the capacity of each facility, spacing between facilities and the time required for hostling each engine determined. This will permit the designing and spacing of the various facilities of the terminal for the orderly movement of engines from the entrance to the house.

In view of the expenditure necessary to provide a modern engine terminal, no terminal should be designed without providing for future expansion, so that it may be made with minimum changes to the original plant.

After a thorough study as to requirements has been made and the capacity of the various parts of the facility determined the adequacy of different proposed sites can be determined, and a layout made, adapted to the topographical conditions.

Site

The selection of an economic site requires a study of many features, including—

1. Land value of each possible site for present and future requirements.
2. Cost of preparing site and of foundations.
3. Drainage, sewer disposal, water supply, electricity.
4. Relation with existing or proposed yards and to passenger or freight stations.
5. Labor supply, including housing facilities and transportation.
6. Fire protection.

A comparison of these items for various sites and their relative values will often show that the selection of the more expensive land will be more than offset by the decrease in locomotive terminal mileage, decrease of foundation work, elimination of employee trains, etc.

Track Layout

Unless there are a sufficient number of engines handled to warrant duplicate coaling and ash facilities, all engines should enter the terminal proper at one point, but an emergency exit should be provided so that in case of derailment or other trouble at the main entrance the terminal will not be tied up.

The number of tracks required, spacing of facilities, etc., depends upon the traffic to be handled at the particular terminal. There should, however, be sufficient trackage to permit the prompt receipt of all engines immediately upon arrival, and the leads so located as to provide for the free movement of engines to and from the yards with minimum possible interference with other movements or between in- and outbound engines.

The layout should provide for the orderly movement of engines without reverse movement between the entrance and the turntable, without regard to the time of arrival of preferred engines.

Crossovers should be so arranged that yard engines or others not requiring turning may have their fires cleaned, and take coal and water without crossing the table.

Sufficient trackage should be provided in advance of each facility for the standing of all locomotives which may have to wait their turn so that they will not interfere with the movement of other engines or trains. Where climatic conditions permit of outside storage, sufficient trackage should be provided for engines ready for service, in order to reduce the size of the engine house to a minimum, and so it will not be necessary to overload the turntable during the peak outbound period.

Water Facilities

Water columns serving all tracks should be located near the terminal entrance, but a sufficient distance from the entrance to permit all engines which arrive in a short period (15 to 30 minutes) to clear the main line.

Water columns should also be located near the turntable so that engines housed or stored for long periods may take water without moving the entire length of the terminal.

Inspection Pits

Where climatic conditions are favorable and the type of repairs warrant, inspection pits located near the terminal entrance will permit of a preliminary inspection prior to the locomotive reaching the engine house and advance notice given to the Foreman of the work to be done. Such a pit should result in keeping a large percentage of the engines out of the engine house, particularly where there is a light repair shed.

The capacity required will be dependent upon whether the work is restricted to inspection or whether any running repairs are made on the pits, and the number of engines requiring inspection at one time.

Ash Pits (See Volume 24, pages 66 and 67, A.R.E.A. Proceedings.)

All inbound, and under certain conditions, at least one outbound track should pass over the ash pit or pits, which should have sufficient capacity to take care of the peak-period demand so that cleaning the fires will not delay the expeditious movement of engines throughout the terminal.

Tracks should be so arranged or pits so located that preferred attention may be given to any engine regardless of its arrival time, and so that cinder cars may be loaded and switched with minimum interference to operation.

Pits should be designed and tracks so located that fire cleaners may work on both sides of the engines.

There are several types of ash pits, all of which give satisfactory service, and in selecting a particular type, consideration must be given to: the engine capacity required; type and class of engine handled; cinder storage capacity; loading and switching of cinder cars; cost of operation; maintenance and construction, and the supply of labor available.

Coaling Station

At large terminals the mechanical type with track hopper and automatic elevating machinery is generally used.

If a mechanical type station is selected the track hopper should have sufficient capacity for the handling of one car without the movement of car, and the grade of the coal storage tracks such that the cars may be readily moved with a car puller. Unless provision is made for sufficient storage or other means of coaling during a breakdown of the machinery, duplicate hoisting apparatus is recommended.

In selecting the type of coaling station consideration should be given to the daily consumption, the various grades and kinds of coal, the source of supply, car supply, density of traffic during the winter season and the desirability of having an emergency supply in storage at the terminal, the cost of switching and the cost of construction and maintenance.

The coaling station should serve all inbound and outbound tracks and have bin storage capacity for 36 hours, and where different grades of coal are used it should be designed with separate bins for each grade.

Fuel Oil Stations

Fuel oil delivery columns should be so located as to serve the same tracks as the water columns. In some cases there may be advantage in a location which will permit taking oil and water at one spot.

Unloading and storage facilities should preferably be at such distance from other facilities as to minimize fire risk. Economy in first cost and operation will be effected if this can be accomplished without duplication of pumping plant.

Sand House

The sand house should have a capacity for the season's requirements, and be located near the sand bins. The dry sand bins may be constructed as a part of the coaling station or on columns between tracks, the latter arrangement permitting engines taking sand or coal without interference to other engines.

The pipe lines for blowing sand from the sand house to the bins should have a minimum number of bends and be built of extra heavy pipe.

All tracks should be served by the sand bins, which if not a part of the coaling station, should be located between it and the wash platform.

Wash Platform

Where weather conditions are suitable the washing of locomotives with a spray system will reduce the cost of wiping and facilitate engine inspection and repairs.

Washing should be the last operation before the locomotive goes on to the turntable, in order that all ashes, coal or sand may be removed.

A wash platform of wood, concrete or macadam, pitched to drain to catchbasins, will protect the roadbed against saturation, and should be located under all the inbound tracks close to the turntable. The platform should accommodate at least one engine on each track and be slightly longer than the engines. An elevated walk on both sides of each track at about the height of a locomotive deck will enable a man to reach the top of the boiler, sand dome, etc., when washing.

Turntable

The turntable should be of sufficient length and strength to meet the extreme demands upon it, and should be equipped with mechanical means of turning.

All approach and departure tracks to and from the turntable should line across the table with the engine house tracks to permit readily moving dead engines or carloads of supplies into or out of the engine house.

Sufficient tangent on all turntable approach tracks should be provided to permit straightening of engine trucks before passing onto turntable.

There should be no facing point switches in the outbound tracks, but trailing spring switches can be used to advantage in the inbound tracks.

Regardless of the type of table selected (deck, through or three-point bearing), adequate drainage must be provided, otherwise there is a possibility of the turntable becoming frozen into the pit during severe weather. Sufficient depth should also be provided for snow and dirt to accumulate below the pedestal.

At many terminals the capacity of the entire plant is fixed by the turntable capacity and it is recommended that in determining the number of turntables required at a terminal, four minutes be allowed per engine for turning, including the time running onto and off of the table, or 15 engines (7½ dispatched) turned every hour. While this speed is, and must frequently be, exceeded during certain periods, the average speed should not greatly exceed this.

Engine House (See Volume 23, pages 323-350, A.R.E.A. Proceedings.)

The engine house should be 20 ft. greater in depth than the longest engine to be housed, in order to allow working space at each end. Where, however, several classes of engines are handled, the designing of a different length section to accommodate each class will decrease first costs.

As the efficiency of the engine house force will depend upon the lighting, heating and ventilation, these features should receive particular attention.

The number of engine house stalls required and the number of stalls per turntable is dependent upon the class of repairs to be made and the time engines will be held in the house. This will require not only the study of the particular terminal, but also of the class of repairs made at other terminals to which the locomotives run, and consideration as to where the work can be done with the least detention to locomotives, the number of assigned engines for which it is the home terminal, number of short turn engines, etc.

The equipment of the engine house for repair work will depend entirely upon the repairs to be made, but provision should be made for dropping wheels, changing side rods, etc.

Steam, air and water should be piped to every pit for use in repairing engines, boiler washing, firing up, etc. Motor driven fans for firing up engines are being used at some points.

Wash rooms, toilet and locker facilities for the engine house force should be located in that building, or closely adjacent, as should also the fan room of the hot-blast heating system if used.

Office and Dispatchers' Building

Adequate office facilities should be provided for the officer in charge of the terminal, and at a terminal handling 75 or more engines per day a separate building should be provided, in which the crew dispatchers should also be located. This building should be adjacent to the engine house and so located that the officer in charge may see the entire terminal from his office window, as should also the crew dispatchers. Rest room, locker and wash rooms for the engine crews, and if there is no Y.M.C.A., sleeping quarters for some engine crews may also be located in this building.

Storehouse

The storehouse should be located centrally for serving both the engine house and shop, to reduce the time required in obtaining material.

Oil and other inflammable liquids should be kept below ground and pumped as required.

The size of this building will depend upon the kind of repair work done at the terminal and the amount of stock to be kept on hand. This will involve not only a study of the class of repairs made at the other terminals to which the locomotives run, but also a study of the amount of stock carried at such terminals and the time necessary to obtain material from them or a central store point.

Oil and Lantern Building

The oil and lantern building should be of fireproof construction located near the turntable where engine supplies can be conveniently obtained, and should be separate from the general store building, in order to provide more convenient access for engine crews and decrease fire hazard.

Power House

The power house should be centrally located for supplying steam and hot water to the various buildings with minimum loss by radiation.

The size of the building will depend upon the equipment installed, boilers, air compressors, boiler washing equipment, generating equipment, switch board, etc.

Lighting

The entire terminal should be artificially lighted, with lights so located as to particularly facilitate the cleaning of fires, taking coal, water and sand, and the turning of engines, without throwing a glaring light into the eyes of the engine runners.

Telephones

Every office and building should be connected by telephone with the engine dispatcher, who should also have telephone connection with the yard office, towers and train dispatchers. A sufficient number of telephone lines should be provided to prevent overloading and to permit quick communication with any other party.

Repair Shop

If the class of repairs to be made requires a shop, it should be located in the rear of the engine house and the tracks should pass through the engine house into it. This will permit engines being dumped in the house and then pushed into the shop.

The shop track should be double-ended if possible, to permit the movement of engines without unnecessary switching.

Toilet, washing and locker facilities should be provided at the shop for all shop employees.

Light Running Repair Shed

Depending upon the relative amount of light repair work and determined from an actual performance record, a light running repair shed near the engine house may be justified to permit the handling of light repairs outside of the engine house. This building should be located with double end tracks, with pits its entire length. The building should be well lighted with natural and artificial light, and provided with steam and air. Such a building for tightening and testing will reserve the higher-priced floor space in the engine house proper for heavy running repairs, and should be located near both the engine house and shop where parts are available and supervision made easy.

Boiler Washing System

The boiler washing system should be located in the power house, with tanks immediately adjacent and piped to each engine house pit.

Fire Protection

Fire hydrants with hose houses and equipment should be located at various points on the terminal, so as to provide at least two streams of water on any structure.

Mains and hydrants should be located with due regard to future expansion of the terminal.

It is recommended that pipe lines be built in loops so as to give even pressure at all points.

RECOMMENDED PRACTICE FOR ENGINE TERMINAL LAYOUTS FOR STEAM LOCOMOTIVES

1. In designing an engine terminal layout, a thorough study of the traffic and operating requirements of the terminal should be made jointly by the Engineering, Operating and Mechanical departments.

2. A terminal should be designed not only for present requirements but also to permit future expansion.

3. Sufficient and properly laid out trackage should be provided to permit the prompt receipt of all engines immediately upon arrival and in advance of each facility for standing locomotives which may have to wait their turn, and so arranged as to provide for the orderly and expeditious movement of engines between the terminal entrance and the house.

4. The required facilities should be provided and placed in proper sequence.

5. Detailed information covering the layout and requirements is given in the 1926 report.

Appendix B

(2) GENERAL LAYOUT AND DESIGN OF PASSENGER CAR SHOPS

L. K. Sillcox, Chairman, Sub-Committee; Leland Clapper, Geo. W. Hand, A. T. Hawk, L. P. Kimball, W. T. Krausch, R. A. Marshall, J. S. McBride, John Schofield, H. W. Williams, A. M. Zabriskie.

The report of your Committee this year is in conclusion of the Progress Report rendered in 1922, in which definite suggestions are offered as recommended practice. A study of the subject was made by the Mechanical Division of the American Railway Association and covered by a Committee Report in the 1925 Proceedings, to which the attention of the members of this Association is respectfully directed.

Viewing present prevailing passenger car maintenance, practices and policies in a comprehensive way, your Committee is impressed with the following considerations, which should be borne in mind:

(1) That a constantly greater recognition obtains and continues on the part of the various administrations concerning the importance of what may be termed higher class traffic, involving the more complicated designs of cars, such as diners, observation cars, club cars, etc. This to a lesser degree is being extended to coaches where it is now found that modern plumbing, proper lavatory facilities with every convenience are demanded as compared to the less elaborate applications contained in coaches used in the recent past.

(2) The physical condition of such equipment is being more closely followed up, and at the same time serious attention is being paid to properly maintaining the cars, but endeavoring to do so within the cost limits of the past; in other words, doing more and better work for the same cost. This has resulted in increased study being given shop methods, materials of construction, and facilities for handling repairs.

(3) There seems to be acceptance on the part of all administrations with respect to the operation of equipment having the required strength for safety with the result that where obsolete cars are not retired, a reinforcing program is instituted. This trend appears to be progressing gradually throughout the country rather than subject to programs involving a quick and possibly more intensive turnover. The result has also been to obtain greater utilization of cars where uniform strength of all classes, and units in each class, obtains, making it possible to use any car in any service, provided, of course, the maintenance is disposed of in a uniform manner.

(4) More self-propelled cars for branch line, local and other service are being pressed into use constantly, and the rise in the rate of acquisition has been very marked of late. If this class of equipment is to be promptly handled and without divided responsibility, a greater burden in the care and rehabilitation of the mechanical apparatus will be placed on the Car

Department, such as has developed, for instance, in the care of electric lighting equipment on cars. This may require certain arrangements being made in the car shops, such as the provision of machine tools, inspection pits between tracks, testing facilities, etc.

(5) For the sake of economy and to allow intensified administration, passenger car repairs are being concentrated more and more in shops designed to meet present-day requirements. This has been brought about very largely from the fact that the older shops have stalls insufficiently high and not of adequate length to properly care for equipment of modern dimensions, necessitating either the rehabilitation or involving new construction to provide clearances prescribed by present trends of design. Shop buildings are being limited to the least number required, resulting in those which are employed having the various departments grouped convenient to the work on the cars themselves to meet the requirement as to intensive use of facilities. Your Committee has made a definite recommendation along this line with a view toward emphasizing the importance of this fact and thus reduce shop overhead or handling expense to a minimum, being a labor item which does not in any physical way improve the equipment.

Layout

The layout and design from the standpoint of economical operation will depend largely on the capacity required by the individual road, as well as upon the type of equipment owned, with due reference to future acquisition. As the capacity must first be settled upon before the layout may be attempted, its determination is the logical starting point. The determination of capacity involves: the number of cars of each type; the policy as regards condition when general repairs are deemed necessary; the average age as well as degree of structural and design obsolescence obtaining; and the seasonal demands for equipment of certain classes.

The number of cars of each class enters the problem to the extent that unless the ownership is quite evenly divided as to number of each class, certain departments may have to be larger than otherwise would be required and possibly to the extent of increasing the size of shop for desired output.

The shopping policy, of course, establishes the repair cycle or frequency of shopping and has a direct bearing on the capacity of shop that must be provided, as it is evident, for instance, that double the output must result where cars are shopped on a 15-months basis than on a 30-months basis.

In general, where the average age is large, a relatively high degree of both structural and design obsolescence will be present and until such time as the equipment may be more profitably retired, rehabilitation to a more or less extent will be required in order that the equipment may be utilized in present-day service. Then again, a rehabilitation program may be desirable to the greatest extent possible in order that such equipment may be made fit for general service use and thus avoid confining it to certain designated service. Rehabilitation in the latter case is used in its broadest sense to include not only structural conditions, but interior arrangement and appointments as well. Such a program will have the added advantage of making it possible to keep the equipment in service a greater length of time between shoppings, thus extending the repair cycle. Rehabilitation from a structural standpoint will include reinforcing of center sill, cross-members, end frames, platforms, transoms, provision of greater capacity in buffers and draft gear, adequate truck capacity, braking power, etc., to bring the strength of the car up to the requirements of any service in which it may be used.

On roads where the demand for equipment is nearly uniform throughout the year, the shopping of equipment may be handled in an ideal manner, provided the shop layout is well considered and properly proportioned. However, there are few railroads so favorably situated that seasonal demands are not of considerable moment. Where a large number of cars of any one class must be repaired in a comparatively short period of time, a very uneconomical shop operation is most likely to result, as it is not possible to keep a well-balanced organization. Desirable labor cannot be obtained where steady employment cannot be assured and the continual disrupting of the organization will react on the efficiency to a marked degree, both in quality and quantity of output. Where the seasonal demand problem must be reckoned with, it is suggested that consideration be given to the manufacture of certain parts of a more or less standard type against the arrival of the cars at the shop. By providing, in advance, such parts as trucks, foundation brake gear members, car seats, piping, upholstery, curtains, sashes, doors, screens, head linings, water coolers, wash stands, mirrors, trap doors, steps, trimming, carpet, battery and lighting equipment, ventilators, etc., the shop organization may be kept quite uniform and at the same time result in the equipment being held out of service for repairs a minimum of time. Such an arrangement would appear to offer a step toward a possible solution to the difficulties of car shopping arising where seasonal demands are quite pronounced. The necessity of considering this phase of the matter is evident when it is considered that a larger ownership is otherwise necessary in order to keep the shop filled and to provide a complement en route to and from the shop in addition to meeting the peak demand. This will in turn make a shop of larger capacity necessary. The more economical layout would, therefore, appear to be one that could take care of certain classes of equipment when transportation pressure for that class is light and at the same time provide some method of employment for the craftsmen who cannot be efficiently employed on that particular class.

An efficiently organized and maintained system of scheduling repairs through the repair shops has an important bearing on the shop capacity. Unless such a plan is in effect and rigidly enforced, the shopping capacity required will of necessity have to be larger than would otherwise be necessary, and repair costs will likewise be greater. The work should progress in logical sequence through the shop and the layout must be such as to make this possible.

In laying out the new shop, after the capacity has been determined, ample provision should be made for future expansion, even to largely governing the selection of site. Very frequently, with old layouts, proper consideration was not accorded this feature, with the result that, where conditions now demand greater capacity or enlarged dimensions to accommodate larger equipment, the condition cannot be met without sacrificing much of the advantage of proper sequence of operation. The general layout should be such that any or all departments may be logically expanded as occasion demands, and due consideration accorded the possibility of maximum length passenger train cars. Judging from past experience, it can safely be said that future cars will be heavier and of the maximum length permitted by roadway restrictions.

Much of the more recently constructed equipment has been not only heavier and larger than during the past, but more luxurious and complex as well. The trend is toward equipment which will provide the utmost in safety and comfort. The first demand necessitates primarily adequate strength and proper design; the latter involves arrangement and control of heating equipment, ventilation, lighting, water supply, toilet and washroom facilities, smoking compartments and lounge room, bathrooms, means of eliminating so far as possible, dust and cinders from car interiors, rich and harmonious appearing upholstery and carpets, and numerous other details that contribute to the comfort of the traveler. These have become a necessity in modern passenger cars, but coincident therewith is the necessity of making repairs when shopping such cars, and at the same time without increasing costs. To meet this requirement, the most efficient operation possible must obtain, and the shop layout is of paramount importance in attaining this end.

The shop layout should take into account the fact that steel is coming into more general use to replace wood as formerly used. Provision for handling this class of material is necessary, bearing in mind that the rehabilitation of equipment will make necessary more or less fabrication of steel parts for underframing as well as side sheets and interior finish. Generous shop space is recommended for this purpose, whether the work is carried on under supervision of the tin shop or whether a separate department may be deemed desirable.

Coach Shop

The flooring used in the repair shop may be concrete, but wood block or equivalent, on a concrete base, is considered better construction. Floor should be laid to drain readily.

The dimensions to be provided in the repair shop will be governed to some extent by the equipment owned, but should also take into account the equipment that may ultimately be acquired. In general, sufficient width should be provided to allow at least 10 ft. between the end of the coupler and wall on side next to the transfer table and 17 ft. clearance on the opposite end, 10 ft. of which should be kept clear as a runway. Ample space is a requisite between tracks, and it is recommended that 24 ft. center to center be provided. Where a row of columns is located between tracks this spacing should be such as to provide 12 ft. from face of column to center line of track on either side. The minimum clearance between floor and bottom chord of truss should be 22 ft.

Each repair track should be served with gas, air, water and electricity to permit the repair work on brake equipment, plumbing and electrical features being checked while car is still on the repair track. Such facilities will many times save the car having to be returned to the shop for adjustment or correction.

Small power-driven tools, such as grinders, cutoff saws and portable drills, contribute greatly to shop efficiency and provision should be made for them to the greatest extent consistent with the size of shop and class of work to be done. A convenient location for such tools is between repair tracks, partially utilizing space that is of little use otherwise although necessary for clearance between adjacent cars.

Consideration should be given to the advisability of providing pits for each repair track to facilitate repairs being made to the equipment suspended beneath the car body without the necessity of raising it. The improved working conditions where a pit is provided will tend to reduce costs and expedite completion of the repairs.

Provision for adequate lighting, both natural and artificial, is of special importance, as much of the work in passenger car repairs is of a particular nature, requiring close work. An efficient lighting system based on the work carried on in each individual building or section will pay big dividends in increased output and better quality workmanship. The illumination of the interior of cars in the repair shop proper is a very important consideration. Many roads have found the installation of an independent temporary circuit to give better results than the use of portable extension. Where this arrangement is adopted, means should be provided so that the temporary circuit may be attached at either end of each car. It is well also to provide means for using a small number of extensions as well.

Paint Shop

Flooring in the paint shop should preferably be of concrete, with proper provision for draining.

The dimensions of the paint shop should provide a depth sufficient to allow a clear space between end of coupler and wall at each end of at least 10 ft., based on the maximum length car likely to be acquired. Tracks should have a spacing of 20 ft., center to center, but it may be desirable to provide the same spacing as obtains in the coach shop.

Painting of cars by the spray process is destined to play an important role in shop operations and provision must be made to take care of such work. The shop building should be of fireproof construction with ample light, both natural and artificial, and special provision must be made for heating to promote quick drying of paint under the most adverse weather conditions likely to be encountered. The unit system of heating has been used with some success, but sufficient experience has not been had to permit a definite recommendation. Particular attention must be given to the matter of ventilation, as it is necessary to remove the paint spray fumes as fast as liberated into the atmosphere. If this precaution is not taken, the labor turnover in this department will be excessive.

It is necessary to provide a separate building for sand blasting. This must either be located at some distance from the other buildings or else a type of construction must be employed that will confine the dust and noise incident to this operation.

Provision must be made to permit the car being given a priming coat of paint immediately after the sand blasting is finished in order to prevent corrosion. This may be done in an adjoining building or space reserved in the paint shop proper. The latter is considered preferable where the layout is such as to make it practicable. Unless this painting is done by the spray process, permanent scaffolding should be provided. This should be adjustable and easily operated, preferably suspended from overhead so they can be pushed up out of the way when not in use.

Wheel Shop

The wheel shop should be provided with adequate storage space for wheels and axles, and if the size warrants, a traveling crane or monorail should be provided.

A vestibule is recommended for the door through which wheels pass where the location is in a cold climate to protect the workmen against drafts so far as possible. Such a vestibule should be approximately 15 ft. long.

Wood block flooring is recommended for the wheel and axle shop.

Truck Shop

The truck shop should be conveniently located with respect to the wheel and axle shop, blacksmith shop and machine shop and as near the point where car is unwheeled as conditions will permit.

The truck shop may be laid out with tracks upon which the trucks are repaired or they may rest directly upon the floor. The former would seem to be more conducive to orderly operation.

Where tracks are used, the flooring may be of concrete, properly drained, otherwise a wood block floor on concrete base is recommended.

Tracks should be spaced at least 15 ft., center to center, or an equivalent floor space where tracks are not employed.

The truck shop should be provided with a traveling crane of at least 15 tons capacity and should be piped for air, gas and wired for electric welding equipment.

Ample storage capacity should be provided adjacent to the truck shop.

Inspection Facilities

Inspection of cars before entering the shop to determine what work is necessary, and after the work has been completed, are important phases of good shop management. It is desirable to do this work independently of the shop proper and to this end consideration should be given to the provision of a building for inspection purposes exclusively. The size of such facilities will, of course, depend largely upon the shop output and the number of inspectors employed. The inspection facilities should include an inspection pit, test equipment to permit testing air brakes, heating, lighting, water supply, plumbing, etc.

Storehouse Facilities

Storehouse facilities merit more consideration than is usually accorded them. More lost time results from deficient or poorly arranged material supply than is often realized. The main and sub-storerooms should be strategically located with reference to shop departments served. In general, a sub- or section storeroom should be located as centrally as permissible to each of the principal departments. Included in the latter will be found the assembly shop or shops, truck shop, paint shop, including mixing and glazing room, mill, upholstery department, trimming shop, air brake and pipe department, sheet metal department and electrical shop. These may be grouped to meet individual requirements, but numerous section storerooms are advantageous to economical operation. Well-designed racks should be provided conveniently to the blacksmith shop for bar and rod stock. Smaller rough castings may well be distributed conveniently to those portions of the shop buildings where they are used. Under certain conditions suitable bins or racks might be provided for this class of stock immediately outside the shop proper and between the wall and transfer table. Much of this space is wasted unnecessarily. Properly laid out roadways and walks are essential to prompt and efficient handling of material.

Toilet and Washroom

Adequate toilet, washroom and locker facilities must be provided based on the maximum number of employees likely to be engaged at one time. The employment of women in passenger car shops is more or less common, and due consideration should be accorded this possibility. It is desirable to locate toilet, washroom and locker facilities as centrally as possible, and each building should have its complements of such facilities to avoid, so far as possible, the lost-time element. In some states a minimum requirement for these facilities is specified by law.

Wood Mill

The wood mill should be located conveniently to the coach shop and lumber storage, with the dry kiln between. Where conditions will permit, a separate building is desirable because of fire hazard. Steam heat should be provided and special attention to ventilation is a necessity. Adequate natural and artificial lighting is necessary. No open wiring should be used in this building.

A concrete or wood block floor is recommended, but if the former, a wood surface should be provided where workmen have to stand in one place.

Power House

The location of the power house will depend on the service it is to render. In general it should be as near the load center as possible with due reference to future expansion. Where refuse from the wood mill is burned under the boilers, the layout should include means of conveying the refuse at a minimum cost. However, where there is a market for such refuse, it is generally more profitable to dispose of it in that manner.

General

The stripping and trimming shop should have a track spacing of at least 20 ft. to facilitate trucking without interference with workmen.

Concrete flooring is recommended for the wash house, stripping and trimming shop, and pipe shop. Same to be properly pitched to drain.

Concrete is also satisfactory for the tin shop, electrical shop and cabinet shop, but should have a wood surface around the work benches and where workmen must stand constantly.

For the machine shop, wood block flooring is recommended. A substantial sub-base is advisable where wood block flooring is used.

The transfer table should be of ample capacity and sufficiently long that cars may be expeditiously moved. Where tractor is used, an additional length of 10 ft. is required. A substantial foundation for the rails under the transfer table is important and continuous concrete runners are recommended. Provision should be made for draining pit and where heavy snowfall is encountered it may be desirable to elevate the rails above the floor of the pit.

Wood block flooring is recommended for the cabinet, upholstery, plating and glazing shops. Construction details may in some cases entail excessive cost, however, in which case concrete with wood surface will offer a satisfactory solution.

Doors in the various buildings for car tracks, where not specified by law, should provide a clear opening of at least 14 ft. in width by 17 ft. in height.

For stub end shops it is recommended that a minimum 30 ft. be provided between the edge of transfer table and the repair shop and paint shop walls. Where painting may be conducted in the open, the space between transfer table and repair shop may be increased to 100 ft. and thus provide convenient space for painting operations.

A generous use of cranes, monorails, hoists, supply tracks and roadways for tractors and trailers will prove a good investment in the handling of materials and heavier parts.

The upholstery and carpet department is one of the most important in a passenger car repair shop, yet it is frequently crowded into an inadequate and poorly situated location. Ample space convenient to the trimming department should be provided in laying out the shop, giving due consideration to the use of power-driven machinery.

Ventilation and heating are vital factors in promoting efficiency of workmen. The sawtooth type of roof construction lends itself remarkably well to providing good ventilation where used in conjunction with ample ventilating sash in the side walls. Ample radiation should be provided by the heating system and well distributed throughout each building.

All wiring should preferably be installed in conduits to reduce the fire hazard and should be made as accessible as possible to facilitate proper maintenance.

It is recommended that all pipe work be placed overhead if possible to promote accessibility for repair.

The size of the manufacturing departments will vary with each carrier, but in general the amount of floor space, exclusive of wheel and axle shop, machine and blacksmith shops, will be approximately equal to the floor space in the repair and paint shops combined.

It is imperative that special attention be given to the matter of fire hazard and fire protective measures. A passenger car shop full of cars represents an investment of considerable moment and every reasonable means to guard against a conflagration is justifiable. Fireproof construction is advisable and in addition fire walls should be employed to the greatest extent possible in order to confine the fire should one get started. The use of a sprinkler system is recommended, particularly in the wood mill, cabinet and finishing shop, upholstery shop and paint shop. Where much wooden equipment is involved, a sprinkler system throughout the shop is advisable.

Great care should be exercised in layout of fire fighting facilities. Hydrants should be so located as to permit two fire lines being accessible to any point of the shops without necessitating excessive lengths of hose. A generous provision of hose carts is recommended. Well-kept roadways to permit outside fire fighting equipment to enter the grounds is essential. A well-organized and trained unit made up of employees is a necessity and the shop design should include a first-class fire alarm system.

A layout of a shop of comparatively recent construction is included as information. This layout is of the Grand Trunk Western Shops at Port Huron, Mich.

Also included herewith is a suggested layout for a shop having an output of approximately one car per working day, but so arranged as to allow expansion in a logical manner. It will be noted in this layout that the various departments are so grouped as to provide intensive utilization of the facilities and to promote high efficiency in operation.

The incoming car first enters the unwheeling shed where trucks are removed and dummy trucks or dollies applied. At the same time a thorough inspection is made and the major repair operations listed. The batteries are also removed and trucked to the battery room. The car is then shifted to the stripping room where all fixtures, sash, doors, screens, upholstery, carpets, etc., are removed and taken to the respective departments for repairs. The trucks, when removed, are taken direct to the truck shop.

After stripping, the car passes onto the transfer table and thence to the sand blast, if required, or otherwise direct to the wash house. After being sandblasted, the car must be given a priming coat to prevent corrosion, and this must be done before exposing the car to the elements, as a very light mist will start corrosion immediately. After receiving the priming coat and being washed, the car is moved via the transfer table to the repair shop, thence across the transfer table to the paint shop. After painting, the car is taken by way of the transfer table to the trimming shop, thence by track to the wheeling hoist and repaired trucks placed in position. Final inspection and tests are made and car released.

The trucks after reaching the truck shop are taken down, certain parts being trucked to the blacksmith or machine shop and wheels and axles taken to the wheel shop. The repaired parts are then returned to the truck shop, trucks assembled and placed on the storage track to await arrival of the car.

The manufacturing departments occupy a two-story structure at the end of the repair tracks, the cabinet shop, glazing and finishing, upholstery shop and plating shop being on the second floor. Where a shop superintendent is in charge, space should also be provided on the second floor for his office, as by so doing he has a commanding view of all operations.

Elevators and a stairway are required between the first and second floors. The elevators must be of sufficient size to accommodate hand trucks, head linings, car seats, etc.

A sawtooth type of roof is recommended for the repair shop to provide ventilation and natural light. The same type roof is recommended for the paint shop.

A material track is provided for the wood mill for handling material from the storage yard and dry kiln. A run-around track connects one end of the transfer table to the main track to facilitate the handling of cars that may be sent in for light repairs or special work.

Conclusions

In conclusion, the following essential points are suggested for your consideration and approval as recommended practice for Passenger Car Repair Shops:

1. Suitable provision to be made for future expansion of all facilities.

2. Capacity should be determined on basis of number of cars to be shopped in a given time, balanced against traffic demands and effect of manufacturing operations.

3. All buildings to be of substantial fireproof construction, amply lighted, both natural and artificial; comfortably heated and well-ventilated.

4. Tracks in Coach Shop should have minimum spacing of 24 ft. center to center, except where columns are located between tracks, when 12 ft. from face of column to center of track should be provided.

5. Tracks in Paint Shop should have minimum spacing of 20 ft., unless local conditions make it desirable for these tracks to line up with Coach Shop.

6. Minimum spacing in the Stripping and Trimming Shed should be 20 ft. and in the Truck Shop 15 ft.

7. Overhead clearance in Coach Shop should be not less than 22 ft. to bottom chord of roof truss.

8. Width of Coach Shop should not be less than the length of longest car plus 27 ft.

9. Width of Paint Shop should not be less than the length of longest car plus 20 ft.

10. Doors should provide a clear opening of 14 ft. by 17 ft. unless otherwise prescribed by law.

11. Generous use of cranes, hoists and monorail is desirable.

12. Layout to be such that all operations follow in logical sequence so far as possible.

13. Manufacturing departments should be grouped as conveniently as possible to the point where the respective parts are applied.

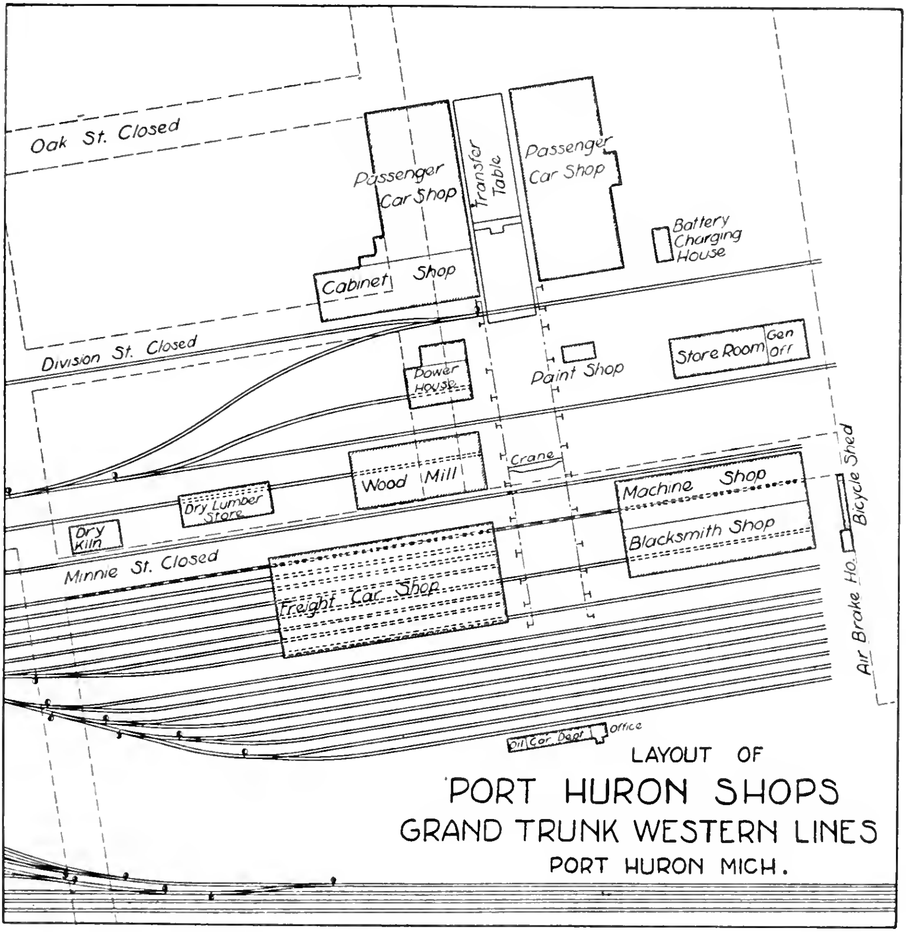
14. Main and sub-storehouses should be located as centrally as possible to the departments they serve. Sufficient sub-storerooms should be provided as to provide material reasonably close to the shop operations.

15. Paved roadways and walks of ample width are highly desirable.

16. Ample storage space for cars to be shopped, as well as finished cars, is essential.

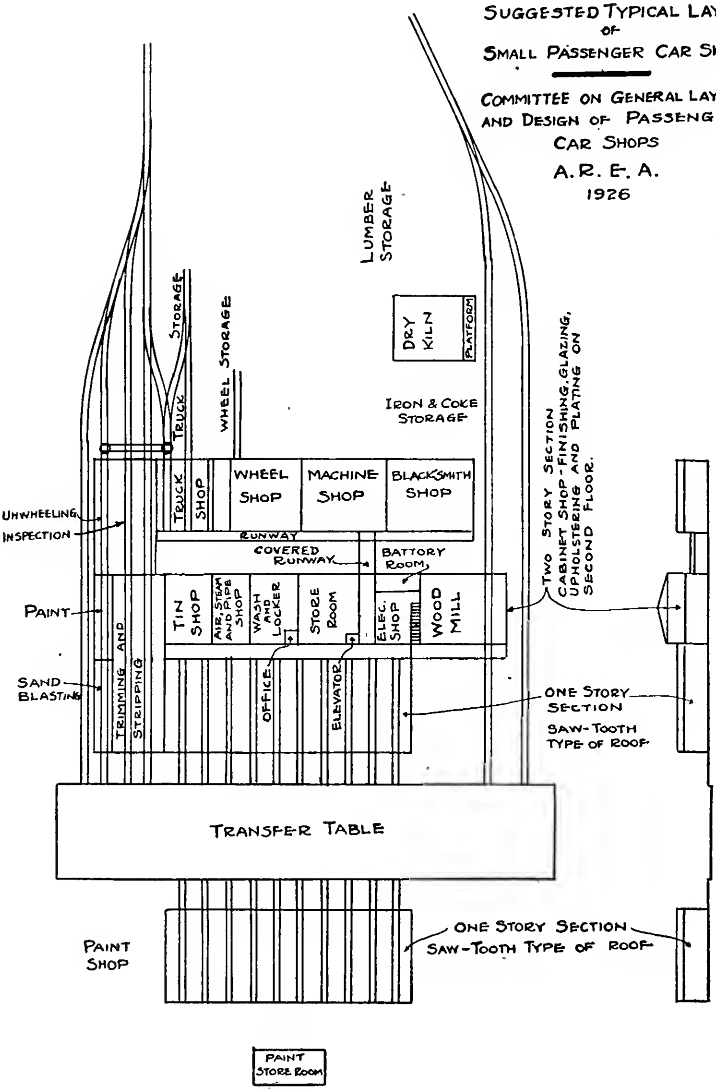
17. Separate inspection facilities are desirable.

18. Special provision should be made for preventing and fighting fires.



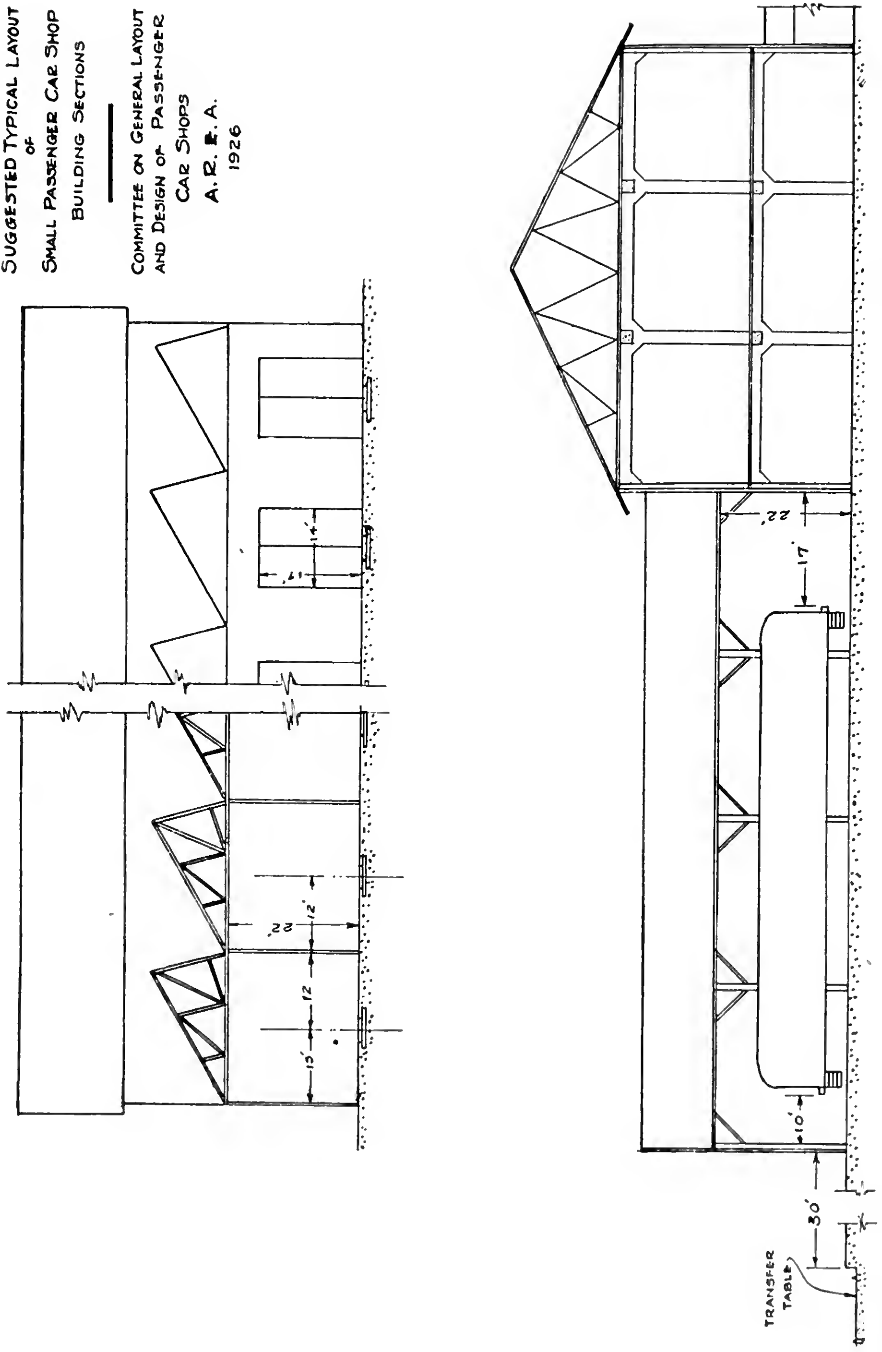
LAYOUT OF
PORT HURON SHOPS
GRAND TRUNK WESTERN LINES
PORT HURON MICH.

A



SUGGESTED TYPICAL LAYOUT OF SMALL PASSENGER CAR SHOP

COMMITTEE ON GENERAL LAYOUT AND DESIGN OF PASSENGER CAR SHOPS
A.R.E.A.
1926



Suggested Typical Layout of Small Passenger Car Shop Building Sections

Committee on General Layout and Design of Passenger Car Shops
A.R.E.A.
1926

Appendix C

(3) THE VENTILATION OF ENGINE HOUSES

L. P. Kimball, Chairman, Sub-Committee; C. I. Anderson, Leland Clapper, A. T. Hawk, W. T. Krausch, G. A. Noren, H. W. Williams.

General

The following are recommendations for general practice in the ventilation of engine houses. They do not apply to houses which are equipped with a mechanical system for smoke removal consisting of special jacks, ducts, fans and stack. Such a system is not recommended for general use in connection with ventilation.

Smoke Jacks

Smoke jacks should be of the fixed type, at least forty-two (42) in. wide, and of such length (preferably at least twelve (12) ft.) as to receive the smoke from stack at its limiting positions, due to the adjustment of the driving wheels to bring the side rods in proper position for repairs. The position of the jacks in the roof should be established with the above condition in view and the elevation of bottom of hood should be sixteen ft. six in. (16′6″) at ends and fifteen ft. six in. (15′6″) at sides above top of rail. The area of flue opening should be at least seven (7) sq. ft. An annular space two (2) in. in width should be provided around the flue. A locomotive entering the house should be spotted with smoke stack under jack as rapidly as consistent with safe handling and should always be kept in such position while under fire.

Steam Blowoff

Provision of a proper system of piping for blowing off steam from boilers should be made in every engine house. Where possible the steam blown off should be used for heating purposes in connection with a boiler washing system, but in all cases discharge should be made outside the limits of the engine house. A ventilator of standard design and at least eighteen (18) in. in diameter should be placed in the roof on the center of each stall and as nearly as possible over the center of steam dome of locomotives handled. This ventilator should be provided with extension if necessary so as to place same above highest part of roof. If regular blowoff piping is temporarily out of service, arrangements should be made to blowoff through portable pipe into this ventilator and the blowing off of locomotives without such provision should be absolutely prohibited.

The features above mentioned will, as heretofore stated, reduce the necessity for other ventilation provisions, but, as with the best of care in operation some smoke and steam will escape, the following additional recommendations are considered essential.

Cross-Section of House

As modern engine houses have stalls generally one hundred (100) ft. or more in depth, at least one break should be made in roof and if desirable complete monitor may be installed. Such breaks or monitors should be provided with pivoted sash or a combination of pivoted sash and fixed louvres, depending upon climate.

Framing

Roof framing should be such that the rafters directly supporting the sheathing or other roof surface are in radial lines and without pockets so as to permit the free passage of smoke to eaves. At the high eaves directly under roof sheathing, if climatic conditions will permit, a continuous opening of four to six (6) in. should be provided to permit the escape of smoke and steam, particularly at breaks and in monitors.

Windows

Large windows should be provided in the outer walls with a generous provision of ventilating sections. As near a continuous row of these ventilating sash as practicable should be provided along the top of windows.

Heating

The relation of the heating system to the ventilation of the engine house is of course apparent. The provision of a hot blast heating system with supply of air taken either from outside or inside of house as conditions may require and circulation by means of underground ducts with outlets in pits and along the outer wall just above floor level is recommended for general use. Such a system designed for frequent air changes will result in the rapid clearing of atmosphere in house even under unfavorable conditions. The use of this equipment during the summer months will materially lower the temperature in the house as well as clear the atmosphere in same.

Appendix D

(4) STOREHOUSES FOR SHOPS AND LOCOMOTIVE TERMINALS

A. T. Hawk, Chairman, Sub-Committee; A. L. Atwill, C. N. Bainbridge, J. W. Dansey, J. L. Haugh, W. T. Krausch, R. A. Marshall, D. A. Porter, J. W. Raitt.

The Committee assignment is limited to storehouses for shops and locomotive terminals. In practice very often the storehouse for these facilities is combined with the System District or Division Storehouse, and even when this is not the case the storehouse may serve several shop and terminal facilities. In view of these conditions only the most general requirements can be given. Also, the size and location will be governed by the services required.

The subject of storehouses is taken to include not only the storehouse proper but all auxiliary facilities consisting of oil storage, material platforms, paint stores, lumber storage yard and sheds, material racks, sheds for coal, coke, charcoal, fire brick, locomotive arch brick, storage or generating of oxygen and acetylene, scrap dock and reclamation sheds.

Tracks and Roadways

Track facilities should be provided for the receipt of incoming materials, for the loading out of materials, for distribution to other points and shipment of scrap.

Paved roadways should connect the storehouse with public highways and all parts of the shops and terminal served by the storehouse. These roadways not only serve in the distribution of materials, but also provide easy access for fire apparatus.

Main Storehouse

The primary consideration is the economical handling of material. The arrangement should be such as to insure ample natural light, the convenient handling, checking and inventorying of materials and ease of supervision. Racks should be so located that the handling of materials will be reduced to a minimum and so that there will be no dark pockets for the accumulation of rubbish, etc.

The most general practice is to place the racks transverse to the house, thus permitting natural light from side windows to illuminate the aisles and racks. Some railroads place the racks longitudinal to the house to permit freer observation of the force. On the other hand, this arrangement requires more artificial lighting and more floor space. A one-story house possesses advantages for easy and short trucking but where very large floor area is required a two- or three-story building is more suitable. Where more than one story is used the upper floors are used for offices (at one end) slow moving and light materials and for an assembling place for work requiring the holding of material until it is assembled for a complete job. Upper floors should be designed for a live load of not less than 250 lb. per square foot.

The first floor, if built over a basement, should be designed for a minimum live load of not less than 400 lb. per square foot.

Elevators of at least four tons capacity should be provided. For larger houses one elevator should be provided for each 20,000 sq. ft. of floor area. These elevators should be of sufficient size and capacity to handle an electric truck and trailer. The self-leveling type of automatic elevator with push button control is desirable.

Electric lighting should be provided, with the lamps over the aisles; plug outlets at ends of the racks. The circuits should be arranged and controlled so that only the lights actually needed would be turned on.

Ventilation should be given careful study, and the main storage part of storehouse, as well as the office portion, should be well ventilated so that working conditions will be as near perfect as possible. Much of the material stored, especially electrical material, should be kept where it is dry and the heat and ventilation should be arranged accordingly for it.

Heating should be provided, as required, for the office portion and also for the stock and workroom sections, the latter at a less temperature than the former. Storerooms should be heated so that it is comfortable for the laborers to work in any part of it without wearing clothing that hampers them in their work.

Office. The office should be of sufficient size to accommodate the help, allowing a minimum of 64 sq. ft. for each clerk, together with space for files and separate rooms for Storekeeper and General Foreman.

In one-story buildings the office should be at the front end of the storehouse.

Where there is a scarcity of floor space available it may be desirable to place the office portion on the second floor.

In buildings of two or more stories the office should be at the front end of the second floor.

Toilet Facilities are more or less regulated by State and Federal requirements. In any event, adequate toilet and wash room facilities should be made both for office force and for storehouse laborers. If there are women employed, rest room should be provided.

Racks. Metal racks of adjustable units are desirable and should be approximately five feet wide at the base, this section three feet high with an offset of twelve (12) in. on each side and then top section three feet wide and five to six feet in height. The adjustable units help very materially in making up proper size of pockets which can be changed from time to time as desired.

Concrete Platforms should be provided along the entire length of storehouses and when motor trucks with trailer trucks are used, a 14 ft. wide platform is recommended. All platforms should have ramps at the ends.

Yard Cranes

Casting Platforms at large shops should have an overhead traveling crane the entire length of the casting platform. This crane should also cover the track or tracks serving the platform, so as to reduce the handling of the castings from car to platform to a minimum.

Casting Storage—Iron Racks, Pipe Racks, Etc.

Local conditions will govern the location. They should, however, be located so as to reduce the handling from the car to storage and from storage to where they are used, to a minimum. Castings should be stored on platforms and at large shops under traveling crane. Where sheet iron is stored, all sheets larger than No. 10 may be stored outside except where climatic conditions prevent. These should be stored on edge in racks made of steel posts with the bottom ends embedded in concrete piers, unless they are to be handled by magnet and crane, then they should be stored flat.

Oil House

The oil house with tracks and switching facilities should be at one end of the storehouse and preferably located at a distance of not less than 50 ft. Oil storage should be in the basement and the first floor used for delivery counter, pumps, oil drums, waste and similar material.

For small stores, oil can be stored in a basement under one end of the storehouse with counter pumps, oil drums and waste on the first floor. The oil house portion should be separated from the storehouse by a fire wall.

Oil Houses should be built of fireproof materials. Tank of sufficient capacity should be provided in the basement except fuel oil and gasoline, which should be located outside with the tanks underground. Provision should be made to remove any tank in the basement. This opening can be filled with material that can be easily removed.

Pumps. Self-measuring pumps are recommended for handling oil. These should be located on the first floor of the oil house. There are a number of the inclosed pumps that are very economical and efficient on the market. In no case should pitcher pumps or a pump that leaks oil around the pistons or delivery spout be used.

Waste. Sufficient space should be provided in the oil house for storage of waste.

Where it is necessary to maintain mixing vats in oil house and the machinery for reclaiming grease, a separate room should be provided for this purpose.

Live steam system of fire protection should be installed in all oil houses. Also, pails of sand should be accessible to put out small fires. Vapor-proof lamps controlled by an outside switch should be used.

Paint Stores—Location. Wherever possible, this building should be part of the oil house, and where not possible, a fireproof building should be provided. The shelving bins in the paint house should be of steel.

Lumber Shed—Location. These should be located in the material yard with sufficient tracks so that switching and handling may be reduced to the minimum.

These should be of frame construction and of sufficient size to keep protected all inside finished lumber. These sheds are usually built enclosed on three sides with one side partly open, this side being next to the track where the lumber is received in cars and this open side should be sufficiently high so as not to interfere with the handling of the lumber between the car and the stacked lumber inside of the building. Lumber, of course, should be piled off of the ground, and it is sometimes found a good practice to store piling on second-hand rails supported by small concrete piers about 12 or 18 in. above the ground. The sides and rear of the shed are usually made of one-inch boards with an inch space between them to allow for ventilation. This siding should not extend below the top of piers.

REPORT OF COMMITTEE X—SIGNALS AND INTERLOCKING

F. B. Wiegand, *Chairman;*
H. S. Balliet,
W. E. Boland,
W. J. Eck,
W. H. Elliott,
G. E. Ellis,
J. V. Hanna,
J. C. Mock,
H. G. Morgan,
F. P. Patenall,
B. T. Anderson, *Vice-Chairman;*
J. A. Peabody,
F. W. Pfleging,
W. M. Post,
A. H. Rudd,
Thos. S. Stevens,
E. G. Stradling,
W. M. Vandersluis,
R. C. White,
Committee.

To the American Railway Engineering Association:

Your Committee on Signals and Interlocking submits report on the following:

(1) Revision of Manual.
(2) Automatic Train Control.
(3) Signals for Highway Crossing Protection.

(1) Revision of Manual

The report submitted at the March, 1925, meeting included all of the signaling matter in the Manual and your Committee have at this time no further revision to offer.

Action Recommended

That this report be accepted as information.

(2) Automatic Train Control

In the report submitted at the March, 1925, meeting, was given the historical data pertaining to this subject including a copy of I.C.C. order No. 13413 and to what extent wayside signals may be omitted in train control territory. Your Committee has kept informed on this subject and submits Appendix "A" in which is given a series of tables compiled from information in the files of the Committee on Automatic Train Control of the American Railway Association. The report includes the mileage of the first I.C.C. order; permanent installations completed or in service; permanent and preliminary installations under construction; contracts executed; devices selected by carriers in the first order; track miles of automatic train control to be installed under way, and a list of the inspections of such installations by the Interstate Commerce Commission.

Action Recommended

That the report in Appendix "A" relating to Automatic Train Control be accepted as information.

Bulletin 281, November, 1925.

(3) Signals for Highway Crossing Protection

In the report presented at the March, 1925, meeting, were included the requisites to be presented to the Signal Section of the American Railway Association. Those requisites were at that time submitted as information; they are again presented, this time for inclusion in the Manual. The report (paper prepared by A. H. Rudd) on Highway Crossing Protection and the requisites are given in Appendix "B."

Action Recommended

That the report in Appendix "B" relating to Highway Crossing Protection be accepted as information and that the Requisites for Automatic Signals for Highway Crossing Protection be approved for publication in the Manual by reference as follows:

REQUISITES FOR AUTOMATIC SIGNALS FOR HIGHWAY CROSSING PROTECTION
Manual of Signal Section, American Railway Association.

Outline of Work for Ensuing Year

1. Revision of Manual.
2. Automatic Train Control.
3. Automatic Signals for Highway Crossing Protection.
4. Signaling (designs; symbols; definitions; rules and instructions; construction and maintenance specifications).
5. Outline of work for ensuing year.

Respectfully submitted,
THE COMMITTEE ON SIGNALS AND INTERLOCKING,
F. B. WIEGAND, *Chairman.*

Appendix A

(2) AUTOMATIC TRAIN CONTROL

W. J. Eck, Chairman, Sub-Committee; W. E. Boland, G. E. Ellis, F. P. Patenall, J. A. Peabody, Thos. S. Stevens.

(a) PURPOSE AND HISTORICAL DATA

The historical data given under Subject (a) of the report for 1924 is continued, bringing the information up to date. In the report above referred to a brief description was given of several devices which were classed in the report of the United States Railroad Administration Committee in 1919 as "Devices Available for Further Tests." It may be of interest to review the progress that has been made in each of these different devices.

American Railway Signals Company

No further progress has apparently been made in the development of this apparatus, which is of the intermittent electrical contact or ramp type, and no installation has been attempted during the past year.

American Train Control Corporation

This device, of the ramp type, has been in service on Chesapeake & Ohio Railway, and has been recently inspected by the Interstate Commerce Commission, but no report has yet been issued. The installation consists of two types; one using direct current on the ramp, and the second or later installation, alternating current. The complete territory between Gordonsville and Staunton, Va., is equipped with these two types, and covers the territory required by the first order of the Commission.

Automatic Control Company

So far as is known, no further progress has been made in the development of this apparatus, which is of the mechanical trip type.

Casale Safety Devices Company

(See Regan Safety Devices Company.)

Clifford Automatic Train Stop

The device, which is of the movable ramp type, mentioned in the United States Railroad Administration report, has apparently been discontinued, and no further experiments are being made so far as is known. This Company has been reorganized as the Train Control Corporation of America, and has conducted experiments of an induction type on the Erie Railroad.

General Railway Signal Company

The intermittent electrical contact type of this Company has received no further development, and no installations are being made.

General Railway Signal Company

The inert roadside element type, commonly known as the Auto-Manual, has been greatly developed, and fourteen installations are under way or have been contracted for covering the full territory ordered on the carriers interested.

This Company has also developed a continuous induction type which is undergoing a practical installation on the Chicago & North Western Railway.

International Signal Company

This Company has an experimental installation on the Erie Railroad, the operation of which is being observed, and reports of its performance have been sent by the proprietors to the railroads.

Miller Train Control Corporation

The installation of this Company on the Chicago & Eastern Illinois Railway has been inspected and approved with reservation by the Interstate Commerce Commission, as will be referred to later.

This Company has developed an intermittent induction type using an inert element on the roadside, and a 20-mile experimental installation is being made between Detroit and Toledo on the Lines of the New York Central.

National Safety Appliance Company

This Company's device, of the intermittent magnetic type, has been developed along the principles first used. Installations have been made or are under way on five different railroads.

Nevins-Wallace

So far as known, this device has received no further development and is not now offered for installation by the proprietors.

Regan Safety Devices Company

This device, which was developed from the Casale ramp device, has been greatly improved over the first proposed arrangement, and was installed upon the Chicago, Rock Island & Pacific Railway between Blue Island and Rock Island, Ill., to fulfill the first order, and has been in operation for over two years. A copy of the Commission's order giving its approval with reservations was given with the 1924 report.

Schweyer

No actual installations of this induction device are in practical operation, but the proprietor has made some development in the apparatus.

Shadle Automatic Train Control Company

This device, of the ramp type, is now handled by the Indiana Equipment Company, but so far as known, no further installation has been made, and the device remains much the same as stated in the United States Railroad Administration report, except the installation on the Cincinnati, Indianapolis & Western has been removed.

Sprague Safety Control & Signal Corporation

This device, of the magnetic induction type, received a trial on the New York Central in 1921, a report of which was issued by the Interstate Commerce Commission. Four installations have been made or are under construction, filling the first order on that number of roads.

Union Switch & Signal Company

This device has been further developed and simplifications made in the detailed parts. Nineteen installations are under construction and in service.

B. F. Wooding

No further tests have been made. The proprietor, it is understood, has developed plans for an induction type, although it has not received a practical demonstration.

Wilson-Wright

So far as known, this device is not being developed, and as the Washington Power Company's railroad line has been abandoned, the device is not now in service.

The Committee on Automatic Train Control of the American Railway Association in its Annual Report for 1921 stated that:

> "Considerable progress has been made in the development of certain devices, particularly the induction type, since that time, but the devices are still in the stage of early development as distinguished from the later stage of refinement which always follows the early development of any new signal and locomotive devices. It is therefore reasonable to conclude that the development of the apparatus in the next few years will render most of the apparatus now available practically obsolete."

From the brief notes given above it will be noted that this statement has proven to be true. Practically none of the devices mentioned above that are receiving any degree of attention are in all respects the same as first proposed, and in many of them radical changes have taken place in the design, although the principle may remain the same.

In addition to the above a few devices have been presented to the carriers in the form of plans and one or two test installations have been made on some roads. Generally speaking, however, there has been no radical development in train control, or no new principle evolved, which was not indicated in the list shown above. In other words, the development has been in improving the devices which have been familiar to the railroads for a number of years, rather than in developing any entirely new schemes.

The annual report of the Interstate Commerce Commission states that for the year ending October 31, 1925, plans of 43 new devices were presented. Reports have been rendered on 40 of these devices, 27 of which were found to be impracticable or unworthy of further consideration as presented and 13 possessing sufficient merit to warrant further consideration.

INTERSTATE COMMERCE COMMISSION ORDERS

As stated in the report for 1924, the carriers under date of March 3, 1924, following the second train control order, presented a petition (full copy of which was included as Exhibit "A" of last year's report), asking that:

"I. That this proceeding be reopened, and a rehearing granted before the full Commission, to the end that the order of June 22, 1922, be amended by

1. Extending the time for compliance therewith to January 1, 1926.

2. Reducing excessive duplication of installations of the same device at great capital expense until further experience and experimentation has solved the question of interchangeability and effect on capacity of moving traffic, as well as the further development of the appliances from the present experimental stage.
3. Striking out from said order the provisions for approval, by the Commission or its representatives, of each installation when completed.
   And further,
4. For a reopening of this proceeding and for a rehearing before the full Commission respecting the order of January 14, 1924, to the end that the said order may be annulled."

Hearings were held on this order in May, 1924, and the following decision of the Commission was issued under date of July 18, 1924:

No. 13413

IN THE MATTER OF AUTOMATIC TRAIN-CONTROL DEVICE

"**It appearing,** That the Commission upon consideration of the record in this proceeding and of its order entered herein on January 14, 1924, and of the petition filed March 3, 1924, by certain carriers required by orders in this proceeding to install train-control devices upon designated portions of their respective roads, entered its order dated March 21, 1924, reopening this proceeding for hearing with respect only to said order of January 14, 1924, as it affects the carriers hereinafter named;

It further appearing, That a full investigation of the matters and things involved has been had, and that the Commission on the date hereof, has made and filed a report containing its findings of fact and conclusions thereon, which said report is hereby referred to and made a part hereof.

It is ordered, That the effective date of said order of January 14, 1924, be, and it is hereby, suspended until further order or orders of the Commission, so far only as it applies to the following carriers: (The 42 roads herein named together with a complete list of carriers appearing in both orders follows as Exhibit 'C').

It is further ordered, That paragraph No. 1 under the heading of 'Functions' in the specifications and requirements for automatic train-stop devices prescribed by the order of June 13, 1922, be, and it is hereby modified to read as follows:

1. Automatic Train Stop:

(a) Without manual control by the engineman requiring the train to be stopped; after which the apparatus may be restored to normal condition manually and the train permitted to proceed.

(b) Under control of the engineman who may, if alert, forestall the application of the brakes by the automatic train-stop device and control his train in the usual manner in accordance with hand signals or under limits fixed by train order or prescribed by the operating rules of the company.

It is further ordered, That in all other respects the said order of January 14, 1924, shall remain in full force and effect.

By the Commission,

George B. McGinty, *Secretary.*"

(Seal)

It will be noted from this decision that the first request was denied; the second was not directly granted, though the Commission expressed a willingness to cooperate with the carriers in conducting tests, but without permitting these tests to serve as an excuse for delaying the order; the third request was not acted upon, and the fourth denied, except that forty-two of the forty-five roads mentioned in the second order for the first time (three having been previously exempted upon individual petition) had the effective dates of the completion of the order postponed until further order of the Commission. The Commission, however, did in their order insert what has been known as the Permissive Clause or Clause "1-b." This will be referred to under the heading of "Permissive Clause."

No further general orders have been issued by the Commission, and no hearings have been held, except one upon petition of the Great Northern Railway, which made a plea for exemption from the second order for the following reasons:

(1) No notice of the Commission's intention to make such order was received, and, therefore, had no opportunity to protest against it or selection of the district, except in the hearings held prior to the entry of the first order of June 13, 1922.

(2) Although the section selected immediately west of the section being installed under the first order is the most practicable one available, the need for automatic train control is small, since the alinement is generally straight and with light grades; the traffic is light, the time of crews on the road is short and the operating conditions are generally favorable.

(3) It is believed that no danger exists on this territory commensurate with the expense of installation as indicated by the accident record.

(4) Satisfactory return has not been earned on the investment already made in the railroad property, as shown by the tabulations of the record for the past five years.

(5) New financing for additional improvements can only be made through new bond issues due to the present market price of Great Northern stock.

(6) No expenditure on train control is justified until the main routes are completely signaled. The company is spending at the present time as much as it seems it can in the extension of its signal system.

(7) A reasonable contribution is already being made toward the development of the train control art. A more expensive device was selected than is now necessary under the requirements of the Commission, because the contract was entered into before it was known that the Commission would permit the forestalling feature to be reinstated.

(8) The patent situation is unsettled, as is evidenced by the suit brought against this Company alleging infringement upon certain patents.

Following the hearing granted the Railroad, the Commission gave its decision in an order dated October 10, 1925, denying these petitions. The report preceding the order concludes as follows:

> "The character and number of trains operated over the line of the Great Northern west of Minot warrant the installation of some

> form of automatic train-stop or train-control device. It is pertinent to state here that an elaborate, complicated, or expensive system of train control is not required to meet the specifications of our order. The purpose of such devices, briefly stated, is to protect a train from accidents by stopping the train automatically when the engineman fails to act. The installation of a reliable device to do this in connection with a system of automatic block signals, as in the case of the carrier here, is not, in our opinion, either difficult or unduly burdensome in view of the protection that will be accorded employees and passengers. The reasons set forth by the Great Northern for requesting relief from the second order are not sufficient. It is, of course, recognized that improvements in the roadbed, bridges, and so forth, must be made, but at the same time there must be progress in methods of protecting trains from the kind of accidents which, as our records show, are caused by failure to observe and obey operating orders or signals.
>
> "We are of the opinion that the request of the Great Northern that the order of January 14, 1924, be vacated and set aside in so far as it concerns that carrier, should be denied, and we so find."

A number of orders have been issued by the Commission exempting a few roads and extending the times for completion of many others.

TESTS

No tests have been conducted during the past year similar to those made previously to the issue of the I.C.C. order of June 13, 1922, although observations have been made on certain devices by the Interstate Commerce Commission Engineers besides the preliminary inspections of trial installations and the final inspections of those installations which have been completed.

In Exhibit "B" of the report of last year the proposal of the railroads to conduct tests was mentioned. This proposal was apparently favored by the Commission, and its report on this subject follows:

> "At the hearing and upon oral argument, it was suggested on behalf of all the carriers now required to install train control devices, that a joint committee of representatives of this Commission and of the carriers be appointed to decide upon and select such train-stop and train-control devices for test purposes as the joint committee may deem to be substantially within our specifications and requirements and worthy of a practical test. The test areas and units for the devices selected by the joint committee should be limited, it is further suggested, to a maximum of about ten miles of road and ten locomotives for each device, subject to agreement as to terms, etc., between the joint committee and the individual carrier. It was suggested that 100 miles in each of the eastern, southern, and western regions, on various railroads under all conditions of density of traffic, heavy grades, and weather, would be adequate.
>
> "The carriers suggest that, pending these tests, our second order should be vacated and set aside; that the time fixed for the completion of installation under our first order, namely, January 1, 1925, should be extended to January 1, 1926; that the installation already made, or to be made, under the latter order be subject to inspection and approval by the joint committee when an installation of ten miles of road and ten locomotives has been made; and that complete installation thereof be dependent upon the report of the committee and this commission.

> "The plan outlined is essentially the same as that which we suggested in 1920 and under which a joint committee of the American Railway Association was appointed in November of that year. This committee conducted tests in conjunction with representatives of our Bureau of Safety. The facts of these tests and the observations made are set forth in our report of June 13, 1922. As a result of these tests we found that there were in actual service under operating conditions devices which were practicable and which would properly perform the functions for which they were designed. Since that time improvements have been made in a great many of these devices. We are satisfied from our tests and observations that devices of various types can be installed in compliance with our order which will meet all our specifications and requirements for adequate automatic train control. To halt the work already under way, in order to await the decision of a joint committee would, in our opinion, unduly delay the progress of train-control. We see no reason, therefore, for vacating or setting aside or for generally extending the effective date of either of our orders insofar as they relate to the carriers covered by the first order, or for delaying in any way the execution and enforcement of these orders with respect to such carriers.
>
> "With this understanding as to the enforcement of the orders now entered, and only upon this understanding, there is merit in the plan of investigation and research suggested by the carriers if they wish to adopt it. Such a plan would doubtless result in the testing of many devices which otherwise might not be given the opportunity of a trial, and would aid in the development of the art and in progress toward the standardization which ultimately may prove desirable. We shall be glad to co-operate in such a plan to the extent of our ability, but shall not permit it to serve as an excuse for delay in the installations required by our orders."

Commissioner Esch advised that the full commission in conference expressed themselves as follows: "It does not seem to the Commission appropriate to grant blanket relief from its orders as asked."

As a result no tests have been arranged for, although the operations of devices in service are being observed and data collected by the Committee on Automatic Train Control of the American Railway Association.

PERMISSIVE CLAUSE

As stated above, the order of the Commission dated July 18, 1924, in refusing definitely to postpone the second order, granted the inclusion of the permissive clause, commonly known as the forestalling feature. This was in the original requirements which were given in American Railway Association Circular A.T.C. No. 2, March 8, 1921. As result of this change in the specifications a large number of carriers have adopted the automatic stop system with the forestalling feature. The Commission's statement, in their order of July 18, 1924, in restoring the Permissive Clause follows:

> "The matter of providing for the permissive feature in automatic train-stop devices was considered in our original report. While there was testimony in that case both in favor of and against the permissive feature, it was inconclusive. At the hearing in this case the testimony was overwhelmingly in favor of the permissive feature. Operating men almost without exception favored the

adoption of such a feature and expressed the opinion that it was sufficient to require the engineman to take some affirmative action to indicate that he is alert, has knowledge of the signal indication, and is operating his train in accordance with the operating rules. The committee representing the carriers were a unit in favor of the permissive feature. The Chief Operating Officer of the Rock Island and one of the locomotive engineers from that road who appeared as witnesses for the train control companies, favored the use of the permissive feature and some of the representatives of the train control companies stated that it was a desirable addition to a train stop. Other representatives expressed a contrary view. Certain carrier officials recognize the possibility that this feature might lead to carelessness, but believe that it should be left to the judgment of the management of a road to decide whether a permissive feature should be employed under certain operating conditions.

"The installation on the Chicago & Eastern Illinois, which has been in operation on a full division since 1914, and the installation on the Chesapeake & Ohio, which has been in operation since 1917, both use the permissive feature and no instance has developed where safety has been adversely affected thereby. Both of these companies favor its continued use for reasons above stated, which they have set forth at the hearings and in petitions which they have filed for a modification of our first order in this respect.

"We are of the opinion that the evidence now before us warrants a modification of our former conclusion with respect to this permissive feature, although we shall continue to keep this matter under close observation. Paragraph No. 1 under the sub-head 'Functions,' of our first order will therefore be modified to read as follows:

1. Automatic train stop:

   (a) Without manual control by the engineman requiring the train to be stopped; after which the apparatus may be restored to normal conditions manually and the train permitted to proceed; or

   (b) Under control of the engineman who may, if alert, forestall the application of the brakes by the automatic train-stop device and control his train in the usual manner in accordance with hand signals or under limits fixed by train order or prescribed by the operating rules of the company.

"The above modification requires no departure from the specifications and requirements contained in our first order; it merely provides an alternative feature which may be adopted, if desired."

INSPECTIONS

The first order of the Commission stated that "After installation made pursuant to this order, which when completed be subject to inspection by and the general approval of the Commission or a division thereof to which the matter may be referred." Many of the carriers felt that on account of the newness of the art, the Commission should inspect shorter installations and indicate whether or not the proposed arrangement would meet the Commission's approval. To meet this situation, the following press notice was issued by Secretary McGinty under date of June 9, 1924.

"The Commission has had many requests that we approve plans and specifications and that we inspect and test short test

> installations and express our opinion as to whether the device concerned would have our approval if installed. Manifestly we cannot undertake to do this and have declined to do so. Should, however, any carrier undertake a complete permanent installation in accordance with our order and complete a section of not less than 20 miles on the portion of the railroad designated in the order and equip not less than such number of locomotives as the Chief of our automatic train-control section and the carrier may agree upon, we will co-operate with the carrier if requested in making a preliminary inspection for the purpose of making such criticisms as may be deemed necessary, reserving final inspection and tests for approval of the complete installation as directed by the Commission's order.
>
> "By 'section of not less than 20 miles' it is understood that this has reference to route mileage and not track mileage. Where double tracks are used in the section, installation should be upon both tracks. As to number of locomotives to be equipped and allocated to the section, no formula is prescribed. The number of such locomotives to be determined for each carrier as a result of agreement or understanding with the Commission."

A list of preliminary and final inspections up to December 1, 1925, is attached as Exhibit "A."

REPORTS

Nineteen reports of the twenty-five preliminary inspections and three of the final inspections by the Interstate Commerce Commission have been issued. The preliminary reports are stated to be for the purpose—

> ". . . . of constructive criticism; the pointing out of such matters as may be helpful to the carrier in checking an installation against the specifications and requirements of the Commission, and comments concerning such other related points as our necessarily brief inspection may suggest."

The preliminary reports take the form of a letter from the Director of the Bureau of Signals and Train Control Devices to the carrier concerned and to the proprietors of the device; before being issued a conference is usually held between the interested parties and the Director of the Bureau of Signals and Train Control Devices. The reports of the inspections of the completed installations are printed and are issued in the form of an order by the Commission giving the approval and mentioning any exceptions which the Commission may make, and which the carrier is expected to correct. The same conference is usually held as with the preliminary reports. The criticisms and comments in the preliminary reports are of two classes: those relating to the device itself, and those relating to the installation of the device on the particular carrier. Comments on the device, which frequently are made, refer to such points as the clearances between different moving parts, possibility of parts being displaced or broken, and comments as to the class of material used. Comments or criticisms on the installations relate to the location of the track element, whether it might be removed without detection or not, the method of protection against fouling the main track from sidings, and the presence of foreign current in the track circuits. Some of these latter criticisms pertain as a matter of fact to the signal system as it has been developed and installed through a number of years. Many of these comments are obvious and the carriers are endeavoring to correct them constantly. In fact, many of them have been corrected before the report of the inspectors was ready for discussion.

APPROVALS

Two additional approvals have been given of devices which have been installed on the completed territory of the carriers concerned. These are the Chicago & Eastern Illinois Railway and the Oregon-Washington Railroad & Navigation Company. The final reports on the other inspections of the completed installation have not yet been issued. The Chicago & Eastern Illinois installation is the same one which was referred to in the last report as not having been approved, but modifications were made which enabled the Commission to approve it as stated above. The essential features of the last two approvals are given in Exhibit "B."

REQUIREMENTS AND SPECIFICATIONS

There have been no changes in requirements and specifications as given in the first order, and as amended by the "Forestalling Clause" in the order of July 18, 1924. With this amendment, the present requirements are shown in Exhibit "C." One or two interpretations have been made, the chief of which is the so-called "recurrent acknowledgment," which was stated by Division I of the Commission under date of July 22, 1924:

> "Interpretation of sub-paragraph 'b' of paragraph 2, under the heading 'functions' in the Commission's specifications and requirements for automatic train control devices. That consistent practice require definite acknowledgment by the engineman at each signal indicating 'stop' adopted."

This applies in a continuous system only, and means that, if a series of stop signals are encountered, an engineman must acknowledge by some action on his part, each and every signal so met. Those carriers which have adopted the continuous control object to it as unnecessary and involving additional expense. The Oregon-Washington Railroad & Navigation Company, upon whose installation a final report has been made, requiring this practice to be added, has asked for a hearing.

The following statement as to use of the permissive clause was issued on July 29, 1924, by Division I of the Commission:

> "With respect to your memorandum of today's date concerning paragraph 1 (b) under 'functions' allowing the use of the permissive feature in connection with an automatic stop, and your question as to whether the permissive feature must be so constructed that while an engineer may forestall an application of the automatic train stop device, the device shall prevent the release of the brakes should an automatic application once start until the train has been brought to a stop. This is the correct interpretation. Paragraph 6, under Design and Construction, specifically provides that the apparatus shall be so constructed as to prevent the release of the brakes after automatic application until the train has been brought to a stop. There is nothing inconsistent in this paragraph with that

> of paragraph 1 (b). Paragraph 1 (b) relates to the forestalling of the application of the brakes *before* the automatic stop device has started to operate. Paragraph 6 refers to an automatic stop device *after* it has begun to operate. It is the plain intendant of the requirement that if the engineer is not alert and the automatic stop once starts to apply the brakes, that application shall continue until the train stops."

SUITS

The only suit thus far filed between the Interstate Commerce Commission and the carriers named in the orders, is that of the Delaware & Hudson Company, which petitioned for the following:

> First—A permanent injunction decreeing, that said orders of the Interstate Commerce Commission be set aside, annulled, and suspended, and that their enforcement, operation and execution be forever enjoined.
>
> Second—An interlocutory injunction suspending and restraining the enforcement, operation and execution of said orders, in whole or in part, and setting the same aside.
>
> Third—Such other and further relief as to justice and equity may appertain.

Evidence was presented in the form of testimony and affidavits before the District Court of the United States, Southern District of New York. The decision, rendered by the three judges, sustained the Commission and denied the petitions of the Railroad Company. The Court, however, stated in its decision that the inclusion of the permissive clause "1-b" constituted a new order, and the railroad would, therefore, have two years from the date in which the permissive clause was announced for completion of their work; that is, until July 18, 1926. The decision has not been appealed.

PROGRESS

Eighteen carriers have completed their installations, and about ten have the work well along.

Nearly all the roads named in the first order have had their date of completion, as required by the order, set back by the Commission.

As of December 31, 1925, there were 7120 track miles of train control under construction or completed out of about 7769 track miles included in the first order, all roads named in first order having decided on the device to be used. The present standing of the roads named in the first order is attached as Exhibit "D." While the mileages given in these tables are substantially correct, slight changes are made by the roads from time to time as the work progresses.

The accompanying map indicates in a general way the location of the territories selected by the carriers named in the first and second orders. The selections so far made of the territories for the second order are usually adjacent to the territories named in the first order.

ANALYSIS OF ACCIDENTS

Work on the analysis of accidents investigated by the Interstate Commerce Commission as published in the Annual Accident Bulletins is being continued by the Committee on Automatic Train Control of the American Railway Association.

The Accident Bulletin No. 93 for the year 1924 which has recently been issued contains its usual statistics regarding railway accidents, and some analysis has been made of those accidents which it would appear possible might be affected by train control. Before, however, stating these tabulations, the method in which the I.C.C. Bulletins are prepared may be of interest.

Accidents are separated by the Commission into several divisions and sub-divisions. There are three primary classifications:

I Train Accidents, those resulting from the operation of trains, with or without casualties, and a railroad property damage exceeding $150.
II Train Service Accidents, those resulting from the operation of trains resulting in casualties to persons and a property damage less than $150.
III Non-Train Accidents, those not directly caused by the operation of trains, but such as result from shop operations, handling freight and materials, maintenance of way, etc.

The first class, that of Train Accidents, is again sub-divided into Collisions, Derailments, Locomotive Boiler Accidents, Other Locomotive Accidents and Miscellaneous. They are, therefore, those which result directly from train operation.

Train Service Accidents are classified under various headings, and generally include those to employees in the regular performance of their duties, such as those resulting from Coupling and Uncoupling Cars, the Operation of Locomotives and Operation of Switches. Accidents at Highway Crossings are included in this heading.

Casualties are classified as occurring to Non-Trespassers and Trespassers. Non-trespassers include employees, passengers, persons carried under contract, those on public highways not classified as trespassers, those on railroad property by license or permission. Trespassers include all persons who pass closed barriers in order to reach railroad property, and include those who attempt to pass trains at highway crossings.

The province of train control may be stated to be exclusively in the field of collisions. While it may be effective in preventing a limited number of other accidents, such as some derailments, its primary purpose is to prevent collisions, and, therefore, the analysis of those accidents classed under the heading of "Collisions" would seem to give all the information of value to train control problems, which can be derived from a study of accidents. Further, trespassers may be eliminated from consideration, as it would seem to be evident that the railroads should not be called upon to spend large amounts to avoid injury to those who wilfully expose themselves to injury, often in the face of direct and positive warnings. After excluding certain classifications of collisions, as will be noted later, there will undoubtedly still be some accidents which cannot be prevented by train control as ordinarily proposed and understood. These may be said to offset the accidents from other causes that train control would prevent, so that the investigations may be narrowed down to a certain number of the collisions.

In order to show the relations of these different classifications of accidents, the following table has been prepared from the tables given in the I.C.C. Bulletin, showing the reportable accidents of all classes:

TABLE A—CASUALTIES FOR 1924—STEAM ROADS

	Total	*Rate per Million Locomotive Miles*	*In Train Accidents*	*In Train Service Accidents*	*Non-Train Accidents*
		NON-TRESPASSERS			
Killed	3659	2.12	328	3331	.....
Injured	45518	26.38	3928	41590	.....
		TRESPASSERS			
Killed	2556	1.48	39	2517	.....
Injured	2853	1.65	58	2795	.....
		ALL PERSONS			
Killed	6215	3.60	367	5848	402
Injured	48371	28.03	3986	44385	95368

The following tables give the accidents, in which there were casualties, due to train operation, together with the damage to railroad property.

TABLE B—ALL CLASSES OF ACCIDENTS

NON-TRESPASSERS

	No. of Accidents	*Rate per Million Locomotive Miles*	*Killed*	*Per Cent*	*Injured*	*Damage to Railroad Property*
Collisions	5166	2.99	103	2.5	1808	$ 5,077,059
Derailments	14259	8.26	150	3.7	1906	16,538,877
Locomotive Boiler Accidents	46	0.03	25	.6	53	275,677
Other Locomotive Accidents	756	.44	...	...	20	352,141
Miscellaneous	2141	1.24	50	1.3	141	1,081,626
Train Service Accidents	46829	....	3331	33.0	41590	....
Non-Train Service Accidents	....	....	402	9.9	95368	....
Total	69197	....	4061	100.0	140886	$23,325,980

Table C—Accidents Involving Casualties

Non-Trespassers

	No. of Accidents	*Per Cent*	*Killed*	*Per Cent*	*Injured*	*Per Cent*
Collisions	509	41.0	103	31.4	1808	46.1
Derailments	604	49.4	150	45.8	1906	48.3
Locomotive Boiler Accidents	26	2.1	25	7.6	53	1.4
Other Locomotive Accidents	12	0.9	..	...	20	.6
Miscellaneous	83	6.6	50	15.2	141	3.6
Total	1244	100.0	328	100.0	3928	100.0
Trespassers			2556		2853	

From the above table, the collisions have been separated as shown in the following tables. These have been separated into different classes for the purpose of future classifications:

Table D—Collisions—1924

	No. of Train Accidents	*Killed*	*Injured*	*Damage R.R. Property*
Rear end	407	27	723	1,077,952
Head on	206	40	532	1,147,149
Broken train	179	..	6	130,719
Side or raking	435	2	1	528,485
Collisions at railway crossings:				
On private right-of-way	50	..	19	77,498
On public streets, etc.	8	..	4	3,876
Trains with car not in trains	120	8	99	116,317
Switching	3,341	24	227	1,714,305
Not elsewhere classifiable	420	2	54	281,358
Total	5,166	103	1,808	5,077,659

Table E

	No. of Train Accidents	*Killed*	*Injured*	*Damage R.R. Property*
Freight	1,130	9	69	688,392
Passenger	57	1	76	69,805
Mixed	11	..	3	4,689
Work	36	5	23	30,939
Yard	2,445	17	166	1,204,805
Not reported	24	..	4	17,199
Two or more freights	474	26	130	1,344,394
Two or more passengers	63	21	715	424,023
Freight and passenger	97	7	286	428,188
Other combinations	784	17	331	832,174
Not reported combinations	45	..	5	33,051
Total	5,166	103	1,808	5,077,659

Referring to table above, it seems reasonable to exclude switching collisions from this number, which gives a total of 1825 collisions, 79 deaths and 1581 injuries, with a railroad property damage of $3,363,354, as the final record of accidents which is subject to correction by automatic train control. Doubtless a number of those would be excluded by a study of the causes in each case, but the necessary information is not available from Bulletin No. 93. As many of these were investigated by the Bureau of Safety, some conclusions might be drawn by a careful study of the published summary of such investigations, though a complete analysis can only be made by a search in the records of the Commission.

Table E gives a different classification of Collisions, and a study will lead to approximately the same conclusions as for table D. In C, yard collisions should quite obviously be eliminated, and doubtless there are a number of others, especially under freight train operation, such as those at slow speed, those due to runaway cars, etc., that should be eliminated in any discussion on train control. Only a study of the records, as stated above, can give even an approximately conclusive answer.

All these tables show the small part that train control can possibly take in reduction of accidents due to railroad operation, when all roads are equipped and the devices are operating as intended.

An Appendix to Bulletin 93 shows the accident record for a number of years, and while there is an increase in the total number of casualties, the number per transportation unit is greatly reduced. For instance, for the fiscal year ending June 30, 1889, 1 employee was killed for each 357 employed; whereas for the last calendar year 1 was killed for each 1164 employed, which is the best record yet made. For injuries, these figures are 14 and 35 respectively. For the first period named, 1,523,000 passengers were carried per passenger killed, and for the last period, 6,314,000 passengers were carried. This is the best record except for 1923. The figures for injuries are 220 and 176, which is the best record, except for 1921.

The Bulletin includes a series of curves and diagrams presenting these figures for the last nine years graphically. These show a constantly decreasing record of fatalities to employees and passengers, and while there may be an increase for a year or two, the "peaks" are successively lower. This is true for the number of trainmen killed per 1000 in service, as well as for injuries. A diagram giving the relation between casualties to passengers and passenger miles, shows a decided improvement in this respect, and beginning with 1913 there has been a pronounced dropping off in injuries even with a greatly increased train mileage. The variation in the deaths to passengers is very much less, the number of them being very much smaller.

Another diagram shows the relation between the different major classes of accidents, and collisions occupy seventh place.

These tables and diagrams clearly show that the railroads are following methods and practices which tend to constantly decrease the accident record.

Map Showing Train Control Installations

KEY TO MAP SHOWING TRAIN CONTROL INSTALLATIONS

——————— Territory Covered by First Order.

- - - - - - - - - - - - - - Indicates Territory Selected for Second Order Where Known.

1.	AT&SF	First Order—Shopton, Iowa, to Chillicothe, Ill. Second Order—Chillicothe, Ill., to Chicago, Ill.
2.	ACL	First Order—Acca, Va., to South Rocky Mount, N. C. Second Order—
3.	B&O	First Order—Baltimore, Md., to Washington, D. C. Second Order—Baltimore, Md., to Philadelphia, Pa.
4.	B&A	First Order—Springfield, Mass., to Rensselaer, N. Y. Second Order—Boston to Springfield, Mass.
5.	B&M	First Order—Boston to Greenfield, Mass. Second Order—Greenfield, Mass., to Troy, N. Y.
7.	CRRNJ	First Order—Red Bank to Winslow Jct., N. J. Second Order—Elizabethport to Bay Head Jct., N. J.
8.	C&O	First Order—Gordonsville to Staunton, Va. Second Order—Staunton to Clifton Forge, Va.
9.	C&A	First Order—Chicago to Bloomington, Ill. Second Order—Bloomington, Ill., to St. Louis, Mo.
10.	C&EI	First Order—Yard Center to Danville, Ill. Second Order—Danville, Ill., to Terre Haute, Ind.
12.	C&NW	First Order—Boone to Council Bluffs, Ia. Second Order—Clinton to Boone, Ia.
13.	CB&Q	First Order—Creston to Pacific Junction, Ia. Second Order—Burlington to Creston, Ia.
14.	CI&L	First Order—Hammond to Monon, Ind. Second Order—
15.	CM&StP	First Order—Bridge Switch to Hastings, Minn. Second Order—La Crosse to Portage, Wis.
16.	CRI&P	First Order—Blue Island to Rock Island, Ill. Second Order—Davenport to Des Moines, Ia.
18.	CNO&TP	First Order—Ludlow to Somerset, Ky. Second Order—Somerset, Ky., to Chattanooga, Tenn.
19.	CCC&StL	First Order—Indianapolis, Ind., to Mattoon, Ill. Second Order—Mattoon to Bridge Junction, Ill.
20.	D&H	First Order—Whitehall to Rouses Point, N. Y. Second Order—Albany to Whitehall, N. Y.
21.	DL&W	First Order—Elmira to East Buffalo, N. Y. Second Order—
22.	Erie	First Order—Port Jervis, N. Y., to Susquehanna, Pa. Second Order—
23.	GH&SA	First Order—Rosenberg to Glidden, Tex. Second Order—Glidden to San Antonio, Tex.
24.	GN	First Order—Minot to Williston, N. D. Second Order—Williston, N. D., to Wolf Point, Mont.
25.	IC	First Order—Champaign to Branch Junction, Ill. Second Order—Waterloo to Fort Dodge, Iowa.

26.	KCS	First Order—Kansas City, Mo., to Pittsburg, Kan. Second Order—Exempt.
27.	LV	First Order—Newark, N. J., to Easton, Pa. Second Order—Easton to Sayre, Pa.
28.	LI	First Order—Harold Avenue to Port Washington and Whitestone Landing, L. I. Second Order—Jamaica, L. I., to Babylon, L. I.
29.	L&N	First Order—Corbin, Ky., to Etowah, Tenn. Second Order—
30.	MC	First Order—Detroit to Jackson, Mich. Second Order—Jackson to Niles, Mich.
31.	MP	First Order—Leeds, Mo., to Osawatomie, Kan. Second Order—
32.	NYC	First Order—Albany to Syracuse, N. Y. Second Order—Cleveland, Ohio, to Buffalo, N. Y.
33.	NYC&StL	First Order—Chicago, Ill., to West Fort Wayne, Ind. Second Order—
34.	NYNH&H	First Order—Air Line Jct., Conn., to Springfield, Mass. Second Order—New Haven, Conn., to Providence, R. I.
35.	N&W	First Order—Hagerstown, Md., to Shenandoah, Va. Second Order—Shenandoah to Roanoke, Va.
36.	NP	First Order—Mandan to Dickinson, N. D. Second Order—Dickinson, N. D., to Glendive, Mont.
37.	OWRR&N	First Order—East Portland to The Dalles, Ore. Second Order—Exempt.
38.	PA	First Order—Harrisburg, Pa., to Baltimore, Md. Second Order—Harrisburg to Altoona, Pa.
39.	PM	First Order—Seymour to North Lansing, Mich. Second Order—Lansing to Detroit, Mich.
40.	PCC&StL	First Order—Columbus, Ohio, to Indianapolis, Ind. Second Order—Pittsburgh, Pa., to Newark, Ohio.
41.	P&LE	First Order—Pittsburgh, Pa., to Youngstown, Ohio. Second Order—Exempt.
42.	Reading	First Order—Camden to Atlantic City, N. J. Second Order—
43.	RF&P	First Order—A. C. Block Station, Richmond to A. F. Block Station. Second Order—Entire line covered in first order.
44.	StL-SF	First Order—Nichols to Monett, Mo. Second Order—
45.	SP	First Order—Oakland to Tracy, Calif. Second Order—Tracy to Fresno, Calif.
46.	Southern	First Order—Spencer, N. C., to Greenville, S. C. Second Order—Greenville, S. C., to Atlanta, Ga.
47.	UP	First Order—Sidney, Neb., to Cheyenne, Wyo. Second Order—North Platte to Sidney, Neb.
48.	WJ&S	First Order—Camden to Atlantic City, N. J. Second Order—Entire line covered in first order.

Exhibit A

INSPECTIONS OF AUTOMATIC TRAIN CONTROL INSTALLATIONS BY INTERSTATE COMMERCE COMMISSION AS OF DECEMBER 31, 1925.

FINAL INSPECTIONS

C. R. I. & P.	Nov. 19–30, 1923	Regan	Ramp
C. & E. I.	Jan. 6–20, 1925	Miller	Ramp
O.-W. R. R. & N.	March 24–April 10, 1925	Union	Two-Speed
G. H. & S. A.	July 13–25, 1925	National	Intermittent Induction
S. P.	July 30–Aug. 12, 1925	National	Intermittent Induction
St. L.-S. F.	Aug. 3–15, 1925	National	Intermittent Induction
C. & O.	Aug. 24, 1925	American	Ramp
N. & W.	Sept. 8–Oct. 10, 1925	Union	Three-Speed
C. B. & Q.	Sept. 22–Oct. 8, 1925	Sprague	Intermittent Induction
U. P.	Oct. 7–Nov. 7, 1925	Union	Two-Speed
G. N.	Oct. 28–Nov. 19, 1925	Sprague	Intermittent Induction

PRELIMINARY INSPECTIONS

Penn.	Sept. 16–25, 1924	Union	Three-Speed
S. P.	Aug. 4–21, 1924	National	Intermittent Induction
St. L.-S. F.	Oct. 15–18, 1924	National	Intermittent Induction
M. P.	Sept. 2–6, 1924	National	Intermittent Induction
C. & A.	Dec. 1–5, 1924	National	Intermittent Induction
G. N.	Nov. 21–26, 1924	Sprague	Intermittent Induction
C. B. & Q.	Feb. 3–6, 1925	Sprague	Intermittent Induction
I. C.	March 2–7, 1925	Union	Two-Speed Continuous
C. N. O. & T. P.	March 2–6, 1925	General	Auto Manual
N. P.	April 14, 1925	Sprague	Intermittent Induction
A. C. L.	March 24–28, 1925	General	Auto Manual
L. V.	April 2–6, 1925	General	Auto Manual
N. Y. N. H. & H.	April 16–May 15, 1925	Union-General	Continuous Stop
C. I. & L.	May 4–9, 1925	Sprague	Intermittent Induction
D. L. & W.	May 18–23, 1925	Union	Two-Speed
L. & N.	May 19–23, 1925	Union	Two-Speed
M. C.	June 15–19, 1925	General	Two-Speed
N. Y. C.	June 15–20, 1925	Sprague	Intermittent Induction
R. F. & P.	June 15, 1925	Union	Two-Speed
C. & N. W.	June 4–12, 1925	General	Two-Speed
P. & L. E.	July 13–19, 1925	Union	Three-Speed
C. M. & St. P.	Sept. 3–14, 1925	Union	Stop
N. Y. C. & St. L.	Oct. 22–Nov. 2, 1925	Union	Intermittent Induction
P. M.	Nov. 3–Nov. 9, 1925	General	Intermittent Induction
D. & H.	Nov. 16–23, 1925	General	Intermittent Induction

Exhibit B

INTERSTATE COMMERCE COMMISSION APPROVALS

Chicago & Eastern Illinois Railway

Oregon-Washington Railroad & Navigation Company

Note.—The full text of the Chicago, Rock Island & Pacific installation was given as Exhibit "C" in last year's report, and is printed on page 350, Volume 26 of the Proceedings.

Interstate Commerce Commission

No. 13413

IN THE MATTER OF AUTOMATIC TRAIN-CONTROL DEVICES

No. 13413 (Sub. No. 2)

In the Matter of Automatic Train-Stop Device of the Miller Train Control Corporation on the Chicago Division of Chicago & Eastern Illinois Railway.

Inspection completed January 21, 1925. Decided March 27, 1925.

The report of the Commission describes the device, its installation and method of operation, after which the Commission states:

As a result of this inspection and test, it was found that the installation meets the requirements of the commission's specifications and order in Automatic Train-Control Devices, supra, and it, therefore, is approved, except as hereinafter indicated:

1. Pneumatic control valve drawing, D-100-A, December 24, 1924, with forestalling and positive-stop-feature, is designed in conformity with mechanical principles, substantially constructed, and is capable, when properly maintained, of functioning as intended. Provision should be made, however, for preventing the possibility of an accumulation of frost or ice from restricting the passageway in the conduit between the control valve and the ramp-shoe housing sufficiently to result in failure on the danger side. The pneumatic control valve, designated as "Reverted to No. 4 valve" on plan dated January 7, 1925, and applied to six locomotives (Nos. 626, 1001, 1009, 1014, 1020, and 1023) is open to such criticism that as at present designed it can not be approved.

Those locomotives, the train-stop equipment of which is not in accordance with plan D-100-A, December 24, 1924, as above, must be equipped in accordance with such plan to warrant approval.

2. To prevent any possible alteration upward of the adjustable height of the ramp contact shoe, a filler block should be placed in each bolting-flange slot between the lower bolt and the lower extremity of the slot.

3. With the ramp-displacement detector which was found to be applied to six ramps, there is a possibility of the line control wire which is looped through the detector becoming grounded, and with the rugged construction of the ramp used in this installation it is believed that such detectors are not necessary.

The Chicago & Eastern Illinois Railway Company will be expected to comply at once with the following requirements as to inspection, tests, and maintenance:

1. Arrangements should be made for careful inspection and test of the train-stop equipment on all locomotives operated in train-stop equipped

territory upon arrival at and before departure from designated inspection and repair points. The inspection and test should include all parts of the apparatus, and before each trip the sealed cut-out valve should be inspected to see that its seal is unbroken and the apparatus properly cut in for service. A daily report as to the condition of the apparatus should be made on a form provided for that purpose and forwarded by the inspector to a designated officer.

2. The roadside apparatus should be frequently inspected and tested for crosses and grounds and the ramps frequently inspected to insure that they are in proper operative condition; reports thereon being made on a form provided for that purpose and forwarded by the inspector to a designated officer.

3. A form should be provided for and used by each engineman in reporting failures of the apparatus and any irregularities in the operation of the device. All such information should be reported in detail.

Certain situations were noted which, in our opinion, should be corrected by the railway company as a precautionary measure in order to secure a greater degree of safety and to prevent a possible failure properly to protect train operations, insofar as it concerns the signal system upon which the train-control device is superimposed. In the following specific respects the railway company should promptly take the necessary action to carry into effect the recommendations made:

1. The interval between a ramp and the signal in advance should be sufficient in all cases to provide adequate braking distance.

2. At crossovers such arrangements should be made as to afford maximum signal protection to main-track traffic.

3. All movements leading to main tracks should be protected through the signal system.

4. For movements at and through interlocking plants ramps should only be energized for high-speed routes.

While these recommendations do not reflect upon the train-control device itself, we feel that as a matter of precaution the carrier's attention should be called to them and it should comply therewith in order that the greatest degree of safety may be insured. The attention of the Chicago & Eastern Illinois officials has been called to these matters.

No. 13413 (Sub. No. 3)

IN THE MATTER OF AUTOMATIC TRAIN CONTROL DEVICE OF UNION SWITCH & SIGNAL COMPANY ON FIRST DIVISION OF OREGON-WASHINGTON RAILROAD & NAVIGATION COMPANY.

Inspection completed April 10, 1925. Decided July 31, 1925.

1. After inspection and test, installation found to meet the requirements of our specifications and order, and installation approved, except as indicated.
2. Requirements prescribed in respect of certain apparatus and operations with which the carrier is expected promptly to comply.

The report of the Commission follows describing the device, installation and method of operation. There is also included in the printed report a dissenting opinion by Commissioner McChord, who believed that the approval should be withheld.

A

(d) Maximum-speed restriction, providing for an automatic-brake application if the prescribed maximum-speed limit is exceeded at any point.

GENERAL REQUIREMENTS

1. An automatic train-stop device shall be effective when the signal admitting the train to the block indicates stop, and so far as possible when that signal fails to indicate existing danger conditions.

2. An automatic train-control or speed-control device shall be effective when the train is not being properly controlled by the engineman.

3. An automatic train-stop, train-control, or speed-control device shall be operative at braking distance from the stop-signal location if signals are not overlapped, or at the stop-signal location if an adequate overlap is provided.

DESIGN AND CONSTRUCTION

1. The automatic train-stop or train-control device shall meet the conditions set forth under general requirements applicable to each installation.

2. The apparatus shall be so constructed as to operate in connection with a system of fixed block or interlocking signals, if conditions so require, and so interconnected with the fixed-signal system as to perform its intended function (a) in event of failure of the engineman to obey the signal indications; and (b) so far as possible, when the signal fails to indicate a condition requiring an application of the brakes.

3. The apparatus shall be so constructed that it will, so far as possible, perform its intended function if an essential part fails or is removed, or a break, cross, or ground occurs in electric circuits, or in case of a failure of energy.

4. The apparatus shall be so constructed as to make indications of the fixed signal depend, so far as possible, upon the operation of the track element of the train-control device.

5. The apparatus shall be so constructed that proper operative relation between the parts along the roadway and the parts on the train will be assured under all conditions of speed, weather, wear, oscillation, and shock.

6. The apparatus shall be so constructed as to prevent the release of the brakes after automatic application until the train has been brought to a stop, or its speed has been reduced to a predetermined rate, or the obstruction or other condition that caused the brake application has been removed.

7. The train apparatus shall be so constructed that, when operated, it will make an application of the brakes sufficient to stop the train or control its speed.

8. The apparatus shall be so constructed as not to interfere with the application of the brakes by the engineman's brake valve or to impair the efficiency of the air-brake system.

9. The apparatus shall be so constructed that it may be applied so as to be operative when the engine is running forward or backward.

10. The apparatus shall be so constructed that when two or more engines are coupled together, or a pushing or helping engine is used, it can be made operative only on the engine from which the brakes are controlled.

11. The apparatus shall be so constructed that it will operate under all weather conditions which permit train movements.

12. The apparatus shall be so constructed as to conform to established clearances for equipment and structures.

13. The apparatus shall be so constructed and installed that it will not constitute a source of danger to trainmen, other employees, or passengers.

14. The apparatus shall be so constructed, installed, and maintained as to be safe and suitable for service. The quality of materials and workmanship shall conform to this requirement.

Exhibit D

First I.C.C. Order 13413

TRACK MILES OF AUTOMATIC TRAIN CONTROL TO BE INSTALLED AND UNDER WAY

	Under Construction	*Total Installation*	*Effective Date of Completion*
Atchison, Topeka & Santa Fe Ry	†209.0	209.0	Completed
Atlantic Coast Line R. R.	243.9	243.9	10-31-25
Baltimore & Ohio R. R	72.6	72.6	1-1-25
Boston & Albany R. R	234.5	234.5	7-1-25
Boston & Maine R. R	27.6	206.0	7-1-25
Central R. R. Company of New Jersey	†65.6	65.6	Completed
Chesapeake & Ohio Ry	†61.0	61.0	Completed
Chicago & Alton R. R	40.0	229.1	7-1-26
Chicago & Eastern Illinois Ry	†210.8	210.8	Completed
Chicago & North Western Ry	298.0	298.0	1-1-26
Chicago, Burlington & Quincy R. R	†139.8	139.8	Completed
Chicago, Indianapolis & Louisville Ry	67.7	67.7	7-1-26
Chicago; Milwaukee & St. Paul Ry	216.2	216.2	1-1-26
Chicago, Rock Island & Pacific Ry	†330.0	330.0	Completed
Cincinnati, New Orleans & Texas Pacific Ry	235.0	235.0	1-1-26
Cleveland, Cincinnati, Chicago & St. Louis Ry	200.8	200.8	7-1-25
Delaware & Hudson Company	20.0	118.3	1-1-25
Delaware, Lackawanna & Western R. R	†282.0	282.0	Completed
Erie Railroad Company	40.0	204.0	1-1-26
Galveston, Harrisburg & San Antonio Ry	†50.6	50.6	Completed
Great Northern Ry	†142.8	142.8	Completed
Illinois Central R. R	244.8	244.8	7-1-25
Kansas City Southern Ry	17.0	121.0	7-1-26
Lehigh Valley R. R	168.4	168.4	3-1-26
Long Island R. R	32.8	32.8	1-1-25
Louisville & Nashville R. R	162.0	162.0	1-1-26
Michigan Central R. R	149.0	149.0	7-1-25
Missouri Pacific R. R	†49.9	49.9	Completed
New York Central R. R	553.11	553.11	7-1-25
New York, Chicago & St. Louis Ry	*143.7	143.7	1-1-26
New York. New Haven & Hartford R. R	†124.0	124.0	Completed
Norfolk & Western Ry	†105.3	105.3	Completed
Northern Pacific Ry	†109.3	109.3	Completed
Oregon-Washington R. R. & Navigation Company	†86.5	86.5	Completed
Pennsylvania Railroad	166.2	166.21	7-1-25
Pennsylvania Railroad, Lewistown Branch	†55.0	....	Completed
Pere Marquette Ry	60.9	60.9	2-1-26
Pittsburgh, Cincinnati, Chicago & St. Louis Ry	*345.5	345.5	7-1-25
Pittsburgh & Lake Erie R. R	227.68	227.68	7-1-25
Reading Co.	†108.2	108.2	Completed
Richmond, Fredericksburg & Potomac Ry	203.2	203.2	7-1-25
St. Louis-San Francisco Ry	†44.4	44.4	Completed
Southern Pacific Company	†98.8	98.8	Completed
Southern Railway	306.0	306.0	1-1-26
Union Pacific Railroad	†204.0	204.0	Completed
West Jersey & Seashore R. R	*116.8	116.8	7-1-25
Total	7,070.39	7,749.20	

---

*Under contract, or material ordered. †Completed.

CENTER OF ROAD

Advantages

(a) Majority of automobiles have left-hand drive; careful driver has his eyes focused on the highway, or at least one of them usually is. Signal on level of his eyes and in center of highway is in more direct line of sight than one on right side of highway, which may be overlooked.

(b) As it constitutes an obstruction in the highway, it cannot be overlooked, especially if the base is painted black and white, checkerboard style.

(c) Highway must be widened on each side of it. Therefore, drivers must exercise more care in turning out for it, than if they had a straightaway road.

(d) Standard location of all such signals should be in the center of the highway and all existing signals should be changed for uniformity, as should all crossing signs, as the obstruction in the middle of the road constitutes additional protection because it draws the attention of the driver to a danger he might otherwise overlook.

(e) With the traveled way widened and improved on account of this location, drivers will naturally follow the traveled way over the railroad at the point they should travel.

(f) Separates traffic crossing railroad into two lanes, and to considerable extent prevents cars cutting in and passing on the crossing itself.

(g) Cars stopped at crossing or signal are less liable to interfere with the view, as driver intending to pass standing or slow moving vehicle ahead naturally turns to left into full view of the signal.

(h) It is better for a drunken driver (of which a few sporadic cases are still extant) and his passengers (if any) to run into this obstruction than into the path or side of a train which may be approaching.

(i) Advertising and other signs are located at the side of the road; few, if any, in the center. Therefore, the location is distinctive.

(j) Traffic officers to be effective must always be in the center of the street. This signal is a silent traffic officer.

Disadvantages

(a) Signals frequently run into and put out of service because they are less visible than those located on roadside.

(b) They obstruct the highway at a point where it should be clear of all obstructions.

(c) As they are only illuminated when train is approaching, which is only a small part of the 24 hours, on dark nights they are not seen if car has poor headlights, and many of the heavy trucks have short-range lights.

(d) At some places where they are installed, authorities require overhead or flood lighting and at others colored lights on base or mast. The Indiana Commission requires one or two red lights at the base of the signal, burning constantly. Other authorities prefer yellow lights or red or yellow flex or Stimsonite, or some other extraneous means for calling attention to the obstruction. Such colored lights burning constantly detract from the effectiveness of the signal itself. Flood lighting costs money.

(e) For a considerable distance along the road the signal is directly in line of the driver's eye and headlights of opposing cars, the glare of which renders it invisible when not lighted and dim when lighted, this perhaps being one of the worst factors.

(f) It is not the province or duty of a railroad to place an obstruction in the highway, especially if liable for damage. One railroad has been sued by a driver who ran into signal so located. We think there are others.

(g) If placed over the highway, it is hidden by the automobile roof a considerable distance from the crossing, and may change indication after driver loses sight of it.

(h) It costs somewhat more to install even if the Highway Department erects the obstruction, and the cost of widening the street is frequently excessive.

(i) Being an obstruction, it requires the vehicle to turn out. Many authorities are of the opinion that the safest crossing is a straightaway level one, where the driver can give all his attention and thought to probability of an approaching train.

(j) It is a particularly bad location for the wig-wag, even if one is used with red light constantly burning.

(k) Cars turning to the left to pass cars ahead are liable to hit the obstruction, especially if opposing headlights form the background.

RIGHT SIDE OF ROAD

Advantages

(a) It does not obstruct the road.

(b) It is in the same relative position as all the other warning or danger signs erected by the Highway Department and other local authorities.

(c) It is the place the driver by force of habit and education looks for information.

(d) It is usually out of the line of headlight glare.

(e) It is not necessary to render it visible by extraneous lighting when no train is approaching.

(f) As it does not require widening of the street approaching the crossing, it can be placed nearer the railroad in most cases than if in the center and thereby gives the latest possible information to the driver.

(g) It is cheaper to install.

(h) It is the place to put it.

Disadvantages

(a) It may have to be placed so far from the traveled part of the highway that it is entirely overlooked.

(b) If near the road, it may have to be high and perhaps underlooked. The use of the short arm cross-buck sign would greatly reduce if not entirely eliminate both these objections.

(c) Automobiles stopping, especially on right side of road (where they should stop) for repairs; parking and petting parties may obscure

Many recognize the weakness of depending on the watchman to cut the lights in. One road provides a thermostatic clock; watchman cuts signals out when coming on duty and winds clock; signals automatically cut in by the clock. In view of damage suit referred to, it is questionable whether the lights should be cut out when the watchman is on duty. If they are, should they be cut over to an indicator giving information to the watchman? This would be comparatively inexpensive, as the track circuits would be in operation whether signals were cut in or not.

If signals are in service with watchman on duty, should the latter be permitted to give hand signals to proceed if crossing signals indicate stop, especially when shifting is being done on the circuit, or should watchman cut signals out when giving signals to proceed? This may be accomplished and danger of his forgetting to cut in avoided by requiring him to stand on a circuit closer or hold in a push button while giving such signals.

One road has circuit by which trainmen, while shifting, may cut out signal, and by use of a restoring circuit halfway between the shifting point and crossing, train automatically cuts it in, another cut-in being provided for trains going away from the crossing after shifting. It should be noted that, while such arrangement would undoubtedly be all right on a single-track road, on double or more tracks, if train were shifting and signal cut out for that reason, high-speed train might be approaching on another track at the same time with signal inoperative and consequently no warning given.

How much are we justified in complicating circuits and increasing costs to meet the above outlined conditions and are there additional problems of this nature, of which the Committee has no present knowledge and concerning which it should take action to if possible effect uniformity for the safety of the traveler on the highway?

Seventh—On multiple-track roads, should signals always indicate for reverse traffic as well as assigned traffic direction? Or should they so indicate only on tracks normally operated in both directions? Or is there some point midway where such protection is necessary and, if so, how is it to be established? If indicating in assigned traffic direction only, what protection should be provided in emergency reverse traffic operation?

We had a case in Maryland on a double-track railroad where we never ran trains against traffic normally. However, we had a broken rail and we put a train over on the other track and ran it against traffic. The engineman whistled three times approaching the crossing, the engine bell was ringing, but the highway crossing signal, of course, was not working because the train was running against the current of traffic. It struck three boys and killed them. We have ordered trains running in that way to take extra precautions. That is a matter where the Train Rules Committee can get in its work, because most of the crossing signals are made to operate only in the direction of traffic and not in the reverse direction. There should be some provision made that when trains are running against the current of traffic the trainmen will at such locations take extra precautions. On one road the trainman has to flag every crossing when they run in a reverse direction. The result is that they do not run in the reverse direction very often.

How far should the railroads properly go in trying to meet conditions brought about by no fault or action of their own?

Eighth—The Rudd-Rhea Report on Railroad Signaling stated, "It can only be presupposed that an engineman 'knows his road' when he has been furnished the means of identifying the location and character of every signal governing him, by a comprehensive and thoroughly uniform system, and then he should be expected to know it." Now, 20 years afterward, by the substitution of "motorist" for "engineman" this statement might well be used to cover highway conditions. The cooperation of public service or utility commissioners, highway officials, railroad officers, and local authorities is necessary. When such a system is provided, the automobile driver should be held strictly to account for any errors on his part. Which brings us to the point of considering his attitude. A great majority of the drivers are careful, painstaking and considerate.

We think our statistics show that about 4 per cent of the motorists are wilfully careless, and you can pick off those 4 per cent and eliminate most of the accidents. It is the careless people whom we cannot protect against. There are many accidents that are not our fault, but, on the other hand, we must establish better protection. The Chairman of this Sub-Committee has a "Cross Crossings Cautiously" sign on the back of his car. He thinks it does some good. At least several people have spoken about it. If he only had it in front so he could see it, it would help him.

We have an educational duty to perform. We owe it to ourselves and our families and it is our duty as citizens to set the example of always driving carefully. It is our duty to urge our neighbors and friends to do likewise. We must help create a great public sentiment in condemnation of the careless and discourteous driver. Where there are no sidewalks, get people to walk on the left side of the highway, facing traffic; do it yourself. It gives you a much better chance to jump; if you are too old to jump quickly, do not walk on the highway unless you want your insurance paid. In driving, acquire the sixth sense of the taxi driver who can guess what the other fellow is going to do and do it first. Take every precaution you can, get others to do so; then stay home as much as possible and, when you do have to ride, use the railroad at every opportunity. It is the safest place you can be.

We have a great mass of statistics culled from the Interstate Commerce Commission reports and arranged in various forms, covering fatalities in different classes of accidents, derailments, collisions, miscellaneous, etc., which we shall now not present, and only give a few comparisons of interest.

In the State of Pennsylvania in 1914, about 45 automobiles were smashed at grade crossings and in 1924, 960, or 20 times as many, while less trespassers were hurt and killed; the theory being that those who were in 1914 walking the railroad are now driving "Henry's" in the same happy-go-lucky fashion as they formerly pressed the ties, and getting theirs in increasing numbers.

REPORT OF COMMITTEE XIV—YARDS AND TERMINALS

J. R. W. Ambrose, *Chairman;*
Irving Anderson,
C. E. Armstrong,
J. E. Armstrong,
Hadley Baldwin,
H. M. Bassett,
E. J. Beugler,
C. H. Blackman,
C. A. Briggs,
W. P. Bruce,
R. A. Cook,
J. D'Esposito,
A. W. Epright,
O. H. Frick,
E. H. Fritch,
Otto Gersbach,
A. L. Grandy,
John V. Hanna,
M. J. J. Harrison,
J. G. Wishart, *Vice-Chairman;*
E. M. Hastings,
R. A. C. Henry,
J. B. Hunley,
H. C. James, Jr.,
D. B. Johnston,
B. H. Mann,
C. P. McCausland,
J. A. McGrew,
A. Montzheimer,
C. H. Mottier,
H. L. Ripley,
H. M. Roeser,
J. E. Saunders,
C. H. Spencer,
E. E. R. Tratman,
W. M. Whitenton,
J. L. Wilkes,

Committee.

To the American Railway Engineering Association:

Your Committee on Yards and Terminals submits the following reports:

(2) Joint Operation of Passenger Terminals (Appendix A).
(3) Scales (Appendix B).
(4) Freight Yard Design, Suggesting Economies in Operation (Appendix C).
(6) Mechanical Means for Controlling or Retarding the Movement of Cars in Hump Yards (Appendix D).
(7) Outline of Work for Ensuing Year.

Action Recommended

1. That the report on Joint Operation of Passenger Terminals be received as information.
2. That the report on Scales be approved.
3. That the report on Freight Yard Design be accepted as information.
4. That the report on Mechanical Means for Controlling or Retarding the Movement of Cars in Hump Yards be accepted as information.

Recommendations for Future Work

1. Revision of the Manual.
2. Study and report upon joint operation of passenger terminals.

A

3. Scales:
    - (a) Automatic indicating devices for weighing.
    - (b) Tolerances for railway service weighing devices.
    - (c) Tolerances for testing, adjusting and maintaining railway track scales.
    - (d) Capacity for motor truck scales.
    - (e) Analysis of Bill H.R. 4465 to regulate and control the manufacture, sale, and use of weights and measures and weighing and measuring devices for use or used in trade or commerce, and for other purposes.
    - (f) Revise combined commodity and scale tolerance.

4. Freight yard design, suggesting economies in operation:
    - (a) Layout for icing cars, etc.

5. The proper size and arrangement of large passenger station facilities as determined by the business handled.

6. Mechanical means for controlling or retarding the movement of cars in hump yards.

7. Outline of work for ensuing year.

Respectfully submitted,
THE COMMITTEE ON YARDS AND TERMINALS,
J. R. W. AMBROSE, *Chairman.*

Appendix A

(2) JOINT USE OF PASSENGER TERMINALS

H. L. Ripley, Chairman, Sub-Committee; J. R. W. Ambrose, I. Anderson, J. E. Armstrong, H. M. Bassett, E. J. Beugler, C. H. Blackman, J. D'Esposito, J. V. Hanna, E. M. Hastings, R. A. C. Henry, J. B. Hunley, B. H. Mann, C. H. Mottier, J. E. Saunders, C. H. Spencer, J. L. Wilkes, J. G. Wishart.

Activities of the Committee

The activities of the Sub-Committee having to do with Passenger Terminals have been confined this year to the subject of the joint operation of passenger terminals and, specifically, to the collection of data on existing jointly operated terminals.

Questionnaire "A"

A questionnaire, appearing in this report as Exhibit A, was forwarded to the Chief Engineer of each "Class One" railroad of the United States and Canada, asking for a list of the important joint passenger stations in which his company was interested, and for certain general information about each property to guide the Committee in making a selection of data for further study. Replies were received from 96 companies, covering 101 joint stations, which the Chief Engineers thought might be of sufficient magnitude to be worthy of further investigation by the Committee.

Questionnaire "B"

From the list of 101 projects furnished in response to the original inquiry, 51 terminals were selected, which appeared to be representative and to offer a reasonable chance of having data of the character needed. A questionnaire, which appears in the report as Exhibit B, was prepared and forwarded to each of these 51 terminals, and 37 responded with the desired information.

Tabulation "C"

These replies covering the 37 terminals have been tabulated in Exhibit C accompanying this report. This Exhibit is preliminary to further study which is contemplated.

Progress Report

The present report is a progress report only. It is presented this year in the belief that it may be of some help in showing the location, character, and scope of some of the larger joint passenger terminal projects, and the extent to which auxiliary facilities are supplied and auxiliary service performed; beyond that of the mere accommodation and handling of passengers within the station and station yard.

From the number of answers received to the first questionnaire, it is evident that joint ownership and joint use of passenger terminals has become an established practice.

The tabulation (Exhibit C) is self-explanatory and is informative of the location; size; number of participating carriers; who they are; whether owning or tenant companies; whether managed by an independent organization or by a single owning carrier; volume of business handled; number of tracks; whether or not space is provided for commercial enterprise; character of business handled; and character of facilities provided in addition to straight station service.

Of the thirty-seven terminals listed:

Two were opened in 1865;
Four between 1880 and 1889;
Five between 1890 and 1899;
Twelve between 1900 and 1909;
Twelve between 1910 and 1919;
Two between 1920 and 1925.

Twenty-four have a separate organization and are separately managed as a Terminal Company.

It is the intention of the Committee to follow the matter further and it is hoped to add some of the more important terminals now missing.

Next year the Committee hopes to offer, for the consideration of the Association, some definite recommendations outlining in particular a practical and equitable basis for distributing the costs involved in the joint ownership and joint use of passenger stations and passenger terminal facilities, which distribution will be fair both to the owning and to tenant lines.

Exhibit A

Boston, May 21, 1925.

To the Chief Engineers—Class I Railroads:

The Directors of the American Railway Engineering Association have instructed the Yards and Terminals Committee to study and report upon Joint Operation of Passenger Terminals. This work has been assigned to Sub-Committee No. 2, of which I am Chairman.

In order to obtain a proper basis upon which to make a start, it is necessary to obtain a list of the important passenger terminals and passenger stations of the country where a joint use is made of them by two or more operating carriers not under the same management or so closely affiliated with it that the two are essentially one.

There is to be a meeting of this Sub-Committee on June 8th, and it is desirable that preliminary information be obtained in connection with as many of these projects as possible before that date. The Committee requests therefore that this letter be given early attention. For this reason, if the answer to any of the eleven questions is not readily available in your case for any one of the terminals in the use of which your company participates, will you be good enough to answer the remaining questions and return them to me without waiting to look up the missing data?

(Signed) H. L. Ripley,
Corporate and Valuation Engineer.

AMERICAN RAILWAY ENGINEERING ASSOCIATION

YARDS AND TERMINALS COMMITTEE

JOINT OPERATION OF PASSENGER TERMINALS

Boston, May 21, 1925.

Data is needed by the Yards and Terminals Committee of the American Railway Engineering Association for the study of Joint Passenger Terminals and Stations.

1. Does your company participate in the joint occupation of any large Passenger Terminals or Passenger Stations, not including the incidental use of simple way stations at junction points? If so, will you please give the Committee the following data:
2. The location, by cities and states, of all such joint terminals.
3. The name by which each of them is known.
4. The name, title and address of the responsible operating officer of the Terminal.
5. The name, title and address of the chief engineering officer of the Terminal.
6. The names of the several companies participating in the use of the Terminal.
7. Is the Terminal operated under a separate organization and management?
8. If not under separate organization, are the records kept as a separate unit or division and statistics compiled accordingly, if you know?
9. Did the consolidation result in the abandonment of other stations? If so, how many, if you know?
10. What was the opening date, the year, if you know?
11. If you can do so conveniently, will you please enclose with your answer a general site plan or diagram of each Terminal and its location relative to the using railroads?

Exhibit B

AMERICAN RAILWAY ENGINEERING ASSOCIATION

YARDS AND TERMINALS COMMITTEE

SUB-COMMITTEE No. 2

July, 1925.

Subject: Study and Report Upon Joint Operation of Passenger Terminals

Data is needed to enable the Yards and Terminals Committee of the American Railway Engineering Association to carry out the instruction of the Directors, as indicated by the subject assigned to them, quoted above. Will you please forward to the chairman of Sub-Committee No. 2 the information requested below?

1. Name of the Passenger Terminal.
2. Opening date (the year).
3. How is the ownership apportioned or divided?

4. What is the basis of payments for service rendered? (Per train? Per car? Per passenger? Per tickets sold? Tolls? A combination? etc.) Please give full information.
5. On what basis are profits divided or deficits made up?
6. Does the passenger terminal include, under its own management and control:
    - (a) An engine terminal.
    - (b) A coach and cleaning yard.
    - (c) Its own motive power for shunting and spotting.
    - (d) Mail facilities.
    - (e) Express facilities.
    - (f) A power plant for producing light, heat, etc.
    - (g) A signal and interlocking plant.
    - (h) Office space for tenant roads.
    - (i) Office space for non-carrier activities.
    - (j) Store space for non-carrier activities.

NOTE.—Where data is called for asking for a separation (as between companies, etc.), please give the separation if known; estimate the split if feasible; or give figures for the terminal as a whole if that is the best data available, making your answer clear as to just what you do. Please do not withhold an answer because of lack of some detail.

7. If an engine terminal is included give approximate number of road (passenger) engines handled and turned:
    - (a) By the terminal company.
    - (b) By the individual roads at their own engine house.
    - (c) Average distance from center of train shed to center of engine terminal or terminals.
8. Coach and cleaning yard, if included:
    - (a) Number of units handled by terminal company.
    - (b) Number of units handled by each individual road in its own yard.
    - (c) Distance, center of train shed to center of coach-yard or yards.
    - (d) Is power for cleaning, heating, lighting, etc., supplied from terminal company power plant?
9. Motive power for shunting and spotting trains or cars:
    - (a) Number of units of terminal company equipment used.
    - (b) Number of units of railroad equipment used as above.
    - (c) Number of turn-around runs, requiring no shunting or spotting of cars.
10. Express building and facilities:
    - (a) Number of cars handled per day.
    - (b) How is track space paid for?
    - (c) How is house and platform space paid for?
    - (d) Does the terminal company furnish the facilities with:
        - Light
        - Heat
        - Power
11. Mail:
    - (a) What is the whole (average) number of mail cars (whole or compartment) handled per day?
    - (b) How is trackage paid for?
    - (c) How is house and platform space paid for?
    - (d) Does the terminal company power plant furnish the facilities with:
        - Light
        - Heat
        - Power

12. Signals and Interlocking:
    - (a) Number of Interlocking Plants.
    - (b) Whether Electro-Pneumatic, Electric or Mechanical.
    - (c) Number of working levers for each interlocker.

NOTE.—Question 13 is intended to develop something of the *character,* as well as the *amount* of business handled. If detail is not available, give totals.

13. Business Handled:
    - (a) Number of trains on average of a recent peak month.
        - (1) Long distance travellers (a) Outbound
        - (b) Inbound
        - (2) Commuters (a) Outbound
        - (b) Inbound
    - (b) Number of trains handled during a single (average) peak hour of 60 consecutive minutes.
        - (1) Long distance travellers (a) Outbound
        - (b) Inbound
        - (2) Commuters (a) Outbound
        - (b) Inbound
    - (c) Average business from each carrier, per day
        - (1) Average number of trains.
          Carrier -a- -b- -c- etc. (Long distance)
          (Commuter)
        - (2) Average number of cars including passenger, mail and express.
          Carrier -a- -b- -c- etc. (Long distance)
          (Commuter)
        - (3) Total average number of switching movements.
          Carrier -a- -b- -c- etc. (Long distance)
          (Commuter)
        - (4) Approximate number of all movements
            - (a) Per day
            - (b) During rush hour.

14. Are tracks for long distance travel and for suburban travel separately provided, by means of:
    - (a) Different track levels
    - (b) Different locations within one station
    - (c) Separate stations

15. Number of tracks:
    - (a) Total number of loading tracks adjacent to passenger platforms:
        - (1) Number of through tracks
        - (2) Number of stub-end tracks
    - (b) Number of additional running, or by-pass tracks, not adjacent to passenger platforms.

16. Was the terminal originally planned to accommodate present tenants or is joint use a later development?

17. The controlling motives for consolidating the service into one terminal, so far as you know them?

18. What advantages over separate terminals have accrued from consolidation?
    - (a) Space saved
    - (b) Time saved
    - (c) Organization reduced
    - (d) Maintenance decreased
    - (e) Flexibility of service
    - (f) Convenience to public
    - (g) Convenience to carriers
    - (h) Gain in goodwill
    - (i) Effect on value of adjacent property
    - (j) Increase in through train and car routes
    - (k) Decreased cost to one or more tenant roads
    - (l) Etc.

19. What disadvantages or objections have developed:
    - (a) Congested streets and approaches
    - (b) Delays to trains from bunching service
    - (c) Increased distances for passengers to travel to facilities and trains
    - (d) Congested concourse through even short delay to outgoing trains
    - (e) Increased cost for one or more tenant roads
    - (f) Etc.

20. What economies have resulted from the consolidation, considering: fixed charges, relative operating costs, maintenance, mileage, better use of power equipment, organization, personnel, etc.?

    If no definite figures are available in terms of money, the Committee would like to have estimates. If no figures are given, please make your answers to questions 17, 18, 19 and 20 in narrative form, and as complete as possible.

21. What features limit the desirability of consolidation of passenger terminals?
    - (a) Unwieldy size and spaces
    - (b) Increased walking distances
    - (c) Number of passengers to be handled per minute during rush hour
    - (d) Street congestion
    - (e) Space required for supporting yards and station grounds
    - (f) Cost
    - (g) Etc.

(Signed) H. L. Ripley,
Chairman, Sub-Committee No. 2.

Corporate and Valuation Engineer,
New York, New Haven & Hartford Railroad,
Room 434, South Station, Boston, Mass.

Joint Operation of Passenger Terminals

I-tem No.	Location	Name of Terminal	Popula-tion (Thousands) 1920	Participating Carriers	Open-ing Date?	Has it Separate		Business Handled				Number of Loading Tracks Adjacent to Passenger Platforms	
						Management and Organization?	Records?	Number of Trains Per Day: An Average of a Recent Peak Month		Number of Trains Handled During a Single (Average) Peak Hour of 60 Consecutive Minutes		Through Tracks	Stub End Tracks
								Long Dist.	Commuters	Long Dist.	Commuters		
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)
1.	Albany, N.Y.	Albany Passenger Station	113	(o)NYC:B&A:D&H:Rutland	1900	No	No	241	93	36	4	12	2
2.	Atlanta, Ga.	Atlanta Terminal Co.	200	(o)A&WP:(o)CofGa:(o)So:GaRR:AB&A:SAL.	1905	Yes		132 in all		30 in all		10	10
3.	Boston, Mass.	Boston Terminal Co.	748	(o)NYNH&H:(o)B&A.	1899	Yes	Yes	228	302	23	79	None	28
4.	Buffalo, N.Y.	D.L.&W. Station	506	(o)DL&W:BR&P:Wab:NYC&StL:SoB.	1917	No		31	14	5	3	None	7
5.	Charleston, S.C.	Charleston Union Sta.Co.	67	(o)ACL:(o)So:SAL	1907	Yes	Yes	16	22	6	4	None	11
6.	Chattanooga, Tenn.	Chattanooga Station Co.	57	(o)CofGa:(o)So:(o)CNO&TP:(o)AGS	1907	Yes		50 in all		Unknown	Unknown	None	
7.	Chicago, Ill.	Dearborn Station	2701	(o)C&WI:(o)C&EI:(o)CI&L:(o)Wab:(o)Erie:(o)AT&SF :GTW.	1885	Yes		82	37	14	5	None	15
8.	Chicago, Ill.	Central Station	2701	(o)IC:MO:C&O:CCC&StL.	1893			78	None	10	None	7	None
9.	Chicago, Ill.	LaSalle Street Station	2701	(o)NYC:(o)CRI&P:NYC&StL.	1902	No	No	66	131	8	20	None	11
10.	Chicago, Ill.	Chicago Union Sta. Co.	2701	(o)Penn[PCC&StL:PFW&C]:(o)CM&StP:(o)CB&Q:C&A.	1925	Yes		265 in all		44 in all		1	23
11.	Cincinnati, O.	Cent.Union Depot & Ry.Co.	401	(o)CCC&StL:(o)B&O:L&N:So:CNO&TP:CN.	1883	Yes	Yes	117	12	17	-	None	8
12.	Cleveland, O.	Clev.Union Pass.Depot Ass'n	796	(o)NYC:(o)CCC&StL:(o)Penn.	1865	Yes		135	19	16	3	8	1
13.	Denver, Colo.	Denver Union Term.Ry.Co.	256	(o)AT&SF:(o)CB&Q:(o)CRI&P:(o)C&S:(o)D&RGW:(o)UP.	1916	Yes		82	26	15	2	9	3
14.	E.St.Louis, Mo.	E.St.L.Relay Passenger Ass'n	772	(o)M&O:(o)L&N:(o)Wab:(o)CCC&StL:(o)C&A:(o)Penn:(o) IC (o)T&StLV:(o)B&OSW:(o)So:(o)CB&Q:(o)StLSW:(o) StLIM&S.	1890	Yes		92 in all		12 in all		6	
15.	El Paso, Texas.	El Paso Union Pass.Depot Co.	77	(o)EP&SWofTex:(o)T&P:(o)GH&SA:(o)AT&SF:(o)Mex.Ctl:(o)SP	1906	Yes		35	None	10		5	4
16.	Erie, Pa.	Erie, Pa.	93	(o)NYC:Penn.	1865			59	2	8		4	2
17.	Fort Worth, Texas.	Fort Worth Union Station	106	(o)H&TC:(o)AT&SF:GC&SF:StL&SW:FW&DC.	1900	Yes		24	None	5	None	2	2
18.	Galveston, Texas.	Union Pass.Depot Co.of Calv.	44	(o)AT&SF:GC&SF:MK&T:IGN:GH&SA.	1897	Yes		20	None	4		None	7
19.	Houston, Texas.	Houston Belt & Term.Ry.Co.	138	(o)StLB&M:(o)GC&SF:(o)T&BV:(o)BSL&W:GCL:ICN	1908	Yes		22	None	13		None	8
20.	Indianapolis,Ind.	Indianapolis Union Station	314	(o)CCC&StL:(o)Penn[PCC&StL]:IC:CI&L:CI&W:NYC&StL:P&E	1922	Yes		175	None	24	None	12	1
21.	Macon, Ga.	Macon Terminal Co.	52	(o)CofGa:(o)So:(o)GS&F:GaRR:MD&S.	1916	Yes		41	35	4	9	6	8
22.	Memphis, Tenn.	Grand Central Station	162	(o)IC:Y&MV:CRI&P:StL&SF.	1914	Yes	Yes	80	None	None	None	4	6
23.	Memphis, Tenn.	Memphis Union Station Co.	162	(o)L&N:(o)NC&StL:(o)MP:(o)StL&SW:(o)So.	1912	Yes	Yes	43	None	12	None	None	8
24.	Montgomery, Ala.	Union Passenger Station.	43	(o)L&N:M&O:SAL:CofGa:WRofA:ACL.	1898	No	No		None		None	5	3
25.	Montreal, P.Q.	Windsor St. Station.	618	(o)CPR:NYC:D&H.	1914	No	Yes	85 Total of all		15 Total of all		None	11
26.	New York, N.Y.	Grand Central Terminal.	5620	(o)NYC:NYNH&H.	1913	Yes		190	240	10	41	11	42
27.	Omaha, Neb.	Union Passenger Station.	191	(o)UP:CGW:CM&StP:CStPM&O:MP:Wab:IC:C&NW:CRI&P.	1900			199	None	30	None	9	5
28.	Ottawa, P.Q.	Union Station.	107	(o)CN:CPR:NYC[O&NY]:	1912	No	Yes	60	4			2	6
29.	Portland, Ore.	N.P.Terminal Co. of Oregon.	258	(o)NP:(o)UP:(o)SP:OWRR&NCo:GN:SP&S.	1882	Yes		68	30	13	8	9	None
30.	Quebec, P.Q.	Palais Station.	95	(o)CPR:CNR:QCRR.	1915	No	Yes	35 Total of all		8 Total of all		1	9
31.	Savannah, Ga.	Savannah Union Station.Co.	83	(o)SO:(o)ACL:(o)SAL.	1901	Yes		68	16	12	2	None	8
32.	Seattle, Wash.	King St.Passenger Station.	315	(o)GN:(o)NP.	1906	No	Yes	24	12	6	None	5	5
33.	Spokane, Wash.	Spokane Union Station.	104	(o)UP[OWRR&NCo]:(o)CM&StP:SIRy.	1914	No		22	None			5	6
34.	Tacoma, Wash.	Union Depot.	96	(o)MP:GN:OWRR&NCo.	1911	Yes		30	None	3	None	5	1
35.	Toledo, O.	Toledo Union Passenger Sta.	243	(o)NYC:HV:B&O:MC:NYC&StL:CCC&StL:PM:Wab.	1886	No		172	None	38	None	9	8
36.	Washington, D.C.	Washington Terminal Co.	285	(o)B&O:(o)Penn:So:C&O:RF&P.	1907	Yes		254	30	10	17	9	21
37.	Wichita, Kan.	Wichita Union Terminal Co.	72	(o)AT&SF:(o)StL&SF:CRI&P:KCM&O.	1914	Yes		32	None	7	None	5	5

NOTES: (o) - Column (e) denotes that carrier against which symbol appears participates in the ownership.

(8-c) Commuters handled at a separate station.

(13-c) Different Location within station for commuters.

(26-c) - Different Location and different track levels for commuters.

(20-f) - Original Station 1853 - Rebuilt 1922.

Joint Passenger Terminals—Facilities

Item No.	Location	Name of Terminal	DOES THE PASSENGER TERMINAL INCLUDE, UNDER ITS OWN MANAGEMENT AND CONTROL:-									
			An Engine Terminal?	A Coach and Cleaning Yard?	Its own motive power for shunting and spotting?	Mail Facilities?	Express Facilities?	A power plant for producing light, heat, etc?	A signal and interlocker plant?	Office Space for Tenant Roads?	Office Space for Non-Carrier Activities?	Space for Commercial Concessions?
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)
1	Albany, N. Y.	Albany Passenger Station	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
2	Atlanta, Ga.	Atlanta Terminal Co.	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
3	Boston, Mass.	Boston Terminal Co.	No	No	No	Yes	Yes	Yes	Yes	Yes	No	Yes
4	Buffalo, N. Y.	D. L. & W. Station	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
5	Charleston, S. C.	Charleston Union Sta. Co.	No	Yes	No	Yes	Offices only	Heat only	No	Yes	Yes	Yes
6	Chattanooga, Tenn.	Chattanooga Station Co.	No	Yes	Yes	Yes	Yes	No	Yes	Yes	No	No
7	Chicago, Ill.	Dearborn Station	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Limited	No	No
8	Chicago, Ill.	Central Station	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No
9	Chicago, Ill.	LaSalle Street Station	No	No	No	Yes-leased	Yes-leased	Yes	Yes	Yes	No	No
10	Chicago, Ill.	Chicago Union Sta. Co.	No	No	No	Yes	Limited	Heat only	Yes	Yes	Yes	Yes
11	Cincinnati, O.	Cent.Union Depot & Ry. Co.	No	No	No	No	No	Yes	No	No	No	No
12	Cleveland, O.	Cleve. Union Pass.Depot Assn.	Yes	Yes	Yes	Yes-leased	Yes-leased	Yes	Yes	No	No	No
13	Denver, Colo.	Denver Union Term. Ry. Co.	No	No	No	Yes	Yes	No	Yes	Yes	Yes	Yes
14	E. St.Louis, Mo.	E.St.L.Relay Passenger Assn.	No	No	No	Yes	Yes	No	No	No	No	No
15	El Paso, Texas.	El Paso Union Pass.Depot Co.	No	No	No	Yes	No	Heat only	No	No	Yes	No
16	Erie, Pa.	Erie, Pa.	No	No	No	Yes-leased	Yes-leased	Yes	No	Yes	No	No
17	Fort Worth, Texas	Fort Worth Union Station	No	No	No	Limited	Yes-leased	Heat only	No	No	Cab.Co.	News-stand
18	Galveston, Texas.	Union Pass.Depot Co. of Galv.	No	No	No	No	Yes-leased	Heat only	No	Yes	No	Lunch&News
19	Houston, Texas	Houston Belt & Term. Ry. Co.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
20	Indianapolis, Ind.	Indianapolis Union Station	No	No	No	Yes	Yes-leased	No	No	Yes	No	No
21	Macon, Ga.	Macon Terminal Co.	No	No	No	Yes-leased	Yes-leased	Heat only	No	Yes	No	No
22	Memphis, Tenn.	Grand Central Station	No	No	No	Yes	Yes	Heat and Power	No	Yes	No	No
23	Memphis, Tenn.	Memphis Union Station Co.	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	No	No
24	Montgomery, Ala.	Union Passenger Station	No	No	No	Yes	Yes	No	No	No	No	No
25	Montreal, Que.	Windsor St. Station	Yes	Yes	Rented	Yes	Yes	Yes	Yes	No	No	No
26	New York, N. Y.	Grand Central Terminal	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
27	Omaha, Neb.	Union Passenger Station	No	No	No	Yes	No	No	Yes	No	No	No
28	Ottawa, P.Q.	Union Station	Limited	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
29	Portland, Ore.	N.P.Terminal Co.of Oregon	Yes	Yes	Yes	Yes	Yes-leased	Heat and Power	Yes	Yes	Yes	Yes
30	Quebec, P. Q.	Palais Station	No	Yes	Rented	No	Yes	Heat and Power	No	Yes	No	No
31	Savannah, Ga.	Savannah Union Station Co.	No	Yes	No	Yes	Yes	Heat only	Yes	No	No	Yes
32	Seattle, Wash.	King St. Passenger Station	No	Yes	No	Yes	Yes	Heat only	Yes	Yes	No	No
33	Spokane, Wash.	Spokane Union Station	No	No	No	Platform	Yes	No	No	Yes	No	No
34	Tacoma, Wash.	Union Station	No	Yes	No	Yes	Yes	Heat only	No	No	No	No
35	Toledo, O.	Toledo Union Passenger Sta.	Yes	Yes	Yes	Yes-leased	Yes-leased	Yes	Yes	No	No	No
36	Washington, D.C.	Washington Terminal Co.	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
37	Wichita, Kan.	Wichita Union Terminal Co.	No	No	No	Yes-leased	Yes-leased	No	Yes	Yes	Yes	No

Joint Passenger Terminals—Facilities

Item No.	Location	Name of Terminal	ENGINE TERMINALS			COACH CLEANING YARD			
			Number of Units Handled Per Day		Average distance from center of train shed to centers of engine terminal or terminals.	Number of Units Handled per Day		Distance Center of Train Shed to Center of Coach Yard or Yards.	Is Power for Cleaning Heating, Lighting, etc. supplied from Terminal Company Power Plant?
			By the Terminal Co.	By the individual roads at their own roundhouse		By the Terminal Co.	By each individual road in its own yard		
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)
1.	Albany, N.Y.	Albany Passenger Station	None	NYC 20; B&A 8	NYC 5750'; B&A 6600'	None	NYC 125; B&A 40; Pullman 35	NYC ¼M; B&A 1 M	Each Co. furnishes own
2.	Atlanta, Ga.	Atlanta Terminal Co.	None	None	---	None	None		---
3.	Boston, Mass.	Boston Terminal Co.	None	(NH 160 and 20 (B&A 61	(NH 4400' and 7300' (B&A 20600'	392 in Sta.	(NH 625: PCo 82 and NH 90 (B&A 260: PCo 50	(NH 4400' and 11000' (B&A 9000'	No
4.	Buffalo, N.Y.	D.L.&W. Station	No Co.	DL&W 14; Wab 4; BR&P 12; NKP 6	DL&W 6M; BR&P 2M; NKP 2M	No Co.	DL&W 36; Wab 12; BR&P 30; NKP 18	DL&W 6M; BR&P 2M; NKP 2M	Yes, for DL&W & Wabash
5.	Charleston, S.C.	Charleston Union Sta. Co.	None	Not answered	Not answered	39	None	All over the yard	Yes
6.	Chattanooga, Tenn.	Chattanooga Station Co.	None	None	None	100	None	500 Feet	No
7.	Chicago, Ill.	Dearborn Station	39	19	5 Miles	332	80 per month	5 Miles	Yes
8.	Chicago, Ill.	Central Station	51	MCRR 27	IC (In 12000' Out 16400' MC (In 7600' Out 2200'	78	None	3400 Feet	Yes
9.	Chicago, Ill.	LaSalle Street Station	None	NYC 40; RI 55; NKP 3	NYC 7M; RI 4.7 & 15.0; NKP 11M	None	NYC 375; RI 310; NKP 36	NYC 4M; RI 5.1 & 1.0; NKP 11M	Individual
10.	Chicago, Ill.	Chicago Union Sta. Co.	None	None	None	None	None	None	None
11.	Cincinnati, O.	Cent. Union Depot & Ry. Co.	None	None	None	None	None	None	None
12.	Cleveland, O.	Clev. Union Pass. Depot Ass'n	None	NYC 18; CCC&StL 19; PRR 15	NYC 7.8M; CCC&StL 6.2M; PRR 7M	None	NYC 72; CCC&StL 50; PC 85	NYC 0.4M; CCC&StL 0.4M; PC 0.5M	Individual
13.	Denver, Colo.	Denver Union Term. Ry. Co.	None	None	None	None	None	None	None
14.	E.St.Louis, Mo.	E.St.L. Relay Pass. Ass'n	None	None	None	None	None	None	None
15.	El Paso, Texas.	El Paso Union Pass. Depot Co.	None	None	None	None	None	None	None
16.	Erie, Pa.	Erie, Pa.	None	NYC 1; PRR 7	NYC 4.5M; PRR 1.6M	None	NYC 6; PRR 40.	NYC 100'; PRR 1.6M	Individual
17.	Fort Worth, Tex.	Fort Worth Union Station	None	None	None	None	None	None	None
18.	Galveston, Tex.	Union Pass. Depot Co. of Galv.	None	None	None	None	None	None	None
19.	Houston, Tex.	Houston Belt & Term. Ry. Co.	7	None	6725 Feet	43	None	6700 Feet	Yes
20.	Indianapolis, Ind.	Indianapolis Union Station	None	None	None	None	None	None	None
21.	Macon, Ga.	Macon Terminal Co.	None	None	None	None	None	None	None
22.	Memphis, Tenn.	Grand Central Station.	None	None	None	None	None	None	None
23.	Memphis, Tenn.	Memphis Union Station Co.	38	None	1700 Feet	100	None	2000 Feet	Yes
24.	Montgomery, Ala.	Union Passenger Station	None						
25.	Montreal, Que.	Windsor St. Station	60	None	2.3 Miles	600	None	2.3 Miles	Yes
26.	New York, N.Y.	Grand Central Terminal.	None	None	None	948	None	In Terminal	Yes
27.	Omaha, Neb.	Union Passenger Station	None		3.5 Miles	None	Each at Council Bluffs	3.5 Miles	No
28.	Ottawa, P.Q.	Union Station	20	CNR 40; O&NY 4	CNR 0.9M; NYC 15M; CPR 8M	119		0.5 and 0.25	Yes
29.	Portland, Ore.	N.P. Terminal Co. of Oregon	3	UP 8; GN 2; SPNS 9; SP 8	2 Miles	180	SPCo 52; SP&S 58	2 Miles	Heat only
30.	Quebec, P.Q.	Palais Station	None	None	None	400	None	Adjacent to Station	All but light
31.	Savannah, Ga.	Savannah Union Station Co.	None	None	None	66	None	1000 Feet	Heat only
32.	Seattle, Wash.	King St. Passenger Station	None	None	None	2	None	0.25 Miles	Heat only
33.	Spokane, Wash.	Spokane Union Station	None	Each Co.	0.75 Miles	None	Each	0.75 Miles	None
34.	Tacoma, Wash.	Union Station	None	Each	0.5 Miles	None	33	200 Feet	Heat only
35.	Toledo, O.	Toledo Union Passenger Sta.	40	HV 3; B&O 6; Wab 3; NKP 2	NYC 2.5M; HV 2M; B&O 2M; Wab 1M; NKP 1.5M	107	None	0.6 Miles	Individual
36.	Washington, D.C.	Washington Terminal Co.	250	None	1.6 Miles	900	None	1 Mile	Yes
37.	Wichita, Kan.	Wichita Union Terminal Co.	None	Each Co.	3 Miles	None	Frisco 14; AT&SF 8	3 Miles	No

Joint Passenger Terminals—Facilities

Item No.	Location	Name of Terminal	MOTIVE POWER FOR SHUNTING AND SPOTTING TRAINS OR CARS			SIGNALS AND INTERLOCKING		
			Number of Units of Equipment		Number of turn-around runs, requiring no shunting or spotting of cars	Number of Interlocking Plants	Electro-Pneumatic, Electric, or Mechanical	Number of Working Levers for each Interlocker
			Of Terminal Company	Of Individual Railroad Companies				
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
1	Albany, N. Y.	Albany Passenger Station	None	NYC 9 - Others use train loco.	25	2	Electro-Pneumatic	44 and 47
2	Atlanta, Ga.	Atlanta Terminal Co.	None	Individual	Not answered	2	Electrical	189 and 176
3	Boston, Mass.	Boston Terminal Co.	None	NYNH&H 5; B&A 5	NH 30; B&A 15	1	Electro-Pneumatic	143
4	Buffalo, N. Y.	D. L. & W. Station	None	2	None	1	Electro-Pneumatic	23
5	Charleston, S. C.	Charleston Union Sta. Co.	None	Individual - No Record	No record	1	Mechanical	52
6	Chattanooga, Tenn.	Chattanooga Station Co.	1	None	1	1	Electric	No answer
7	Chicago, Ill.	Dearborn Station	22	Unknown	None	None	Hand thrown switches	——
8	Chicago, Ill.	Central Station	14	None	None	5	4 Mech; 1 Elec.	118; 17; 89; 96; 57
9	Chicago, Ill.	LaSalle Street Station	None	5	None	1	Electric	145
10	Chicago, Ill.	Chicago Union Sta. Co.	No	No	No	2	Electro-Pneumatic	95 and 171
11	Cincinnati, O.	Cent.Union Depot & Ry. Co.	None	None	None	None	None	None
12	Cleveland, O.	Cleve.Union Pass. Depot Assn.	None	NYC 4; CCC&StL 4; P Co. 2	None	None	None	None
13	Denver, Colo.	Denver Union Term.Ry.Co.	None	None	None	2	Electric	88 and 78
14	E.St.Louis, Mo.	E.St.L.Relay Passenger Assn.	None	Not answered	Not answered	None	None	None
15	El Paso, Texas	El Paso Union Pass.Depot Co.	None	Not Answered	Not answered	None	None	None
16	Erie, Pa.	Erie, Pa.	None	NYC 1; PRR 1	NYC 2; PRR 4	None	None	None
17	Fort Worth, Texas	Fort Worth Union Station	None	None	None	None	None	None
18	Galveston, Texas	Union Pass.Depot Co. of Galv.	None	None	None	None	None	None
19	Houston, Texas	Houston Belt & Term. Ry. Co.	7	None	None	4	3 Elec; 1 Mech.	66; 28; 21; 13
20	Indianapolis, Ind.	Indianapolis Union Station	None	4	8	None	None	None
21	Macon, Ga.	Macon Terminal Co.	None	None	Not answered	None	None	None
22	Memphis, Tenn.	Grand Central Station	None	None	None	None	None	None
23	Memphis, Tenn.	Memphis Union Station Co.	None	Road engines used		1	Electro-Pneumatic	116
24	Montgomery, Ala.	Union Passenger Station	None	None	None	None	None	None
25	Montreal, Que.	Windsor St. Station	5	None	None	2	Electric	28 and 88
26	New York, N. Y.	Grand Central Terminal	None	35	12	6	Electric	263;326;97;12;45;91
27	Omaha, Neb.	Union Passenger Station	Not answered		Not answered	2	Electric	96 and 80
28	Ottawa, P.Q.	Union Station	7	None	2	2	1 Elec; 1 Mech.	No answer
29	Portland, Ore.	N.P.Terminal Co. of Oregon	11	None	None	1	Electric	56
30	Quebec, P.Q.	Palais Station	4	None	None	None	None	None
31	Savannah, Ga.	Savannah Union Station Co.	None	Not answered	All back in	4	2 Elec; 2 Mech.	12;20;32;32
32	Seattle, Wash.	King St. Passenger Station	None	3	None	2	Mechanical	85
33	Spokane, Wash.	Spokane Union Station	None	Not answered	Not answered	None	None	None
34	Tacoma, Wash.	Union Station	None	1	No switching	None	None	None
35	Toledo, O.	Toledo Union Passenger Sta.	None	8	None	2	1 Elec; 1 Mech.	89 and 30
36	Washington, D.C.	Washington Terminal Company	15	None	Very few	3	Electro-Pneumatic	27;172;83
37	Wichita, Kan.	Wichita Union Terminal Co.	None	No regular units assigned	6	2	Electric	70 and 65

Joint Passenger Terminals—Facilities

Item No.	Location	Name of Terminal	EXPRESS FACILITIES					
			No. of Cars Handled Per day	Track Space How Paid For?	House and Platform Space How Paid For?	Does the Terminal Co. furnish the facilities With		
						Light	Heat	Power
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
1	Albany, N. Y.	Albany Passenger Station	D & H 25 NYC &B&A - 100	Uniform agreement for express operations over rail lines between N.Y.C. & Am.Ry. Express Co.	Annual Rental	No	Yes	No
2	Atlanta, Ga.	Atlanta Terminal Co.	60	Included in building rent	Monthly Rental	Yes	Yes	Yes
3	Boston, Mass.	Boston Terminal Co.	166	Included in Term'l facilities of tenant R.R.s	Contract	Yes	Yes	Yes
4	Buffalo, N. Y.	D.L.& W. Station	45	Contract for exp.operations over Rail lines	Contract	No	Yes	No
5	Charleston, S.C.	Charleston Union Sta. Co.	14 (est.)	No charges	Monthly basis-C.U.S.Co.	No	No	No
6	Chattanooga, Tenn.	Chattanooga Station Co.	Not answered	Not answered	Not answered	Yes	Yes	None used
7	Chicago, Ill.	Dearborn Station	164	No special tracks	Rental by Express Co.	Yes	Yes	Yes
8	Chicago, Ill.	Central Station	Term.Co.56½:MCRR 28	Wheelage basis	Express Co. pays rental	Yes	Yes	Yes
9	Chicago, Ill.	LaSalle Street Station	125	Included in term'l facilities of Railroads	Rental by Express Co.	Yes	Yes	Yes
10	Chicago, Ill.	Chicago Union Sta. Co.	None	None	Space in basement on rental basis	Yes	Yes	Yes
11	Cincinnati, O.	Cent.Union Depot & Ry.Co.	None	None	None	None	None	None
12	Cleveland, O.	Clev.-Union Pass.Depot Assn.	78	Terminal Co.	Rental by Express Co.	Yes	Yes	Yes
13	Denver, Colo.	Denver Union Term.Ry.Co.	25	Uniform Express Contract	Uniform Express Contract	Yes	Yes	Yes
14	E.St.Louis, Mo.	E.St.L.Relay Passenger Assn.	None	None	None	None	None	None
15	El Paso, Texas	El Paso Union Pass.Depot Co.	Not answered	None	None	No	Yes	No
16	Erie, Pa.	Erie, Pa.	7	Included in term'l facilities of Railroads	Express Co.	Yes	Yes	Yes
17	Port Worth, Tex.	Fort Worth Union Station	None	None	Leased by month	No	No	No
18	Galveston, Tex.	Union Pass.Depot Co.ofGalv.	No records	None used	On interest rental basis	No	No	No
19	Houston, Tex.	Houston Belt & Term.Ry. Co.	14	Furnished by Terminal Co.	Leased to Express Co.	No	No	No
20	Indianapolis, Ind.	Indianapolis Union Station	120	Included in lease	Included in lease	Yes	Yes	Yes
21	Macon, Ga.	Macon Terminal Co.	54	No charge	Fixed annual rental	No	Yes	No
22	Memphis, Tenn.	Grand Central Station	20	No charge	Interest rental basis	No	Yes	Yes
23	Memphis, Tenn.	Memphis Union Station Co.	No answer	Flat rental	Flat rental	Yes	Yes	Yes
24	Montgomery, Ala.	Union Passenger Station	No answer	No charge	Annual rental	Yes	Yes	Yes
25	Montreal, P.Q.	Windsor St. Station	40	No answer	No answer	Yes	Yes	Yes
26	New York, N.Y.	Grand Central Terminal	105	General agreement with Express Co.	Unloading platforms-general agreement with Express Co. Platforms & Storage space under lease.	Yes	Yes	Yes
27	Omaha, Neb.	Union Passenger Station	137	No. chg. as Carriers provide same under contract	Agreed amount for rental plus Maint.& Repairs	No	Yes	No
28	Ottowa, P.Q.	Union Station	10	No exclusive trackage	Each road has proportionate space	Yes	Yes	Yes
29	Portland, Ore.	N.P.Terminal Co. of Oregon	51	No payment by Express Co.	On interest rental basis	No	No	No
30	Quebec, P.Q.	Palais Station	14	No answer	No answer	No	Yes	No
31	Savannah, Ga.	Savannah Union Station Co.	4	No charge	Lease of land	No	Yes	No
32	Seattle, Wash.	King St. Passenger Station	36	Rentage	Rentage	Yes	Yes	Yes
33	Spokane, Wash.	Spokane Union Station	No answer	No answer	No answer	Yes	Yes	Yes
34	Tacoma, Wash.	Union Station	None	Rental	Rental	No	Yes	No
35	Toledo, O.	Toledo Union Passenger Sta.	40	N.Y.C.	Express Co.	Yes	Yes	Yes
36	Washington, D.C.	Washington Terminal Co.	No answer	No charge	Rental	Yes	Yes	Yes
37	Wichita, Kan.	Wichita Union Terminal Co.	4	No charge	Rental basis for warehouse, no charge for platform.	No	Yes	No

Joint Passenger Terminals—Facilities

Item No.	Location.	Name of Terminal	MAIL FACILITIES. The whole (average) number of mail cars (whole or compt) Handled per day.	Trackage How paid for?	House and platform space How paid for?	Does the Terminal Co. power plant furnish the facilities with: Light	Heat	Power
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
1.	Albany, N.Y.	Albany Passenger Station.	202	Mileage Basis	Platform, Mileage charge, House, fixed annual.	No.	Yes.	No.
2.	Atlanta, Ga.	Atlanta Terminal Co.	75	Wheelage Basis	Agreed rental paid quarterly.	Yes.	No.	No.
3.	Boston, Mass.	Boston Terminal Co.	32 storage mail cars which vary.	Included in Term. facilities of tenant R.Rs.	Paid on basis of business handled.	Yes.	Yes.	Yes.
4.	Buffalo, N.Y.	D.L.&W. Station.	27	On a car space basis.	Lump sum for all.	Yes.	Yes.	Yes.
5.	Charleston, S.C.	Charleston Union Sta. Co.	14 (est.)	No charges.	No charges.	No.	Yes.	Yes.
6.	Chattanooga, Tenn.	Chattanooga Station Co.	30	Per foot in car.	Stated rental.	Yes.	Yes.	None used
7.	Chicago, Ill.	Dearborn Station.	Not answered.	No special tracks - No charge.	No special space - No charge.	Yes.	Yes.	Yes.
8.	Chicago, Ill.	Central Station.	56	Wheelage Basis.	Wheelage basis.	Yes.	Yes.	Yes.
9.	Chicago, Ill.	LaSalle Street Station.	80	Included in terminal facilities of Railroads.		Yes.	Yes.	Yes.
10.	Chicago, Ill.	Chicago Union Sta. Co.	147	(Above track level on rental basis. (Track level- Wheelage and ownership basis.	(Above track level on rental basis. (Track level - Wheelage and ownership basis.	Yes.	Yes.	Yes.
11.	Cincinnati, O.	Cen. Union Pass. Depot & Ry Co.	None	None	None	None.	None	None.
12.	Cleveland, O.	Cleve. Union Pass. Depot Ass'n	70	NYC 2/3 : CCC&StL. 1/3	By Railroads.	No.	No.	No.
13.	Denver, Colo.	Denver Union Term. Ry. Co.	40	None exclusively leased to R.P.O.	House paid for on sq.ft.basis, no special platform space.	No.	No.	No.
14.	E.St.Louis, Mo.	E.St. Relay Passenger Ass'n	None	None	Small transfer only.	None	None	None.
15.	El Paso, Texas.	El Paso Union Pass. Depot Co.	16	None	None	Yes.	Yes.	No.
16.	Erie, Pa.	Erie, Pa.	6	Included in terminal facilities of Railroads.		Not. ans	Not. ans	No
17.	Fort Worth, Texas	Fort Worth Union Station.	None	None	None	None	None	None.
18.	Galveston, Texas.	Union Pass. Depot Co. of Galv.	No record available.	None	No exclusive facilities used.	No	No	No.
19.	Houston, Texas.	Houston Belt & Term. Ry. Co.	7	No special terminal charges.	No special terminal charges.	Yes.	Yes.	Yes.
20.	Indianapolis, Ind.	Indianapolis Union Station.	96	Paid by Tenant Co.	Paid by Tenant Co.	Yes.	Yes.	Yes.
21.	Macon, Ga.	Macon Terminal Co.	56	No charge.	Fixed annual rental.	No.	Yes.	No.
22.	Memphis, Tenn.	Grand Central Station.	30	No special tracks.	Paid by Tenant Co.	No.	Yes.	Yes.
23.	Memphis, Tenn.	Memphis Union Station Co.	Handled by each R. R.	Basis of cars handled.	Basis of cars handled.	Yes.	Yes.	Yes.
24.	Montgomery, Ala.	Union Passenger Station.	No answer.	No charge.	No answer.	No ans.	No ans.	No ans.
25.	Montreal, P.Q.	Windsor St. Station.	8	General contract.	General contract.	Yes.	Yes.	Yes.
26.	New York, N.Y.	Grand Central Terminal.	45	No specific payment.	Substations by lease- No special payment for platforms.	Yes.	Yes.	Yes.
27.	Omaha, Neb.	Union Passenger Station	100	No direct charge for special facilities.	No direct charge for special facilities.	No.	Yes.	Yes.
28.	Ottowa, P.Q.	Union Station.	60	No charge made.	No charge made.	Yes.	Yes.	Yes.
29.	Portland, Ore.	N.P. Terminal Co. of Oregon.	17	No charge made.	No charge made.	Yes.	Yes.	Yes.
30.	Quebec, P.Q.	Palais Station.	12.	General Contract.	None.	None.	None.	None.
31.	Savannah, Ga.	Savannah Union Station Co.	10	No charge.	No charge for storage. No Platform used.	No.	Yes.	No.
32.	Seattle, Wash.	King St. Passenger Station.	20	On basis of packages handled by each road.		No.	Yes.	No.
33.	Spokane, Wash.	Spokane Union Station.	No carloads.	Included in terminal facilities of Railroads paid for on wheelage basis.		Yes.	Yes.	Yes.
34.	Tacoma, Wash.	Union Station.	None	None	None	None.	None	None.
35.	Toledo, O.	Toledo Union Passenger Sta.	50	Railroads	Railroads	Yes.	Yes.	Yes.
36.	Washington, D.C.	Washington Terminal Company.	128	No special trackage.	No separate house.	No.	No.	No.
37.	Wichita, Kan.	Wichita Union Terminal Co.	none	No charge.	Rental basis for warehouse. no chg. for plat.	No.	Yes.	No.

Appendix B

(3) SCALES

M. J. J. Harrison, Chairman, Sub-Committee; J. B. Hunley, C. A. Briggs, Hadley Baldwin, A. W. Epright, E. M. Hastings, H. M. Roeser, C. H. Spencer.

(A) AUTOMATIC INDICATING DEVICES FOR WEIGHING

The Committee has not changed its views that it would be impracticable to attempt to write a general specification for this class of weighing device, and it has no reason at this time to change its previous recommendation, which was to the effect that the railroads tentatively use the tolerances adopted by the Sixteenth National Conference on Weights and Measures, so far as they apply to new heavy-duty automatic indicating scales used in determining weights for the sole purpose of fixing charges for transportation of freight and baggage.

The Committee has under consideration the advisability of recommending the minimum value of the minimum graduation, and the value of the minimum distance between graduations, for the above class of scales. The Committee is not, however, prepared to make a definite recommendation at this time.

(B) TOLERANCES FOR RAILWAY SERVICE WEIGHING DEVICES

It is the feeling of the Committee that the present state of the art of scale design justifies a certain broadening of existing tolerances for beam scales as adopted by the Eleventh National Conference on Weights and Measures, in so far as they are applicable to scales used for weighing freight and baggage. This has been brought to the attention of the Committee on Specifications and Tolerances of the National Conference on Weights and Measures, but a mutually agreeable revision has not yet been obtained. The matter is being followed up, and it is hoped that a more definite report can be made at an early date.

(C) TOLERANCES FOR TESTING, ADJUSTING AND MAINTAINING RAILWAY TRACK SCALES

The Committee is not unanimous in its views on this subject, and desires at this time, therefore, to report only that the matter is being actively handled.

(D) CAPACITY FOR MOTOR TRUCK SCALES

The condition which led to the inclusion of this subject in the docket (namely, receipt at certain new motor truck scales, of modern standard design and construction, of vehicles whose gross weights exceeded the capacity thereof) has recently been overcome through action of local traffic regulatory authorities in limiting the gross weight of vehicles to weights consistent with the supporting strength of local pavements, and more especially through active enforcement of such restrictions. This action was taken by the authorities referred to for their own protection and with a view to prolonging the economic life of their pavements.

It is recommended that this action be called to the attention of the Association for the information of the membership.

(E) ANALYSIS OF BILL "H. R. 4465" TO REGULATE AND CONTROL THE MANUFACTURE, SALE AND USE OF WEIGHTS AND MEASURES AND WEIGHING AND MEASURING DEVICES FOR USE OR USED IN TRADE AND COMMERCE AND FOR OTHER PURPOSES

The measure referred to failed of passage in the last session of Congress. It is understood that a similar measure is to be introduced at an appropriate time in the coming session of Congress.

The Committee has carefully considered the provisions of H. R. 4465, finds nothing therein detrimental to the interests of the railroads, and recommends that support be given to National legislation of this character in order that annoyances and expense incident to the adoption of conflicting policies by individual adjoining States may be avoided.

(F) TABULATION COVERING COMBINED COMMODITY AND SCALE TOLERANCE FOR BULK GRAIN TRANSPORTATION IN CARLOADS

The Committee on Weighing of the American Railway Association, at its meeting held at Chicago on September 11, 1925, considered the above question, and tentatively adopted a table of tolerances. This table was subsequently referred through the regular channel to this Committee for review and report. The proposed table is as follows:

Loads (Lb.)	Commodity Tolerance	Total Tolerance for Two Hopper Scales	Total Tolerance for Commodity and Two Hopper Scales	Total Tolerance for Two Track Scales	Total Tolerance for Commodity and Two Track Scales	Total Tolerance for Commodity and One Hopper Scale and One Track Scale
60,000	75 lb.	60 lb.	135 lb.	120 lb.	195 lb.	165 lb.
66,000	82 lb.	66 lb.	148 lb.	132 lb.	214 lb.	181 lb.
70,000	87 lb.	70 lb.	157 lb.	140 lb.	227 lb.	192 lb.
77,000	96 lb.	77 lb.	173 lb.	154 lb.	250 lb.	212 lb.
80,000	100 lb.	80 lb.	180 lb.	160 lb.	260 lb.	220 lb.
88,000	110 lb.	88 lb.	198 lb.	176 lb.	286 lb.	242 lb.
100,000	125 lb.	100 lb.	225 lb.	200 lb.	325 lb.	275 lb.
110,000	137 lb.	110 lb.	247 lb.	220 lb.	357 lb.	302 lb.

Column 1 shows the capacity and 110 per cent of capacity of the cars ordinarily used for the transportation of bulk grain.

Column 2 is ⅛ of 1 per cent of the value shown in column 1, representing invisible loss and waste incident to the handling of bulk grain from scales to cars in loading, and from cars to scales in unloading.

Column 3 represents the tolerance for the two hopper scales used, namely, 1/20 of 1 per cent for the loading hopper scale, and 1/20 of 1 per cent for the unloading hopper scale, or 2/20 (1/10) of 1 per cent for two hopper scales.

Column 4 shows the totals of columns 2 and 3, or the total tolerances applicable for the commodity and two hopper scales used.

Column 5 represents the tolerance when two track scales (each 1/10 of 1 per cent) are used, one at the loading point and the other at the unloading point.

Column 6 shows the totals of columns 2 and 5, or the total tolerances applicable for the commodity and two track scales used.

Column 7 shows the total tolerances applicable for the commodity and one track scale and one hopper scale.

It is reported to the Sub-Committee that the results obtained by the Bureau of Standards during the fiscal year 1925 are as follows:

Average numerical per cent maximum error of weighing for all track scales tested	0.27 per cent
Tolerance corresponding to the above	0.20 per cent
Average numerical per cent maximum error of weighing for all track scales tested which were used for weighing grain	0.19 per cent
Tolerance corresponding to the above	0.10 per cent

It is noted in the figures quoted immediately above that the actual average errors materially exceeded the tolerances, and the excess was relatively greater in the case of grain-weighing scales.

It is furthermore believed that the figures quoted above should be considered as fairly representative of conditions throughout the United States, as the tests from which the figures were developed were made generally in all sections of the country.

From careful consideration of the foregoing and other facts, it is the best judgment of the Committee that the tolerance tabulation quoted above is satisfactory for use in adjusting claims based on alleged disparities in weights of bulk grain in carloads, and that the values shown therein are the best and fairest that can be proposed at the present time.

(G) REVIEW OF SPECIFICATIONS FOR ALL SCALES OTHER THAN TRACK

This item was referred to the Committee at the Buffalo meeting, held on September 14, 1925. It is understood, however, that the

Federal Specification Board has under consideration the matter of preparing specifications for weighing equipment for Government service, and that the above Board expects to take action in the very near future.

It is felt advisable to await a definite announcement of the policy of the Federal Specification Board, and to consider the effect of such policy on railroad weighing requirements, before initiating any action with the manufacturers.

(H) DEVELOPMENTS IN THE MATTER OF LEGISLATION RELATIVE TO THE METRIC SYSTEM OF WEIGHTS AND MEASURES

This item also was referred to the Committee at the Buffalo meeting. There have been no new developments in the matter since the last report of the Committee was submitted. It is the intention of the Committee to keep in active touch with the matter.

Appendix C

(4) FREIGHT YARD DESIGN, SUGGESTING ECONOMIES IN OPERATION

J. E. Armstrong, Chairman, Sub-Committee; J. R. W. Ambrose, C. E. Armstrong, C. H. Blackman, W. P. Bruce, R. A. Cook, O. H. Frick, A. L. Grandy, J. V. Hanna, H. C. James, Jr., D. B. Johnston, C. P. McCausland, J. A. McGrew, W. M. Whitenton, J. G. Wishart.

Effect of Delays and Extra Handlings

Between the moment a freight car is ready for movement from the loading track at the point of origin and the moment it is delivered on the unloading track at the point of destination, all time spent by it while not in motion, or while making movements which do not advance it on its journey, decreases the potential gross earnings of the car by decreasing the number of trips which it may make in a given time and increases the cost of each trip by the amount of the fixed, operating, maintenance and other charges involved in these delays and extra handlings. A major portion of this non-productive time and movement occurs in yards so that, all other things being equal, the fewer the yards through which a freight car must pass and the less its time and handling in each of them, the greater will be its potential net revenue earning power per annum.

Justification for an Additional Yard

Whether a yard is being designed for a new railway, or as relief for one or more yards which are apparently inadequate to handle the traffic on an existing railway, the principles of design are the same. In either case every means of avoiding the construction and operation of a yard in addition to those already in operation should be exhausted before deciding to incur the expenditures which the new yard would involve. An additional yard is only warranted when it can be shown either that existing facilities cannot be made adequate to handle the immediately prospective traffic, or that the construction and operation of the additional yard will result in a net saving.

Yards are Supplementary Units

In the broad view no one yard should be regarded as a separate entity. The kind and amount of work to be done on the traffic passing through it is directly affected by the work done in preceding yards and in turn directly affects the work to be done in succeeding yards. The yards of one railway should be regarded as supplementary units, each being so designed and operated as to give the most economical results for the railway as a whole. In the final analysis this view should be extended to include all yards of all railways. This broad view, however, important as it is, is not within the scope of the present report.

Purpose of Report

This report is the first of a series which are to be submitted outlining the information required and the use of that information in determining the proper design of a yard. It is confined to the requirements governing the number and length of receiving, classification and departure tracks only and the determination of the type of yard in which these tracks are to be assembled. Subsequent reports will cover the other tracks and facilities required in a complete yard design.

Number of Receiving Tracks

The number of receiving tracks should be such that there will be one available whenever an arriving train offers to enter the yard. This number depends upon the arriving time of the trains and upon the average length of time that a train occupies a receiving track. Fewer receiving tracks will be required when trains arrive at approximately equal time intervals and when they are promptly removed from the receiving tracks, than when they arrive bunched in peak periods and when they are not promptly removed from the receiving tracks. The approximate arriving time of trains may be determined from a study of the dispatcher's train sheets, and the approximate time they will remain on the receiving tracks may be determined from a knowledge of the proposed method of operating the yard. For preliminary purposes it may be assumed that the number of receiving tracks should equal the maximum number of trains normally expected to arrive in a period of two hours.

Number of Departure Tracks

The number of departure tracks should be such that there will be one available for assembling a departing train whenever necessary. This number may be determined from information in regard to departing trains, similar to that used in regard to arriving trains in determining the number of receiving tracks. For preliminary purposes it may be assumed that the number of departure tracks should equal the maximum number of trains normally expected to depart in a period of two hours.

Number of Classification Tracks

The number of classification tracks should be such that there will be one available for each classification to be made in the yard. In addition to the tracks for the ordinary classifications of cars for forwarding beyond the yard, there should be a track for each of the special classifications which may be handled separately within the yard, including bad order, weigh, refrigerator, stock, and other cars as required. One or two extra or unassigned classification tracks will also usually be found advantageous. An analysis of the consist of the trains which are to be passed through the yard will usually indicate a possible number of classifications greatly in excess of the number of classification tracks which could reasonably be provided. Conference with the appropriate operating officers will, however, establish a permissible grouping of these separate classifications so as to reduce their number and still adequately meet the requirements of the traffic. For preliminary purposes it may be assumed that the number of assigned classification tracks should equal the number of classifications so determined to be the permissible minimum.

Length of Receiving and Departure Tracks

The length of the receiving and departure tracks should be such that each will accommodate a complete train including one or more assisting locomotives where used. The length of the trains depends upon the ruling gradients of the lines tributary to the yard, the class of power used, the consist of the trains whether all loads, all empties, or mixed loads and empties, and upon whether there is a normal set out or fill out point between the ruling gradient and the yard. Investigation of these features and of the length of the trains actually being handled over the lines in question will permit of determining the required length of the receiving and departure tracks.

Length of Classification Tracks

The length of the classification tracks should be such that each will normally hold all accumulated cars of the assigned classification until they are to be moved off of the classification track under normal operation and without special movement of switching power. Cars of each classification may accumulate so slowly, or the requirements of the traffic may be such as to require each departing train to be made up of a number of classifications; or cars may accumulate so rapidly as to warrant making a whole train of each classification. In the former case the classification tracks should be relatively short, while in the latter case they may be used as departure tracks with their lengths determined accordingly. When the expected accumulation of cars of one classification requires an exceptionally long classification track it will normally be advantageous to provide more than one track for that classification rather than a single track of greater length than a departure track.

Total Capacity

The total combined capacity required for the receiving, classification and departure tracks in an average yard may be roughly assumed to be about equal to the total number of cars to be passed through that yard in twenty-four hours. The capacity of the receiving tracks will be about equal to the capacity of the departure tracks and the sum of these two will be about equal to the capacity of the classification tracks. This distribution is, however, only approximate and will vary in each individual case, depending largely upon the extent that storage of cars is provided for in the allocation.

Type of Yard

The type of yard in which these receiving, classification and departure tracks should be assembled depends upon the number of cars to pass through the yard, the number of classifications and the speed with which these classifications must be made, and upon such special consideration as may obtain at that yard. If the total number of cars and the number of switching cuts per train is small a single flat yard, to handle the traffic in both directions, is indicated. If the total number of cars is large but the total number of switching cuts per train is small a single flat yard, to handle the traffic in both directions, or possibly two flat yards, each handling the traffic in one direction only, is indicated. If the total number of cars is relatively small, but they are normally received in a short period of time, and the number of switching cuts per train is large and they must be made promptly so as to pass the cars through the yard in a limited time, a hump yard may be indicated. If the total number of cars is large and the total number of switching cuts per train is also large a hump yard is indicated.

Expansion

Expansion should be allowed for whichever type of yard is indicated as the ruling gradients may be reduced and the tractive power of locomotives and volume of traffic may increase. It should, therefore, be designed with a view to the possibility of increasing the length and number of tracks with a minimum of alteration to the yard and of interference with operation while the enlargement is being made.

Single Flat Yard

In a single flat yard the longer tracks will normally be the receiving and departure tracks and the shorter tracks will normally be reserved for classification purposes. Since the two-hour period in which the maximum number of trains arrive from one direction may not coincide with the two-hour period in which the maximum number of trains depart in that direction, and since neither of these periods may coincide with the similar periods for trains in the opposite direction, the total number of receiving and departure tracks, when these tracks are used interchangeably, need not ordinarily equal the sum of these four maximum numbers of trains. A study of the probable arriving and departing time of trains in both directions, and of the time each train will probably occupy a receiving or departure track, will determine the total combined number of these tracks required. Since a yard of this type may usually be worked from both ends and the longer classification tracks may have sufficient capacity to permit of using each end of several of them for a separate classification, the total number of classification tracks need not ordinarily be the sum of the number of classifications to be made in each direction. A study of the total number of classifications to be made in each direction and of the probable number of cars of each classification which may accumulate before they are moved off of the classification track will indicate the possibility, if any, of using each end of one or more classification tracks for separate classifications, and will permit of determining the total number of classification tracks required.

Double Flat Yard

When two flat yards are required, each handling the traffic in the direction opposite to that handled in the other yard, it may be possible to lay them side by side in such manner that, while their classification tracks are separate, their receiving and departure tracks may be used in common, or it may be necessary to entirely separate these yards from each other. With the two yards laid side by side the total number of receiving and departure tracks may be determined in the same manner as for a single flat yard. With the two yards entirely separate, however, a study of the probable arriving and departing time of trains moving in a single direction, and of the time each of these trains will probably occupy a receiving or departure track, will determine the total number of these tracks required in the corresponding yard. Although in either case each of these flat yards may usually be worked from both ends, each is a one-direction yard, and the classifications to be made at each end of each individual track will be identical. Consequently, no one classification track can be used for two separate classifications and the total number of classification tracks for that yard should ordinarily equal the full number of classifications to be made in the direction served by that yard.

Hump Yard

When a hump yard is indicated it may be required in one direction only, with a flat yard to serve the opposite direction, or a separate hump yard may be required in each direction. As a hump yard normally consists of a set of receiving tracks, a set of classification tracks, and where required, a set of departure tracks, with these sets placed end to end in sequence, there is usually no opportunity of using any of the tracks interchangeably, and the full requirement of each must normally be provided. In the exceptional case it may be possible to provide a single hump yard to handle the traffic from both directions over a single hump in one direction and thus secure common use of and, consequently, a minimum number of receiving and of departure tracks. Similar common use of classification tracks cannot be secured, however, for hump yard operation will not permit of mixing, on one track, cars moving in opposite directions, and the full requirement of classification tracks must be provided. A disadvantage of this arrangement is the necessity for the reverse movement through the yard of traffic moving in one of the two directions if the yard is laid parallel to the line of movement, or the necessity for the diversion of all traffic from its normal line of movement if the yard is laid perpendicular to the normal line of movement.

Hump Yard Departure Tracks

The necessity for separate departure tracks as a part of a hump yard design depends upon whether or not cars of single classifications accumulate rapidly enough to permit of forwarding them in whole trains. Where they do so accumulate the classification tracks may be used as departure tracks until such time as relief must be provided for the classification yard by building tracks onto which to move whole trains which are accumulated during periods when, on account of passenger train movements, or for any other reason, freight trains cannot be moved out of the yard and onto the main track. Where they do not so accumulate and each train must normally be made up of a number of classifications, the construction of departure tracks in the first instance will permit of building short classification tracks and will facilitate assembling different classifications into a single train.

Action Recommended

It is recommended that this report be accepted as a progress report and that no conclusions be drawn from it for insertion in the Manual until such time as the proposed series of reports, covering yard design, have developed to a stage where more nearly complete conclusions, in regard to this assignment, may be drawn.

Appendix D

(6) MECHANICAL MEANS FOR CONTROLLING OR RETARDING MOVEMENT OF CARS IN HUMP YARDS

Otto Gersbach, Chairman, Sub-Committee; A. W. Epright, E. H. Fritch, A. Montzheimer, C. H. Mottier, J. E. Saunders, E. E. R. Tratman, J. G. Wishart.

Although the principle of classifying freight cars by gravity has been used by the railroads in their large yards for a number of years, very little has been accomplished in the utilization of mechanical appliances to control the speed of cars until very recently, regardless of the fact that the method of employing hump riders is expensive, hazardous, and often results in heavy damage to merchandise and equipment.

The first and in fact the only device in use for a long time was an iron or steel shoe, generally known as a track skate. While this skate varies in shape and size on the different roads, the design in all cases is very similar and consists of a triangular shaped casting, approximately two feet in length, the upper side of which is curved to fit the rim of a car wheel, the bottom side being straight, with flanges on both sides to fit over the head of a track rail. On American railroads these skates are intended for emergency only and are kept at convenient points most accessible to the yard men, either along the lead or between the yard tracks. In case it is desired to stop the car, a skate is placed on one of the rails in front of the wheel, which then rides on the skate and the desired effect is produced by sliding friction of the skate on the rail. This arrangement is not only crude, inefficient and inconvenient, but sometimes results in serious injury or death to the men, as it is usually necessary to cross a number of tracks to reach the car and the man must assume an awkward position between the tracks while placing the skate on the rail. Furthermore, in wet or frosty weather there is a tendency for the skate to slide along the rail without giving the desired effect. Also, use of the skate tends to cause flat tires and since the skate is placed under the one wheel only, an extra strain is produced on the axle and journal boxes. This is not serious, however, with modern equipment.

The danger to yard men in setting the skate by hand has now been eliminated in the westbound Gibson Yard of the New York Central Railroad by using a device whereby the skate rests on a movable bed and is thrown onto the rail by means of an air cylinder, controlled by an electric push-button from a tower. In the above installation, this device is placed on each yard track and the towermen also operate the switches and car retarders, which will be described later.

A similar device (shown in Fig. 1) has recently been installed in the Potomac Yard of the Richmond, Fredericksburg & Potomac Railroad, but instead of having a skate on each yard track, only one skate is used. This skate is placed on a track reserved to receive the "run-away" cars and is also thrown onto the rail from a tower by means of air. A small light in the tower indicates when the skate is on the rail. This skate varies from the ordinary track skate in that it contains a sand chamber with an opening below to sand the rail for the purpose of providing additional friction.

Another arrangement to avoid the expense and hazards due to placing track skates on the rail by hand is the electrically-operated skid now in service in the Lille Yard of the Northern Railway of France.

The general principle is illustrated by the drawing (Fig. 2) reproduced from *Engineering News-Record* of October 9, 1924. As there described, a guard rail (A) is placed parallel with one of the running rails so as to form a groove or channel; two guard rails then extend this groove at an angle so as to diverge from the running rail. A plate or shoe (B) riding on the two rails has a wheel stop (C) on the top, while on the under side is a block (D) sliding in the space between the two rails. The end of the plate is feather-edged, so that a wheel running on the track rail will ride up onto the shoe.

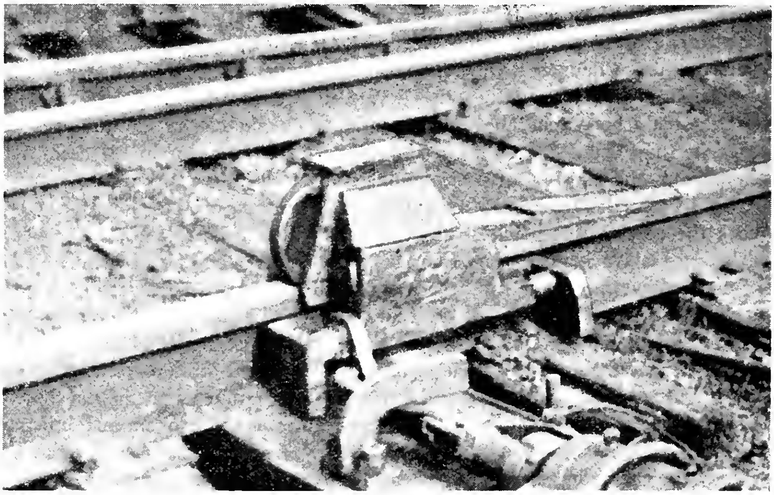


FIG. 1—TRACK SKATE DEVICE
POTOMAC YARD, RICHMOND, FREDERICKSBURG & POTOMAC RAILROAD

Bars riveted to the webs of the rails form guides for a sliding block (E) which is attached to an endless cable (F) operated by a motor-driven drum. Lugs on top of this block engage the lower part of the sliding shoe. The operator in the brake tower notes the speed of the approaching car and by means of a push-button he causes the motor-driven rope and block to push the shoe or track brake along the groove. Current is then reversed automatically and the block or sliding carriage (E) is drawn back to its normal position, leaving the shoe in place on the track. The car wheel then rides up on the shoe causing it to slide along the rail and thus check the car by the sliding friction. At the point where the grooves diverge from the running rail, the shoe is guided away from the wheel, leaving the car free to proceed at its reduced speed. The device is then ready for a second operation.

In the present installation there are six shoes on the ladder tracks, controlled from a tower, and ten shoes on a group of ten classification tracks, controlled from a second tower. With this arrangement the cars may be checked twice in their passage from the switching grade to the body tracks. The brakes of the first group on the six ladder tracks are used to check heavy cars or cuts and also cars whose speed is such that they are likely to overtake preceding cars. These shoes have a maximum travel of 66 ft. The brakes of the second group, at the entering ends of the body tracks, have a maximum travel of 98 ft.

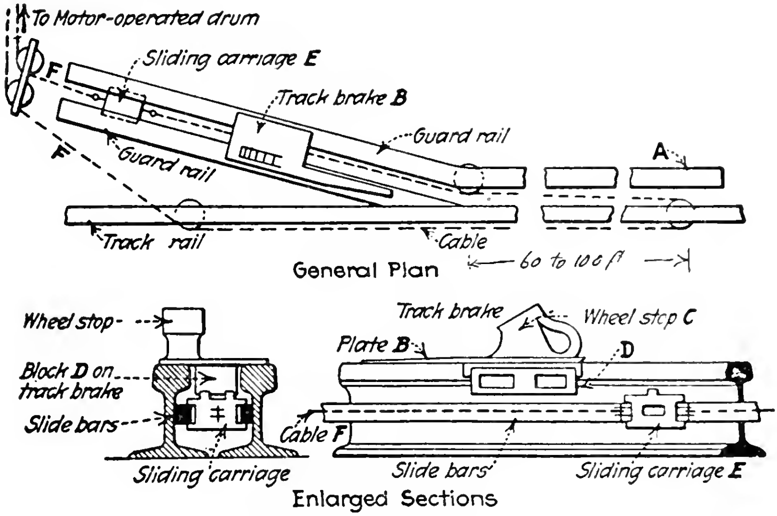


Fig. 2—Track Brake—Lille Yard

There is no switching hump in the Lille Yard, but the receiving tracks are on a descending grade of 0.5 to 0.6 per cent, and the cars are uncoupled on a starting grade of 1.8 per cent with a length of 263 ft. Then there is a grade of 0.8 per cent for 328 ft. and then 0.5 per cent along the ladders and into the body tracks. The speed of cars, unchecked by the track brakes, when at the foot of the starting grade, does not exceed ten miles an hour.

In some European yards the skate is placed on the rail by hand at point ahead of the switches and is automatically thrown aside when it strikes the frog.

Another European device used to stop cars which have gotten beyond control is known as the "Chain Drag," and consists of a chain of large size weighing four or five tons with a hook at one end which catches on axle of the car. This chain when not in use lies along the center of track or coiled up in a well under the track. When desired to stop a car, the hook is thrown up to catch the axle by a lever in control of a switchman and the chain dragging over the ties soon brings the car to rest.

In considering the above schemes we should bear in mind that in France and other European countries, where gravity switching is more generally employed than in America, the cars are much lighter than our cars and the hand brakes are often entirely omitted or are operated by a lever located at the side of the car. Such brakes, handled by a man on the ground, are not intended to regulate speed when car is in motion but are applied mainly to hold cars when placed on sidetracks.

The railroads have long recognized the disadvantages of operating hump yards under the present prevailing method of using car riders, and we find records of a number of plans which have been proposed for overcoming these objections covering a period of over forty years. With very few exceptions these schemes were all based on the idea of retarding the speed of the car by gripping the sides of the wheels. The first installation of such a device of which your Committee has knowledge was tried out at Gibson Yard about twenty years ago and consisted of angle irons approximately 30 ft. in length arranged in pairs, one being on each side of a track rail. These bars were connected by levers and operated by air cylinders. This device never proved successful, as the cars were continually climbing the rail and there was not sufficient braking power to produce the desired effect. This failure was largely due to the fact that the long rigid bars lacked flexibility and maintained only one point of contact with each pair of trucks for part of the distance through the retarder, same being with the front wheel while car was entering and with the rear wheel while leaving the retarder.

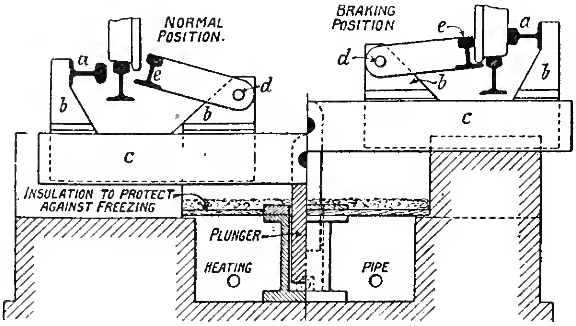


Fig. 3—Frolich's Rail-Brake

A track brake or retarder based on the principle of check rails arranged in pairs to grip the wheel and operated from a tower was invented by Dr.

Frolich, Railway Superintendent of the German Government, in 1921, and is now in operation in the Halle Yard and several other yards under his jurisdiction. It is also being installed in yards in some of the neighboring countries. In this installation the check or brake rails consist of ordinary track rails placed parallel with the running rails (see Fig. 3). The outside rail (a) rests with its web in a horizontal position and is fastened to a rigid support (b) while the inside rail (e) is in an upright position supported by an arm revolving vertically on pivots (d). The supports for both inside and outside rails are fastened on a common block (c) having a sliding contact on the bed which is raised and lowered by hydraulic pressure. The track rails are fixed and as the bed supporting the check rails is raised, the flange of the wheel rests on the base of the inside rail which moves about the axis and the wheel is gripped from both sides. The amount of pressure applied is dependent on the weight of the load, and in order to assist the operator a special weighing device has been designed which records the axleloads and transmits the information to an indicator board located in the tower. Derailments due to pressure of the check rails are impossible, as the grip is relieved when the wheel starts to climb the track rail and the flange of wheel leaves the base of the inside brake rail. This retarder is described in more detail in the February, 1925, Bulletin of International Railway Congress, and the October 24, 1924, issue of the *Railway Age*. There is a question as to its being adaptable to American railway yards, as the pressure acts on the two sides of the wheel at a point approximately 4 inches above top of running rail, which would not be allowable on U.S. equipment as the maximum clearance permitted by M.C.B. rules is only 2½ inches above top of rail. Even this clearance is not available in practice as cars are frequently found with projections below the 2½-inch line. This is particularly true of the column bolts located outside of the wheels. Furthermore, on account of the heavy foundations and pit necessary it is placed principally on lead tracks, and these facts, together with the big difference in weight, size and construction between the American car and the European car should be taken into account before trying it out in this country.

The first successful and practical installation of a system of car retarders tried out on an American railroad, which will satisfactorily control the speed of the cars and eliminate the necessity for car riders in hump yard operation, was completed in December, 1924, at the Gibson Yard of the New York Central Railroad under the direction of Geo. Hannauer, Vice-President, and supervision of E. M. Wilcox, Master Car Builder of the Indiana Harbor Belt Railroad. This device is based on the principle of gripping the wheel, but instead of using long continuous bars, the brake rail is divided into short sections approximately 8 ft. long connected in series of four to a rigid frame about 34 ft. long (see Fig. 4). Removable shoes approximately 12 inches long are fastened to the short sections to form contact with the wheel and take care of the wear, and springs are placed

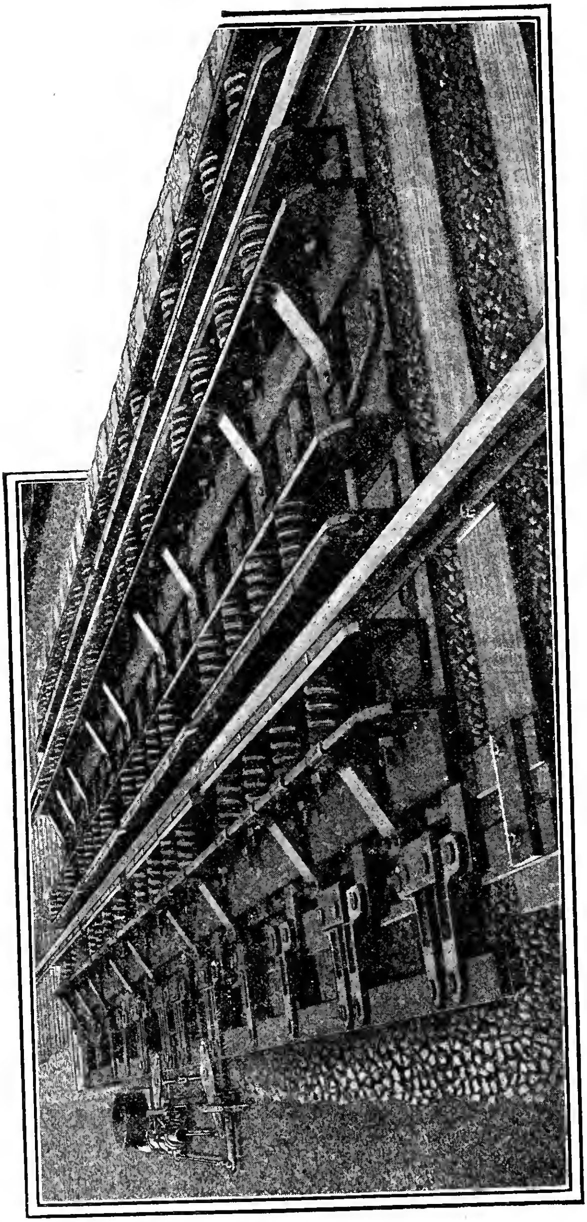


FIG. 4—HANNAUER CAR RETARDER

between the short sections and the frame to add flexibility and distribute the pressure. The frames on both sides of the running rail are held and thrown by a series of levers which are connected to and operated by an air cylinder. The shoes are made of brakeshoe metal and last from three to twelve months, depending on location and service. The first units were assembled on the ground and placed on a concrete base, but the concrete base was found unnecessary and the later units were fastened on the track ties. For the new installations the parts are assembled at the plant comprising a unit 36 ft. long by 11 ft. wide before being shipped. The retarders are located not only on the hump lead ahead of the switches, but also along the yard leads and on the yard tracks back of the frogs. In several cases where it was desired to protect certain tracks and the space was limited, the retarder was placed on one running rail only, opposite the frog. In such cases self-guarded or flanged frogs were used and guard rails omitted. In the present installation there is a total of 68 retarder units controlled electrically from five towers.

In yards on other roads which are now being equipped with this retarder, the number of retarders in proportion to number of yard tracks has been reduced, largely on account of improvements in construction and method of operation which have been developed from experience during the short time the Gibson plant has been in operation; also the retarders are operated by all-electric as well as electro-pneumatic plants and the towers or central points from which the retarders, together with the switches, are operated and controlled have been consolidated and reduced in number. Care should be used, however, in determining the location and number of towers for a given yard, as it is important that the operator be so located that he can judge the speed of the car approaching and passing over the retarders he controls.

The track skates, also operated from the towers and already referred to, are located on the yard tracks back of the retarders. They are intended for emergency only and are seldom used.

There is a wide variation in the amount of power required to control the different cars passing on a given grade, dependent principally upon the load and to assist the operator in handling the cars over the retarders under his control, he is furnished with a list of the cars in train order with a symbol after each car number indicating the approximate weight or character of the load. At the Gibson Yard five classifications are now used, as follows: E—empty; LL—light load; L—average load; XL—heavy load, and XXL—extra heavy load.

Yard men are used to operate the retarding machines and are allowed to exercise their seniority in taking these jobs, dependent on their ability. When through humping cars they leave the tower and do other yard work.

Information regarding the original installation not shown in this report may be found in the November 15, 1924, issue of the *Railway Age*.

The following are some of the principal benefits of car retarders over the old method of hump switching which have been demonstrated since the Gibson plant has been in operation:

Unit cost for switching cars over the hump has been reduced approximately 40 per cent.

Personal injuries of a serious character have been eliminated.

Car damage and necessity of transferring cars and shifting loads has been reduced to a point where this work is now handled by less than one-half the car repair force previously required.

Less freight damage.

Saving in cost for cleaning yard on account of less coal and other material being jarred from cars.

Increased yard capacity. This plant recently handled 1116 cars over the one hump in a working period of 5 hours 31 minutes, or at the rate of 200 cars per hour. By the old method an average of less than 100 cars per hour were handled for a like period.

Less delay and interference on account of bad weather. No trouble has been experienced in keeping the retarders working during zero weather or during heavy sleet or snowstorms, when humping operations were seriously interferred with where car riders are employed. Steam lines, oil and air were provided for fighting snow and ice, but seldom used.

Avoids the necessity of using inexperienced men on the hump when business is heavy, as it is the practice for the old men to take the more desirable jobs when new men are added on account of increased business, which usually occurs during unfavorable weather, when it is most desirable to handle the cars with as little delay as possible.

Facilitates shoving train out of receiving yard, as end cars can be pushed over crest before they are uncoupled and thus assist the rear portion up the incline. The slack necessary to enable the pin puller to uncouple the first cut of cars is obtained by holding car in the retarder located on the starting grade.

In connection with the studies and tests made in developing the Hannauer retarder, it was found that a number of changes in the yard design were necessary to obtain the best results, some of which may apply to hump yards without retarders. The following suggestions are based on the experience in perfecting this device on the Indiana Harbor Belt Railroad.

High speeds should be avoided. The grades should be so fixed and located as to give, as nearly as possible, a continuous speed of approximately six miles per hour down the hump and along the leads rather than to have a long steep grade on the hump incline for the purpose of giving the car a high velocity and depending on the momentum to carry it through the switches and into the yard tracks. There are several reasons for this. First, the rate of acceleration is greater at slow than at high speeds; also, there is less waste of energy with uniform speeds, both of which result in more economical use of the total difference in elevation between the summit of the hump and the yard tracks. Second, there is a limit to the braking effectiveness of a retarder unit. Third, fewer retarder units will be required and the initial cost for installation will be reduced. Fourth, less power will be used, the brake shoes will last longer, resulting in saving in maintenance expense. Fifth, less danger of accidents, and cars will not cause serious damage or delay should they collide or get off the track.

The route between the summit of the hump and the classification tracks should be as short and direct as possible. There should be no long spaces between the car retarders. This not only makes a better working arrangement but saves in the initial cost of construction. One of the objects of the long steep grade on a hump incline in the past was to separate the cars at long intervals to avoid the possibility of one car overtaking another on the leads. By use of retarders the spacing is done uniformly and at slow speeds so that a comparatively short distance between cuts of cars is sufficient.

For the above reasons it is suggested that in designing a new yard to be equipped with retarders the hump incline be short with a grade of approximately 4 per cent for a distance of about 35 ft. to give the car a quick break-away. There should then be two retarder units occupying a space of approximately 70 ft. on a 2.0 per cent grade, after which the leads for yard tracks may begin. Where scale is used the incline will have to be lengthened proportionately, but on a reduced grade. On the ladder track and through the switches, the gradient should vary between 1 per cent and 1.2 per cent, depending on the local conditions and character of the cars to be handled. Curves should be compensated for at the rate of .03 per cent per degree of curve. On classification tracks beginning at heel of the frog an .8 per cent grade is recommended for a distance of about 40 ft., after which the gradient should be .3 per cent. The last retarder should be located on each yard track where the .3 grade begins. On tracks where classification consists of heavy loads or there is a tendency for the cars to accelerate, a pair of spring guard rails located near the center of the track may be used to reduce the speed. These can be tightened in summer and loosened in winter as desired. Also the departure end of the classification tracks should have a short opposing grade to prevent cars from running beyond the clearance point of the outgoing switches.

The above grades are intended to apply for all seasons of the year. The advantage gained by the so-called "winter hump" can be obtained by releasing the car at the summit of the incline during low temperatures instead of at the retarder, as is done normally. The experience at Gibson has shown that raising the hump in winter compensates only to a slight degree for the added car resistance experienced during cold weather, and that better results can be obtained by moving the train back and forth to loosen up the truck bearings just before humping the train. While this may require more power it is necessary only during extreme weather. Another method suggested for warming up the cars is to pour hot oil in the journal boxes.

The most recent and extensive installation of the Hannauer retarder system is in the Markham Yard of the Illinois Central Railroad, where the northbound yard is being equipped with the electro-pneumatic and the southbound yard with the all-electric machine. Plan and profile are shown of the southbound yard (see Fig. 5) as the more typical layout, although the northbound yard is much the larger.

A device known as a "Mechanical Hump" for adjusting the grade above the track scale where cars are weighed in gravity switching, was designed and standardized by the Pennsylvania Railroad in May, 1909. The rules of the Interstate Commerce Commission require that the speed of cars over the scale platforms must not exceed four miles per hour and that each car must be entirely alone upon the scale for a minimum of three seconds. Furthermore, for rapid and accurate weighing, it is desirable to maintain a uniform interval between cars and a uniform speed without brake application and the above device was designed to fulfill the above requirements by taking care of the variation due to changes of temperature and other local conditions. In the design as originally built, the table was in two sections, the outer ends resting on pin-bearings and the inner or adjoining ends resting on saddle castings which can be raised or lowered by hand-operated toggle lever jacks. This arrangement is known as a single apex hump and gives a short ascending grade on the approach side to bunch the cars and thus relieve the couplers for uncoupling, while on the other side the gradient is increased to the scale.

This arrangement was not entirely satisfactory because the acceleration of the front end of the car on the down grade was offset to some extent by the resistance of the rear truck still on ascending grade and to eliminate this difficulty, the hump was redesigned in June, 1915. In the new design the table was made in three sections, as shown (Fig. 6). The middle section, which is 9 ft. long and constitutes the apex of the hump, is level at all elevations and moves vertically between fixed guides on the side walls of the pit. The two end sections pivot on end pins and have bronze friction plates with fixed guideways to limit the lateral movement. The pivoted section on the ascending side of the hump is 15 ft. long, while the section on the descending side, adjacent to the scale, is 21 ft. long. Four main shoes or saddle castings support the middle section and also contain the shoe bearings of the end sections. In adjusting the table, these castings are raised by four 15-ton ball-bearing screwjacks and steel shims ½-inch and 1-inch in thickness are inserted under the shoe casting to give the required elevation. This operation requires about 15 minutes. The lift of the table is from a minimum of 1½ inches to a maximum of 5 inches, giving grades of 0.8 per cent and 2.8 per cent, respectively, on the upper side and 0.6 and 2.0 per cent on the side adjacent to the track scale. This appliance is described more in detail in the August 14, 1924, issue of the *Engineering News-Record.*

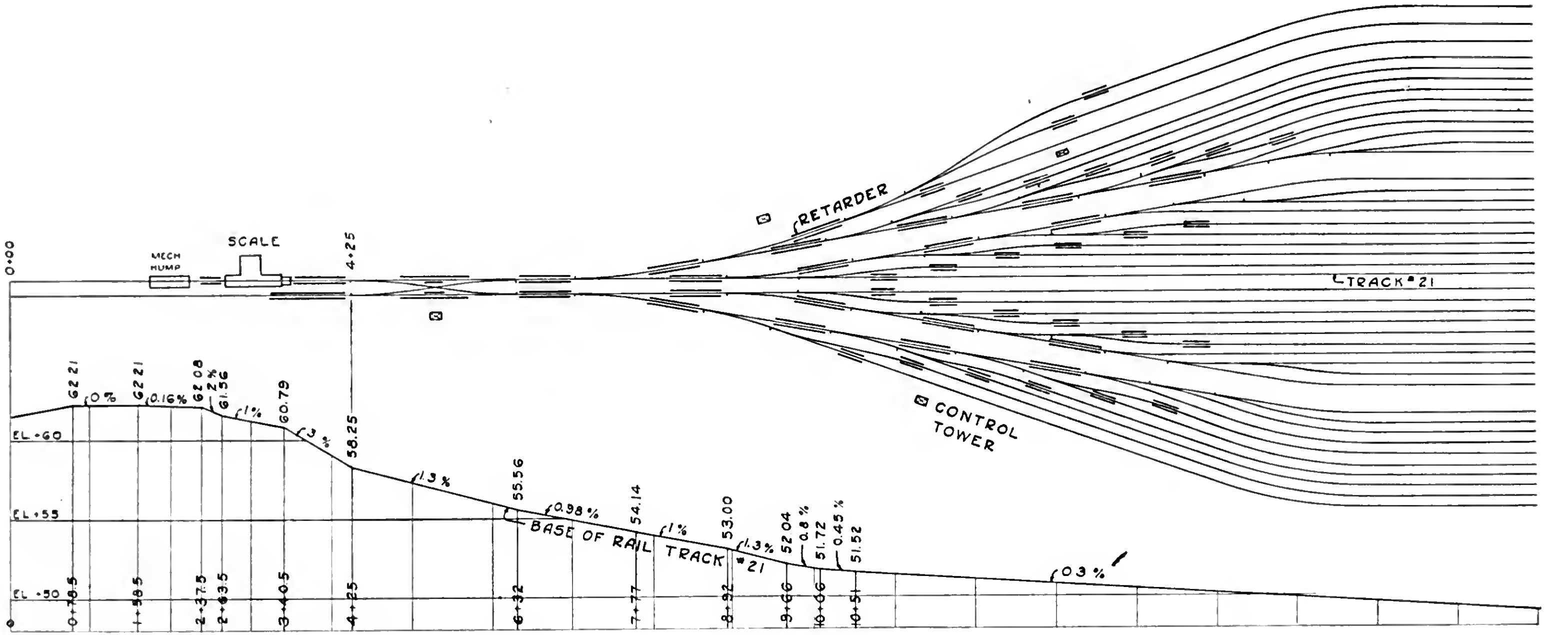


FIG. 5—SOUTHBOUND CLASSIFICATION, MARKHAM YARD, ILLINOIS CENTRAL RAILROAD

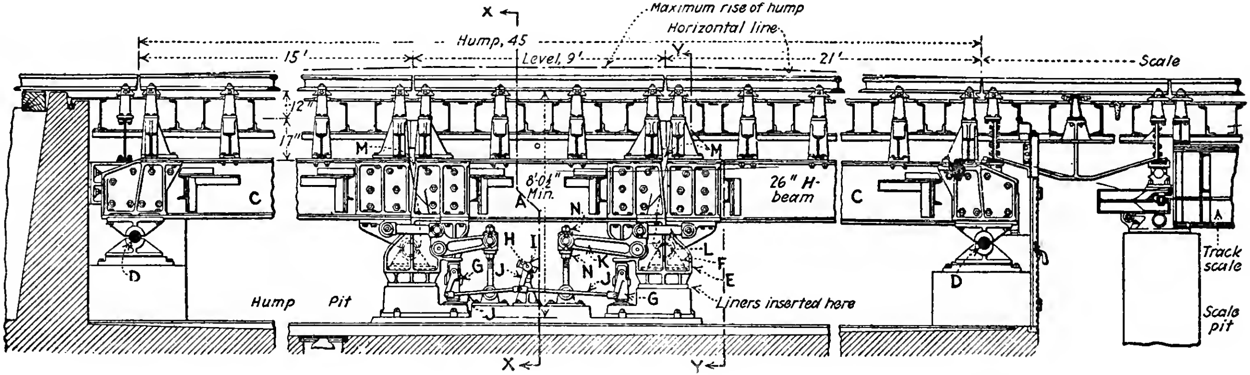


FIG. 6—MECHANICAL HUMP FOR GRAVITY SWITCHING—PENNSYLVANIA RAILROAD

REPORT OF COMMITTEE IX—SIGNS, FENCES AND CROSSINGS

T. E. RUST, *Chairman;*
ANTON ANDERSON,
F. D. BATCHELLOR,
J. F. BURNS,
R. E. CHAMBERLAIN,
C. W. CHARLESON,
W. E. COLLADAY,
L. B. CURTISS,
C. T. DIKE,
G. N. EDMONDSON,
F. M. GRAHAM,
C. E. HERTH,
W. O. HOUSTON,

A. B. GRIGGS, *Vice-Chairman;*
MARO JOHNSON,
E. R. LEWIS.
A. C. MACKENZIE,
G. P. PALMER,
H. M. SHEPARD,
C. E. SMITH,
W. H. SPEIRS,
T. H. STRATE,
W. C. SWARTOUT,
M. D. THOMPSON,
W. J. TOWNE,
A. H. UTTER,
I. D. WATERMAN,

Committee.

To the American Railway Engineering Association:

Your Committee presents herewith report covering the following subjects:

(1) Revison of the Manual (Appendix A).
(2) Methods of apportioning the cost of highway improvements adjacent and parallel to railroad rights-of-way (Appendix B).
(3) The elimination of highway grade crossings (Appendix C).
(4) The use of natural rock asphalt as a substitute for planking in road crossings (Appendix D).

The Committee reports progress on the subject of Specifications for Steel Fence Posts.

Action Recommended

1. That the changes in the Manual in Appendix A be approved and the revised version substituted for the subject matter now in the Manual.

Recommendations for Future Work

1. Revision of the Manual.
2. Continue the Study of Methods of apportioning the cost of highway improvements adjacent to railroad rights-of-way.
3. Continue the study of improved methods of preventing corrosion of fence wire.
4. Continue the study of specifications for steel fence posts.
5. Grade crossing protection as a substitute for grade separation.
6. Present practice in the construction and maintenance of snow fence.

Respectfully submitted,

THE COMMITTEE ON SIGNS, FENCES AND CROSSINGS,

T. E. RUST, *Chairman.*

Bulletin 282, December, 1925.

Appendix A

(1) REVISION OF THE MANUAL

G. N. Edmondson, Chairman, Sub-Committee; C. E. Herth, G. P. Palmer, W. J. Towne.

Your Committee is recommending the following changes in the Manual:

(a) Revision of the Highway Crossing Sign, a subject that was specifically assigned to us.

(b) Revision of the present Bridge Sign.

(c) Various minor corrections, and revisions intended to cut down the amount of space devoted to tables and illustrations.

(d) Revision of the Specifications for Bituminous Crossings.

(a) HIGHWAY CROSSING SIGNS

In 1914 the Association adopted a standard highway crossing sign of the crossbuck type with wooden post 16 ft. long, 4 ft. in the ground, center of the crossarms 10 ft. 9 in. above the ground line, crossarms 8 ft. long by 12 in. wide, placed at an angle between them of 50 degrees, or making an angle of 25 degrees from the horizontal.

This sign is similar to most of the signs used to-day as far as the type is concerned, and apparently is favored by a majority of the railroads. The Committee endeavored to get information regarding the design and location of signs now in use by a questionnaire, but the amount of information so far obtained is limited. However, from that information and previous information which the Committee had, they find very little uniformity in the design and location beyond the type. A study of what information the Committee has received shows that many lines at the present time must have several different types of crossing signs on account of the requirements of the States through which they pass.

The passing of laws by various State legislatures known as "Stop Laws," which are in effect in the states of Virginia, North Carolina, Georgia, Mississippi, Louisiana, and to a certain extent in Minnesota and North Dakota, and possibly other states, has made a difference in the type of sign, in that some of them are requiring a rectangular board with the words "STOP—STATE LAW," or something similar as a substitute for other types of signs.

On the type of sign similar to the one in the Manual which is used so extensively the length of the crossarms used by different railroads varies from 3 ft. 4 in. to 8 ft. 0 in., the majority being from 6 ft. 4 in. to 8 ft. 0 in. The angle formed by the crossarms with each other and with the horizontal is not uniform and varies from 30 degrees to 90 degrees between the arms. In Volume 15 of the Proceedings, on page 862, is shown a statement of crossing signs in use at that period. The Committee had intended to make a similar comparison up to date, but did not get sufficient information to do so.

The location of the sign generally favored seems to be on the side of the highway, but we find an increasing use of the sign in the center of the highway, especially in the case of warning signals, with the crossing sign on the same post.

In September, 1924, Committee X—Signals and Interlocking, requested a revision of the crossing sign as it appears in the Manual for use with the flashing light signal. At the instance of the Committee on Highway Crossing Protection of the Signal Section of the A.R.A., they suggested a crossing sign with 4 ft. arms placed at an angle of 90 degrees with each other or 45 degrees from the horizontal, claiming the present sign is too large for use on the same post with the flashing light. This plan is one that was submitted by the Lehigh Valley and has been approved by the Public Service Commission of New York State and is in use. It is also similar to a sign used by the New York Central in connection with flashing light signals, and the sign that probably will be recommended for use with flashing light signals by the New York State Public Service Commission.

The sign of the Lehigh Valley, as approved by the Commission, is not specific as to the height beyond showing the flashing light as 6 ft. 7 in. above the ground and the railroad sign placed as close above that as could be located.

The sign of the New York Central, as approved by the Public Service Commission, shows two different heights, depending on whether located in the center of the highway or at the side. The sign in the center of the highway has the flashing light 11 ft. 8 in. above the groundline with the crossing sign 2 ft. 8 in. above. The sign at the side of the highway has the flashing lights located 9 ft. 8 in. above the highway and the crossing sign 2 ft. 8 in. above that height.

It is believed that the New York State Public Service Commission will recommend a standard with the lights from six to nine feet above the surface of the highway, preferably six feet, and the center of the crossbuck sign shall not be less than 2 ft. 8 in. above the horizontal bar supporting the lamps, making the center of the sign not less than 8 ft. 8 in. above the highway.

The question of revising the crossing sign has been handled with Committee X, also with the Committee on Grade Crossing Protection and Trespassing of the Operating Division, A.R.A. The Committee of the A.R.A. believe our present sign is all right, excepting they have recommended the center of the sign should be 10 ft. above the roadway and the post painted alternate black and white stripes. Mr. C. L. Bardo, when Chairman of that committee, stated on January 25, 1925, as follows:

> "There is no uniformity with respect to the laws of the states as to the crossbuck sign. As a result of the activities of the Hoover Committee there is no doubt in my mind that there will be substantial legis-

lation in many of the states within the next three or four months dealing with this question of standard crossbuck signs, and it is my view and that of the A.R.A. Committee on Grade Crossing Protection and Trespassing that it would be most unwise to delay the adoption of the present A.R.E.A. 1914 standard, since the railroads have not only been active, but aggressive in a political way in getting the legislatures and state authorities awakened to the importance of legalizing and standardizing highway crossing signs.

"It is the view, as stated above, of the A.R.A. Committee on Grade Crossing Protection, and we are unanimous in this, that the A.R.E.A. crossbuck sign of 1914 should not be disturbed and that wherever laws of the state permit of its use, it should be used. We see no objection, nor any reason why it should be changed, and certainly it would be very much to the discredit of the railroads if, when they are approached by the legislatures in the several states, it should develop that we have not a standard crossbuck sign which would be substantially adopted by the state legislatures. It is my opinion that the railroads should follow their hand and cooperate wherever the possibility of cooperation exists and get the A.R.E.A. standard of 1914 adopted, leaving it to the future to work out refinements in the details when the occasion and opportunity affords."

And on February 12th he gave their final conclusions as follows:

"In the last analysis our position may be stated as approving the A.R.E.A. standard crossbuck sign in principle, leaving it to the individual roads to work out with the interested State Commissions and others such modifications in the design as may be necessary and can be agreed upon. This leaves the individual roads to proceed with all the latitude possible, and it is our further view that the man in the street upon whom we must depend for proper observance of the information conveyed by the crossbuck sign would not be interested as to whether the crossarms were set at an angle of 40 or 90 degrees, or whether the sign is 12 ft. from the ground or 14 ft. from the ground, and, in fact, would have no interest with respect to these particular dimension details."

Mr. W. J. Towne, Chief Engineer of the Chicago & Northwestern Railway, who has succeeded Mr. Bardo as Chairman of the A.R.A. Committee on Grade Crossings and Trespassing, advises that it seems to him advisable to standardize, at least generally, as stated in the above paragraph of Mr. Bardo's letter, as quoted, of February 12, 1925.

Committee X, through their Chairman, Mr. F. B. Wiegand, has submitted a plan which is in use by the New York Central, Lines West, showing a crossbuck sign mounted on the same post with the flashing-light signal, light 8 ft. above the ground line and the center of the crossarms 14 ft. 3½ in. above the roadway, and advises that that sign met their requirements, this sign having 5 ft. 6 in. crossarms, angle not shown but presumably 50 or 60 degrees between the arms. However, he advises that their committee is willing to agree to a sign with 4 ft. crossarms, set at 90 degrees with each other.

Mr. A. H. Rudd, as Chairman of the Committee on Highway Crossing Protection, Signal Section, advises that they favor the adoption of a sign with the 4 ft. arms, 45 degrees with the post and at right angles to each other on the sign, he seeming to favor the standard as it will be recommended by the New York State Public Service Commission.

The Sectional Committee on Code for Traffic Signals of the Engineering Standards Committee have recommended for adoption the following two rules taken from their report, which it will be noted is practically the same as the New York State Public Service Commission's proposed order:

Rule 41, Location:

> The railroad standard highway crossing sign and the signal shall be mounted on the same post.

Rule 43, Flashing Light Type:

> (a) Height—The lamps should preferably be not less than 6 ft. nor more than 9 ft. above the surface of the highway.
>
> (b) Width—The two lamps should be mounted horizontally 2 ft. 6 in. centers.

This, however, does not specify the height or size of the highway crossing sign.

The New York State Public Service Commission has already issued an Order dated June 4, 1925, standardizing the flashing-light signal, and have the Order in regard to the crossing sign about ready to issue after making a few tests. However, they do not intend to substitute the sign on the flashing-light signal post for the standard sign as now used and approved by the Commission. As a matter of fact, the Chief Engineer advises that he does not think it desirable or advisable to have the two signs alike and that there should be a distinction between the two signs so there will be no confusion or any chance to mistake the two, as the absence of a flashing warning light might be taken by the traveler to indicate that no train was approaching.

The Committee would like to call special attention to the Grade Crossing Law of the State of Minnesota, approved April 24, 1925, and issued by the Minnesota Railroad and Warehouse Commission, and which shows a new standard crossing sign which they have adopted and which is to be used in future installation or renewals in the State of Minnesota.

This sign is a crossbuck sign with 4 ft. arms, angle about 70 degrees between the arms, two heights to the underside of the lower corner of the arms being given, one 5 ft. where there are no pedestrians and 7 ft. where there is pedestrian travel. The crossarms simply have the two words "Railroad Crossing." The supporting post has diagonal stripes from the ground to the center of the crossing sign.

At crossings where "Stop" sign is required, this is fastened to the post of the crossing sign, also any other signs that are necessary in connection with the protection of crossings.

In Volumes 15 and 16 of the Proceedings of the Association there has been furnished certain information with regard to laws and rulings of the Public Service Commissions on the erection and maintenance of crossing signs.

The Committee has obtained a large amount of information with regard to the laws at the present time, but have not had sufficient time to consolidate this into form for presentation and publication in the Proceedings. The Committee will work on this and submit to the Association for publication as soon as it is properly consolidated.

In connection with the discussion and passing of "Stop Laws," the Committee would like to call attention to the following interesting item.

The Standard Oil Company of Indiana has placed an advertisement through the West headed "Thirty-one Million Railroad Crossings Without an Accident," which reads as follows:

> "During 1924 the vehicles operated by the Standard Oil Company crossed railroad tracks 31,000,000 times without an accident. This is an average of 85,000 crossings a day. This record is attributed to the effort on the part of the management to impress all employees with the need and desirability of careful driving. The Company pointed out the dangers of careless driving and furnished placards reading: *'This car stops at all railroad crossings.'* Each driver was asked to pledge himself to cooperate and to evidence his good intentions by displaying the placard on the rear of his machine."

Such results as this we believe are strong proof of what can be done by carefulness at railroad crossings.

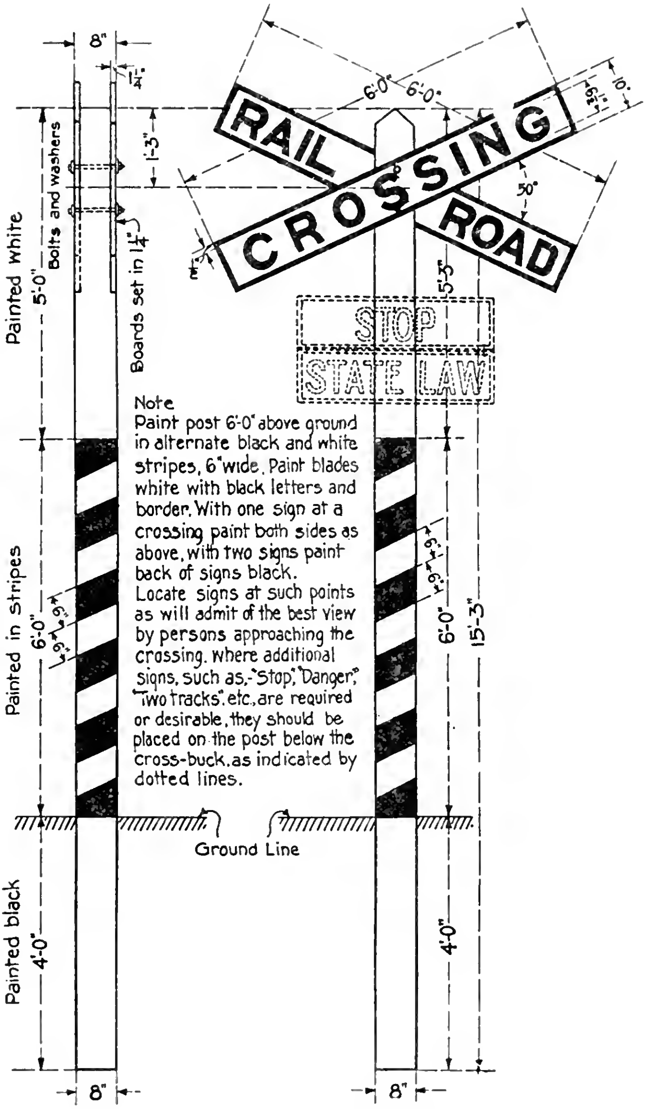
The Committee, therefore, submits to the Association for approval and adoption for publication in the Manual the two plans of highway crossing signs shown on the following pages, the first, Fig. 1, being a revision of the present plan and to be substituted in place of the standard sign now shown on page 456 of the Manual, and the second, Fig. 2, a new sign for use with warning signals at highway crossings.

A brief description of the changes that were made in the proposed sign shown in Fig. 1, from our present sign is as follows:

> The center of the crossarms has been lowered to a height of 10 ft. above the ground line instead of 10 ft. 9 in. as shown on the old plan.
>
> The suggested wording on the sign has been changed to "Railroad Crossing."
>
> The post is shown as diagonally striped, black and white, for 6 ft. above the ground.
>
> The length of the arms has been reduced from 8 ft. to 6 ft., and the width of the arms has been decreased proportionately.

We appreciate, with regard to the wording on the blades, that the laws of many states specify what the wording shall be, but we believe that we should establish a suggested wording with the idea that any reference to our standard or practice would show that form as being standard with this Association and might have a tendency to get such wording adopted as standard eventually in all states.

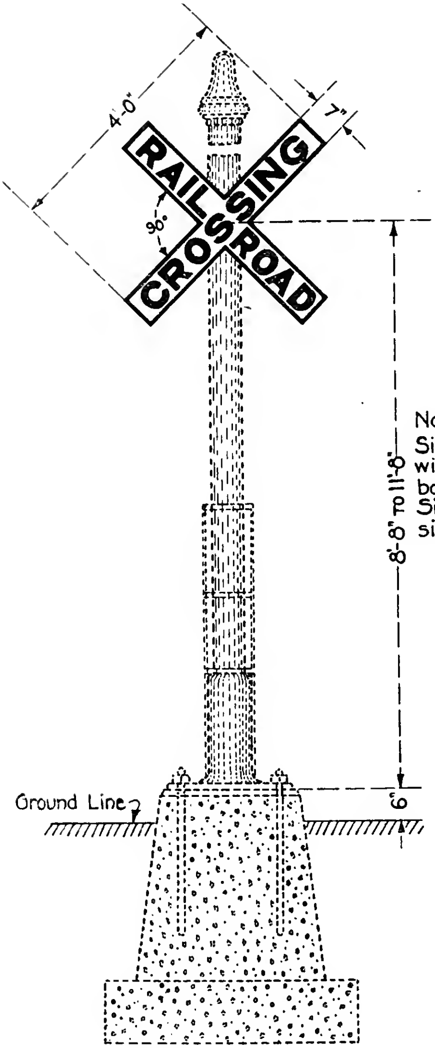
The question has been raised as to why we should adopt a standard sign and why we should show any wording on the sign whatever, but



Note
Paint post 6'-0" above ground in alternate black and white stripes, 6" wide. Paint blades white with black letters and border. With one sign at a crossing paint both sides as above, with two signs paint back of signs black.
Locate signs at such points as will admit of the best view by persons approaching the crossing. Where additional signs, such as,-"Stop", "Danger", "Two tracks", etc., are required or desirable, they should be placed on the post below the cross-buck, as indicated by dotted lines.

Fig. 1.—Crossing Sign

Note.—Lettering on Crossing Sign is suggested except where it conflicts with local requirements.



Note:–
Sign to have white field with black letters and border.
Sign to be installed each side of crossing.

Fig. 2.—Sign for Use With Highway Crossing Signal

we feel that it is better to lead with a proposed sign and endeavor to get a uniform sign rather than leave it to the varying minds in the many states that handle this subject.

The Committee thinks it would be well if this sign is adopted that copies of it be distributed to the Commissions of all States with the idea that when this subject is before them they would know what our recommendations are and what is largely used to-day, since this would tend to get more uniformity in the signs throughout the country.

With regard to the sign to be used with warning signal, it is felt by the Committee that this sign, while following out the general principle of the type, should be slightly different from the sign used without the signal indication. Also we have to take into consideration the fact that many of these warnings are being placed in the center of highways and when so placed the sign should not extend any great distance beyond the warning lights so as to interfere with traffic on the highway. This is not so serious when the sign is placed on the side of the road. We also believe, that while using the crossbuck principle, this sign is sufficiently different from the other sign to avoid confusion.

(b) BRIDGE SIGN

On page 462 of the 1921 edition of the Manual is shown a standard Bridge Sign as adopted by the Association.

It was thought by the Committee that the numbering used on the sign should indicate that the decimal system of numbering bridges should be adopted and that the Association should go on record as favoring that method of bridge numbering. Therefore, we submit in Fig. 3 a revised plan of a Bridge Sign showing this system of numbering bridges and recommend the substitution of this sign in the Manual in place of the present sign.

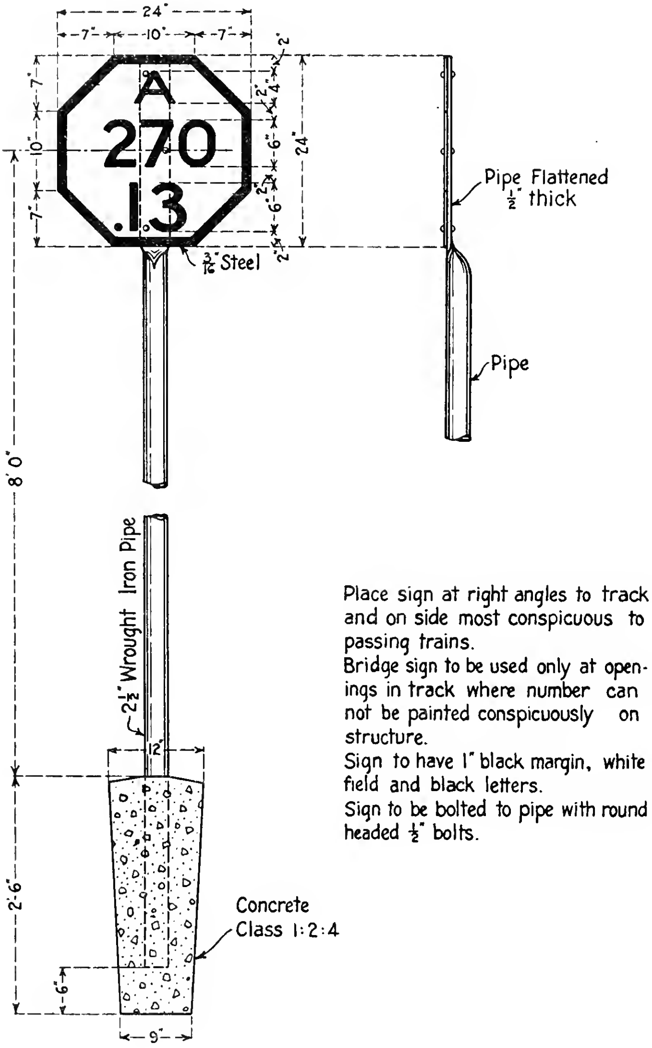
(c) VARIOUS MINOR REVISIONS

(1) **Materials Required for Fencing.**—On page 443 of the Manual is published a table showing quantity of material needed for barbed wire and board fence.

Under our Specifications for Standard Right-of-Way Fence we specify that intermediate or line posts shall not be more than 20 ft. apart, center to center. The Committee, therefore, recommends that the information shown in this table covering spacing of posts 22, 24, 26, 28 and 30 feet, should be removed from the Manual as it is not consistent with our fence specifications.

In this same table in the third column we recommend that the word "Ft." should be added under the figure "100" so as to definitely show what the "100" refers to. This is indefinite now.

(2) **Barbed Wire.**—On page 443 of the Manual is published a table showing the characteristics of different kinds of barbed wire.



Place sign at right angles to track and on side most conspicuous to passing trains.

Bridge sign to be used only at openings in track where number can not be painted conspicuously on structure.

Sign to have 1" black margin, white field and black letters.

Sign to be bolted to pipe with round headed ½" bolts.

Fig. 3.—Bridge Sign

This information is not complete as to the manufacturing conditions to-day, and we submit for substitution in the Manual in place of the present table the following:

BARBED WIRE FENCE

Style of Wire		Gauge of Strand	Spacing of Barbs	Weight in Pounds		
				Per Rod	Per 100 Ft.	Per Mile
Baker's Perfect	Regular or Cattle, 2 Pt	12½	5 in.	0.88	5.31	280.0
" "	Thickset or Hog, 2 Pt	12½	3 "	0.97	5.87	310.0
Ellwood	Regular or Cattle, 4 Pt	12½	5 "	0.94	5.68	300.0
"	Thickset or Hog, 2 Pt	12½	3 "	1.00	6.06	320.0
Ellwood Glidden	Regular or Cattle, 2 Pt	12½	5 "	0.92	5.60	295.0
" "	Thickset of Hog, 2 Pt	12½	3 "	0.99	5.97	315.0
Ellwood Junior	Regular or Cattle, 2 Pt	12½	5 "	0.88	5.31	280.0
" "	Thickset of Hog, 2 Pt	12½	3 "	0.94	5.68	300.0
American Glidden	Regular or Cattle, 2 Pt	12	5 "	1.00	6.06	320.0
" "	Thickset of Hog, 2 Pt	12	3 "	1.08	6.54	345.0
Lyman	Regular or Cattle, 4 Pt	12	6 "	1.14	6.92	365.0
"	Thickset or Hog, 4 Pt	12	4 "	1.25	7.58	400.0
Waukegan	Regular or Cattle, 2 Pt	12½	5 "	0.87	5.26	277.5
"	Thickset of Hog, 2 Pt	12½	3 "	0.94	5.68	300.0
"	Regular or Cattle, 4 Pt	12½	5 "	0.964	5.84	308.3
"	Thickset of Hog, 4 Pt	12½	3 "	1.066	6.46	341.1
American Special	Regular or Cattle, 2 Pt	14	5 "	0.630	3.82	201.7
" "	Thickset or Hog, 2 Pt.	14	3"	0.667	4.04	213.3

(3) **Smooth Steel Wires.**—On page 444 of the Manual is shown a table together with cuts giving the exact size and characteristics of No. 1 to No. 20 gage steel wire according to the American Steel & Wire Company's gage.

We find that the characteristics shown in the last two columns of that table are incorrect and the information shown in Table A should be substituted therefor. We have also added to this the column of "pounds per foot," which the Committee believes would be useful information.

The Committee recommends the substitution of the revised table for that now published in the Manual.

(4) **Wire Gages.**—On page 445 of the Manual is shown a table of the comparative sizes of wire gage in decimals of an inch.

The Committee in checking this over finds that there are some inaccuracies in that table according to present-day records and we submit Table B, which we recommend be substituted in the Manual in place of the present information.

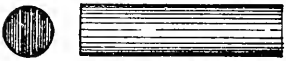
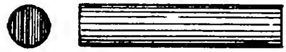
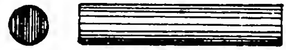
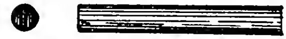
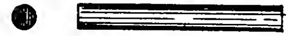
(5) **Barbed Wire.**—On page 446 of the Manual there are shown some diagrams and descriptions of various types of barbed wire.

The Committee finds on investigation that this information is not complete and we therefore submit information shown in Table C and recommend it be substituted in the Manual in place of the information now shown.

(6) **Wire Nails.**—On pages 447 and 448 of the Manual is shown some information covering common nails.

Table "A"

SMOOTH STEEL WIRES

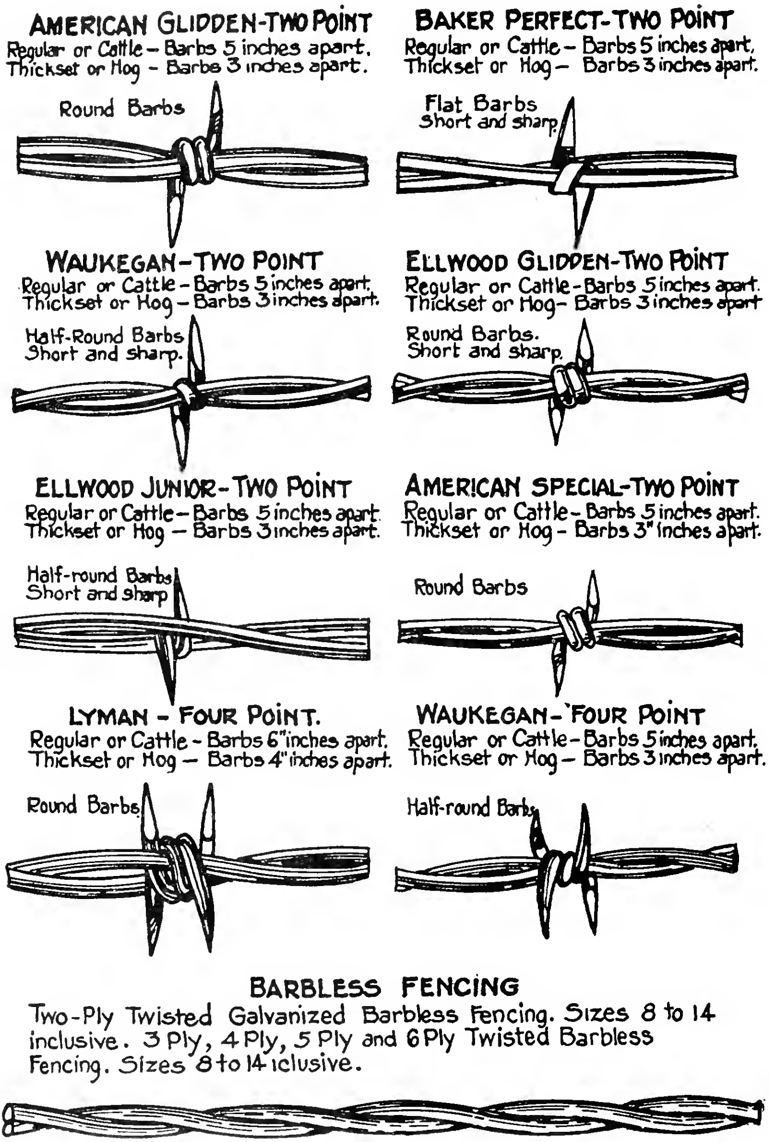
Cuts showing exact sizes of No. 1 to No. 20 gauge steel wire by American Steel and Wire Company gauge.	Gauge	Lbs. to Mile	Lbs. to Foot	Feet to 1 lb.
	1	1128.00	0.2136	4.681
	2	970.40	0.1838	5.441
	3	836.40	0.1584	6.313
	4	714.80	0.1354	7.386
	5	603.40	0.1143	8.750
	6	519.20	0.0983	10.170
	7	441.20	0.0835	11.970
	8	369.60	0.0700	14.290
	9	309.70	0.0586	17.050
	10	256.70	0.0486	20.570
	11	204.50	0.0387	25.820
	12	156.70	0.0296	33.690
	13	117.90	0.0223	44.780
	14	90.13	0.0170	58.580
	15	73.01	0.0138	72.320
	16	55.00	0.0104	95.980
	17	41.07	0.0077	128.600
	18	31.77	0.0060	166.200
	19	23.67	0.0044	223.000
	20	17.05	0.0032	309.600

(To replace table on page 444 of Manual)

TABLE "B"—COMPARATIVE SIZES OF WIRE GAGE—IN DECIMALS OF AN INCH

No. of Wire Gauge.	A.S.& W.Co. or Washburn & Moen	American Wire Gauge (B.&S.)	Birmingham or Stubb's	British Imperial Standard	Old English
7/0	.4900			.5000	
6/0	.4615	.5800		.4640	
5/0	.4305	.5165	.5000	.4320	
4/0	.3938	.4600	.4540	.4000	.4540
3/0	.3625	.4096	.4250	.3720	.4250
2/0	.3310	.3648	.3800	.3480	.3800
1/0	.3065	.3249	.3400	.3240	.3400
1	.2830	.2893	.3000	.3000	.3000
2	.2625	.2576	.2840	.2760	.2840
3	.2437	.2294	.2590	.2520	.2590
4	.2253	.2043	.2380	.2320	.2380
5	.2070	.1819	.2200	.2120	.2200
6	.1920	.1620	.2030	.1920	.2030
7	.1770	.1443	.1800	.1760	.1800
8	.1620	.1285	.1650	.1600	.1650
9	.1483	.1144	.1480	.1440	.1580
10	.1350	.1019	.1340	.1280	.1340
11	.1205	.0907	.1200	.1160	.1200
12	.1055	.0808	.1090	.1040	.1090
13	.0915	.0720	.0950	.0920	.0950
14	.0800	.0641	.0830	.0800	.0830
15	.0720	.0571	.0720	.0720	.0720
16	.0625	.0508	.0650	.0640	.0650
17	.0540	.0453	.0580	.0560	.0580
18	.0475	.0403	.0490	.0480	.0490
19	.0410	.0359	.0420	.0400	.0400
20	.0348	.0320	.0350	.0360	.0350
21	.0317	.0285	.0320	.0320	.0315
22	.0286	.0253	.0280	.0280	.0295
23	.0258	.0226	.0250	.0240	.0270
24	.0230	.0201	.0220	.0220	.0250
25	.0204	.0179	.0200	.0200	.0230
26	.0181	.0159	.0180	.0180	.0205
27	.0173	.0142	.0160	.0164	.01875
28	.0162	.0126	.0140	.0148	.01650
29	.0150	.0113	.0130	.0136	.01550
30	.0140	.0100	.0120	.0124	.01375
31	.0132	.00893	.0100	.0116	.01225
32	.0128	.00795	.0090	.0108	.01125
33	.0118	.00708	.0080	.0100	.01025
34	.0104	.00630	.0070	.0092	.00950
35	.0095	.00561	.0050	.0084	.00900
36	.0090	.00500	.0040	.0076	.00750
37	.0085	.00445		.0068	.00650
38	.0080	.00396		.0060	.00575
39	.0075	.00353		.0052	.00500
40	.0070	.00314		.0048	.00450
41	.0066	.00280		.0044	
42	.0062	.00249		.0040	
43	.0060	.00222		.0036	
44	.0058	.00198		.0032	
45	.0055	.00176		.0028	
46	.0052	.00157		.0024	
47	.0050	.00140		.0020	
48	.0048	.00124		.0016	
49	.0046	.000986		.0012	
50	.0044	.000878		.0010	

BARBED WIRE FENCE



AMERICAN GLIDDEN-TWO POINT

Regular or Cattle – Barbs 5 inches apart.
Thickset or Hog – Barbs 3 inches apart.

BAKER PERFECT-TWO POINT

Regular or Cattle – Barbs 5 inches apart.
Thickset or Hog – Barbs 3 inches apart.

WAUKEGAN-TWO POINT

Regular or Cattle – Barbs 5 inches apart.
Thickset or Hog – Barbs 3 inches apart.

ELLWOOD GLIDDEN-TWO POINT

Regular or Cattle – Barbs 5 inches apart.
Thickset or Hog – Barbs 3 inches apart

ELLWOOD JUNIOR-TWO POINT

Regular or Cattle – Barbs 5 inches apart
Thickset or Hog – Barbs 3 inches apart.

AMERICAN SPECIAL-TWO POINT

Regular or Cattle – Barbs 5 inches apart.
Thickset or Hog – Barbs 3" inches apart.

LYMAN - FOUR POINT.

Regular or Cattle - Barbs 6" inches apart.
Thickset or Hog – Barbs 4" inches apart.

WAUKEGAN-FOUR POINT

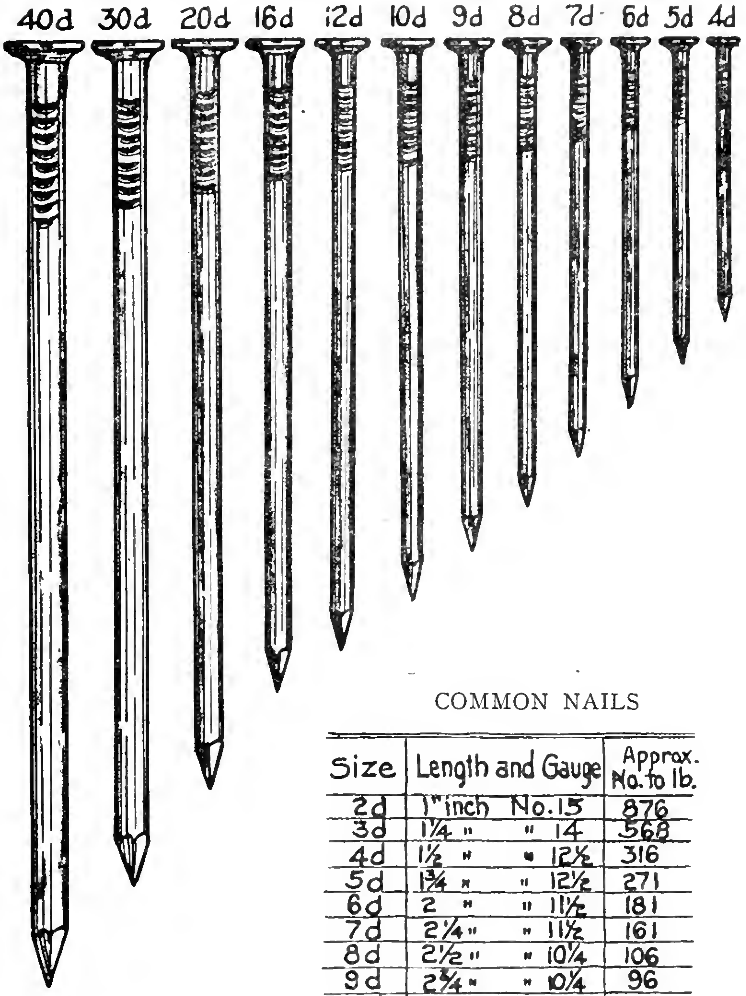
Regular or Cattle – Barbs 5 inches apart.
Thickset or Hog – Barbs 3 inches apart.

BARBLESS FENCING

Two-Ply Twisted Galvanized Barbless Fencing. Sizes 8 to 14 inclusive. 3 Ply, 4 Ply, 5 Ply and 6 Ply Twisted Barbless Fencing. Sizes 8 to 14 iclusive.

Fig. 4

TABLE "C"



Illustrations
Actual Size.

COMMON NAILS

Size	Length and Gauge	Approx. No. to lb.
2d	1" inch No. 15	876
3d	1¼ " " 14	568
4d	1½ " " 12½	316
5d	1¾ " " 12½	271
6d	2 " " 11½	181
7d	2¼ " " 11½	161
8d	2½ " " 10¼	106
9d	2¾ " " 10¼	96
10d	3 " " 9	69
12d	3¼ " " 9	63
16d	3½ " " 8	49
20d	4 " " 6	31
30d	4½ " " 5	24
40d	5 " " 4	18
50d	5½ " " 3	14
60d	6 " " 2	11

In connection with the President's request that the information in the Manual be consolidated or reduced as much as can consistently be done, the Committee submits a new plan and table as shown in Fig. 5, on which has been combined the information formerly shown on pages 447 and 448. This has been done by cutting off four of the sizes shown in the Manual, but we do not see that that makes any material difference. This enables us to combine on one page the two tables of the characteristics of the nails. The Committee, therefore, recommends its substitution in the Manual in place of the information now shown on pages 447 and 448.

(7) **Fence Staples.**—On page 448 of the Manual is shown a table of fence staples.

Your Committee recommends that there be added to the two columns showing the size of staples the following:

Length 2¼ in., number to pound 47.
Length 2½ in., number to pound 40.

(d) SPECIFICATIONS FOR BITUMINOUS CROSSINGS

On pages 49, 50 and 51 of Bulletin 277, Supplement to the Manual 1921, Part 1, Specifications for the Construction of Bituminous Crossings are given.

The study made during the past year by a Sub-Committee of Committee IX of Natural Rock Asphalt developed some minor changes that should be made in those specifications. These are shown below and the Committee recommends they be approved and the revised paragraphs substituted for the present recommendations in the Manual.

SPECIFICATIONS FOR THE CONSTRUCTION OF BITUMINOUS CROSSINGS

Present Form	*Proposed Form*
2. Foundation.	
All the old ballast shall be removed for the full width of the crossing between lines not less than two feet outside each rail and replaced with new ballast consisting of clean crushed stone having a depth of not less than 6 inches below the bottom of the tie.	All the old ballast shall be removed for the full width of the crossing between lines not less than two feet outside each rail and replaced with new ballast consisting of clean crushed stone or clean gravel preferably washed, having a depth of not less than 6 inches below the bottom of the tie.
All ties not in good condition shall be removed and replaced with new ties (preferably treated ties) and fitted with tie plates. All badly worn track material shall be replaced with new material, eliminating rail joints if practicable.	Provision shall be made for draining the roadbed. All ties not in good condition shall be removed and replaced with new ties (preferably treated ties) fitted with tie plates. All badly worn track material shall be replaced, eliminating rail joints if practicable.

Present Form	*Proposed Form*
Provision shall be made for draining the roadbed. The track shall be carefully lined and surfaced. The new ballast shall be thoroughly tamped to form an unyielding foundation, the surface of which, after being tamped shall be four inches below the top of rail for a crossing where an emulsified material is used; three inches where a cut-back material is used and one and one-half inches where rock asphalt is used. Where the crossing is to be constructed of rock asphalt the voids in the stone ballast above top of tie shall be filled with limestone screenings sprinkled with water and tamped to form a solid, water-bound pavement which shall be allowed to dry before the rock asphalt is applied.	The track shall be carefully lined and surfaced. The new ballast shall be thorougly tamped to form an unyielding foundation, the surface of which shall be four inches below top of rail for a crossing where an emulsified material is used; 3 inches where a cut-back material is used, and one and one-half inches where rock asphalt is used. Where the crossing is to be constructed of rock asphalt the voids in the stone ballast above top of tie shall be filled with fine stone and tamped to form a solid pavement. The foundation shall be dry when rock asphalt is applied.
The new stone ballast shall conform to the American Railway Engineering Association specifications for stone ballast.	The new ballast shall conform to the American Railway Engineering Association specifications for ballast.
4-A. Method of Constructing Pavement. Flangeways—Particular attention shall be given to thoroughly compacting the bituminous concrete adjoining wood or steel flange guards or rail heads. Where wood or steel flange guards are not provided and flangeways are cut by trains passing over the crossing, they shall be sealed by applying to the grooves a solution of two parts bitumen and one part water.	Particular attention shall be given to thoroughly compacting the bituminous concrete adjoining flange guards or rail heads. Where flange guards are not provided and flange ways are cut by trains passing over the crossing, they shall be sealed by applying to the grooves a solution of two parts bitumen and one part water.
4-B. Method of Constructing Pavement. Flangeways—Particular attention shall be given to thoroughly compacting the bituminous concrete adjoining wood or steel flange guards or rail heads.	Particular attention shall be given to thoroughly compacting the bituminous concrete adjoining flange guards or rail heads.

Present Form	*Proposed Form*
4-C. Method of Constructing Pavement.	
If a rock asphalt is used, the following paragraph shall govern:	If a rock asphalt is used, the following paragraphs shall govern:
Wearing Surface—The rock, etc.	Wearing Surface—The rock, etc.
Flangeways—Particular attention shall be given to thoroughly compacting the rock asphalt adjoining wood or metal flange guards or rail heads.	Flangeways—Particular attention shall be given to thoroughly compacting the rock asphalt adjoining flange guards or rail heads. Flange guards should be placed and securely fastened to the ties before any ballast is spread about the top of the ties.
	Rock asphalt should be spread at least 4 in. thick, for a distance of at least 6 in. from the rail before being compacted, so as to withstand the effects of vibration.

Appendix B

(2) METHODS OF APPORTIONING THE COST OF HIGHWAY IMPROVEMENTS ADJACENT AND PARALLEL TO RAILROAD RIGHTS-OF-WAY

R. E. Chamberlain, Chairman, Sub-Committee; Anton Anderson, W. C. Swartout.

The work of your Committee this year on the above subject has consisted of completing and, where necessary, correcting the information published last year and of tabulating this information for ready reference.

These additions and corrections are given below. The tabulation appears as Table D.

ARIZONA

State highway funds are provided in the following manner:

(a) By a general levy, 25 per cent of which is spent in the state at large and 75 per cent spent by the Highway Department in the county where it was raised.

(b) By special legislation for particular projects.

(c) By a gasoline tax of 3 cents per gallon, 50 per cent of which tax goes to the county.

(d) By a State bond issue. (Not utilized in past few years.)

(e) By Federal aid.

County road funds are obtained as set forth above and also as follows:

(a) By a direct tax.

(b) By a $1.00 poll tax.

(c) By a variable appropriation from the U. S. Forest Service.

(d) By county bond issue. A large amount is raised in this manner and much of it is matched with Federal Aid.

CONNECTICUT

The highways of this state are financed from the taxes on motor vehicles, gasoline tax and general taxation. During 1924 this state spent about $8,000,000—$5,000,000 of which was derived from automobile fees; $1,000,000 from gasoline tax and approximately $2,000,000 from civil list funds appropriated by the legislature from all revenues received.

DELAWARE

Delaware state highways are paid for by bond issues which are paid off through gasoline taxes. County highways are paid for from county funds raised by local taxes. There is no law in this state specifically assessing railroad property for highway improvements.

ILLINOIS

In this state there are no assessments on any property, railroad or private, regardless of location of highway. Entire cost paid by state out of proceeds of two bond issues, one for $60,000,000 and one for $100,000,000, interest and sinking fund requirements of which are taken care of by automobile license fees.

IOWA

A gasoline tax of 2 cents per gallon is now collected. All primary road improvements and maintenance is now done by the State Highway Commission out of the Primary Road Fund.

MINNESOTA

The trunk highways are constructed and maintained by the state. State aid roads are constructed and maintained by the county, the expense being borne jointly by the state and county. County and township roads are constructed and maintained by the townships. In securing the necessary right-of-way for highways the various governmental departments, as well as the State Highway Commissioner, have a right to obtain the same by eminent domain proceedings. The law of this state is such that in determining the resulting damages to the owner of land, if property is being taken for right-of-way for highway purposes, the special benefits resulting to such owner may be deducted therefrom up to the extent and amount of such damages. The railroad companies have not been required to pay any part of the cost of a rural highway.

MONTANA

For the purpose of raising revenue for the construction, maintenance, and improvement of public highways the Board of County Commissioners of each county in this state may levy and cause to be collected a general tax upon taxable property in the county of not less than two mills, and not more than five mills on the dollar, which shall be payable to the County Treasurer with other general taxes. There is also established a general road tax of two dollars per annum on each male person over the age of twenty-one years and under the age of fifty years, who is an inhabitant within the county, and payable by each person liable therefor at any time within the year. The collection of these taxes is under the direction of the Board of County Commissioners. The foregoing provisions do not apply to incorporated cities and towns which, by ordinance, provide for the levy and collection of a like general tax and a like special tax within such cities and towns for road, street and alley purposes. All moneys collected under the provisions of this act belong to the general road fund of the county. There are also some statutory provisions permitting additional levies to be made for highway purposes where the matter has been submitted to a vote of the people at some general or special election, and there is also a provision for issuing bonds by a county for highway construction. These bonds and interest are paid by a general tax upon all the taxable property of the county including railroad property.

NEW HAMPSHIRE

The funds in this state for highway purposes come from licensing motor vehicles and gasoline tax of 2 cents per gallon. This gives an income of approximately $2,000,000 annually. All of the highway work is of a State Aid nature, the state assisting the towns so that the towns raise money by direct appropriation. There are no special assessments against the railroads for highway improvements.

NEW YORK

State highways are built or improved from the proceeds of bond issues or direct appropriation by the legislature. A system of state and county highways is built partly from appropriations by the State Legislature and funds of the various counties raised by taxes. Railroads do not pay an assessment based upon benefit from an improvement but are taxed on the state and county tax roll based upon the assessed valuation of the railroad property the same as the other property owners.

NORTH CAROLINA

State highways are built and maintained by a tax of 4 cents per gallon on gasoline and a graduated license tax on automobiles, and to hasten the work the State has issued $85,000,000 of bonds, the carrying charge and sinking fund for which is paid out of the gasoline and automobile tax. There is no ad valorem or assessment tax for state highways.

NORTH DAKOTA

Under the general law of this state railroads bear only such portion of the cost of the highway as the general levy of the townships upon all property reaches the railway valuation in such taxing district. The State Board of Equalization fixes the value of railway rights-of-way at a uniform sum per mile. This valuation is allocated to the taxing district in which the property is located in accordance to the mileage therein. If the township board levies an eight mill road tax, this levy is spread against the railroad valuation the same as other property.

OREGON

All state roads and highways are paid for by receipts from automobile licenses and a gasoline tax and by bond issues, the principal and interest of which are taken care of by receipts from these taxes. Forest and post roads are paid for jointly by the state and United States. County roads are constructed with the proceeds of bond issues or of general taxation, and both the principal and interest are taken care of by general taxation, together with an apportionment of one-quarter of automobile licenses received by the state.

PENNSYLVANIA

There is no provision in the laws of the state governing the construction of state highways which provides for assessing railroad companies, other than the provisions of the Public Service law which authorized the Commission to assess the company a portion of the cost of eliminating grade crossings. The money available for the construction of state highways is derived by indirect taxation and bond issues so far as the state is concerned and by direct taxation in the municipalities. Highway construction is paid for in several ways as follows: At the total cost of the state; the joint cost of the state, county, township or borough; or state and county.

SOUTH CAROLINA

Local assessment for highway improvements are authorized only in the counties of Florence and Beaufort. In Florence County an amount not exceeding one-third the cost of the improvement may be assessed against property within one and one-half miles of the highway, of which assessment two-thirds must be assessed against property within three-quarters of a mile of the highway and the remainder against other property. All property within such limits, including railroad property, is assessed with its proportionate share based on the value of the property as assessed for general taxation. In Beaufort County an amount not exceeding one-half of the cost of the improvement may be assessed on abutting property or property adjacent within ten miles of the highway. No basis is fixed for the assessment on various parcels and classes of property. In general, highways are paid for out of the proceeds of a gasoline tax of five cents per gallon, the proceeds of which are used on the construction of state and county highways.

SOUTH DAKOTA

There are no provisions for special assessments for the construction and improvement of highways outside of cities and towns. The state highway program is supported by a 3-cent tax on gasoline, a state levy on all the taxable property in the state, including property located within cities and towns, and such Federal Aid moneys as is apportioned to the state by the Bureau of Public Roads. In addition to this the state receives 47 per cent of all the motor vehicle license fees collected in the state. The county highway program is maintained by regular road and bridge levy made upon all the taxable property in the county, including properties located in cities and towns. The county also retains 47 per cent of the motor vehicle license fees collected within the county. The township highway program is carried on by the regular road and bridge levy made by the township upon all the taxable property within the township.

Table D shows in a general way a summary of the methods of the various states in raising the funds for road construction and maintenance. The collection of entirely complete and accurate information on a subject of this kind is very difficult and no doubt there are a number of errors and omissions both in the text and in the table. It is interesting to note at least 40 per cent of the states are now financing their highway improvement or maintenance wholly or partly from a gasoline tax of from 2 cents to 5 cents per gallon; that the construction of improved highways by special assessment is becoming unusual, and that bond issue retired by the gas tax, motor license fees or otherwise are being used by many states. The trend seems to be away from the raising of road funds by ad valorem taxes, a method which is usually more unfair to the railways than any of the others.

If this subject is re-assigned to the Committee it might be profitable to study the fairness or unfairness of the different methods of raising revenue for highway improvements, from the railroad standpoint, and the trend of judicial decisions in such cases as have been contested by the railways. A study of the matter of Federal Aid might also elicit some interesting information.

TABLE D

Method of Apportioning Cost of Street and Highway Improvements Adjacent and Parallel to Railroad Rights-of-Way

STATE	General County Tax	State Bond Issue	General Township Tax	State Funds	County Bond Issues	Special District Tax	Gasoline Tax	Motor License	Benefit Basis	Frontage Basis	Valuation Basis	REMARKS.
Alabama	X						X	X				
Arizona	X			X	X		X					Railroads not assessed.
Arkansas									X			Railroads assessed on mileage basis.
California	X	X				X	X					
Colorado		X										
Connecticut				X			X	X				Railroads not assessed
Delaware	X	X					X					Railroads not assessed - Bonds retired by gasoline tax.
Florida							X	X		X		Assessments legal only in counties with population between 75000 and 100000
Georgia	X						X	X				No special assessments
Idaho	X					X						Legality of district tax doubtful.
Illinois		X						X				Bonds retired by motor licenses
Indiana						X			X		X	
Iowa							X	X				Federal aid used
Kansas	X		X	X		X			X			Federal aid about $15,000 per mile
Kentucky	X						X	X				
Louisiana	X				X							County bonds retired by advalorem tax
Maine	X			X								No special assessments
Maryland	X	X			X		X	X				Bonds retired by general taxes - Motor and gasoline tax used for maintenance only
Massachusetts				X				X				Railroads not assessed
Michigan	X	X										Federal aid used
Minnesota	X		X	X								
Mississippi						X						Property taxed on advalorem basis
Missouri		X						X				Bonds retired by motor license fees
Montana	X				X							
Nebraska				X								
Nevada	X	X		X			X					Bond issues retired by poll and gasoline tax
New Hampshire							X	X				
New Jersey	X											No special assessments
New Mexico												
New York	X	X		X								No special assessments
North Carolina		X					X	X				Bond issues retired by motor license and gasoline tax
North Dakota			X									
Ohio							X		X	X		
Oklahoma					X							Bonds retired by advalorem tax
Oregon	X	X			X		X	X				Bonds retired by motor license and gasoline tax
Pennsylvania	X	X	X									No special assessments
Rhode Island												Railroads not assessed
South Carolina	X						X					
South Dakota	X			X			X	X				Federal aid used
Tennessee	X											
Texas												
Utah	X				X							Bonds retired by advalorem tax
Vermont												Railroads not assessed
Virginia							X	X				No special assessments
Washington									X			
West Virginia		X		X			X	X				No special assessments
Wisconsin	X		X									
Wyoming												

Appendix C

(3) ELIMINATION OF HIGHWAY GRADE CROSSINGS

A. B. Griggs, Chairman, Sub-Committee; W. E. Colladay, C. T. Dike, E. R. Lewis, H. M. Shepard, T. H. Strate, M. D. Thompson, C. E. Smith.

The following, being the third report of your Committee, is submitted as final on the subject as assigned, namely: "Elimination of Highway Grade Crossings," and covers in part major items, (8) Design, (9) Construction Methods, (10) Costs, and (11) Bibliography, as shown in the outline of study appearing at page 630 of the 1924 Proceedings.

A partial report was made last year on Design, with the submission of some typical plans and illustrations of existing structures.

As shown in the Outline of Study, the subject of Design is divided into three principal topics—Overgrade Crossings, Undergrade Crossings and Approaches.

DESIGN

Over-Grade Crossing—Highway Over Railroad.—In designing a structure for an over-grade crossing, the kind of traffic to be accommodated is the first consideration, street railways, vehicles and pedestrians being those for which provision should be made, according to location.

When providing for street railways, the usual arrangement for city streets is that the track or tracks occupy the middle portion of the roadway, with space on either side for vehicles and a sidewalk on the outside for pedestrians on one or both sides according to the volume of traffic expected to use the structure. Such sidewalks should be protected by railing or balustrade. For interurban railway lines the arrangement may be modified to have the electric line track located on one side of the structure corresponding to its location with respect to the roadway on either side of the crossing.

The usual vertical clearance of a highway structure above top of rail of a steam line is 22.0 ft.; however, in order to obviate the expense of digging the ballast out from under the track in resurfacing it is recommended that the clearance in original construction be made 22.5 ft. to provide for a six-inch raise of the tracks.

The required roadway width for electric cars is 11 ft. for each track. For each line of motor vehicles a width not less than 9 ft. should be provided and where sidewalks are required a minimum width of 6 ft. is considered good practice. To reduce cost in bridge construction sidewalks may be cantilevered from the main structure.

Highway grades and supports on the railroad right-of-way should be preferably so designed that additional railroad tracks may be built without changing the highway structure. The vertical supports of the highway structure should have a side clearance of not less than 8 ft. from the center of the nearest track of the steam road.

The highway approach grades should not exceed that which prevails in the section of the country for highways of the class under consideration and intersecting grades are to be connected with suitable vertical curves.

The slopes of approach fills are dependent upon the character of the material used. In urban locations the slopes may be sodded, planted or seeded to prevent damage from erosion. In cases of restricted widths of right-of-way for the highway, retaining walls may be necessary, but slopes may be protected by either timber or concrete cribbing made up in suitable dimensions when more economical than retaining walls. Where an elimination is subject to future revision, concrete cribbing may be used, but for permanent work a retaining wall is more suitable.

Type of structure to be adopted will depend upon the conditions in any given case. The wooden structure on piles or frame bents as shown on page 600 of the 1925 Proceedings is in common use but is being replaced on some roads by steel or reinforced concrete slab construction on reinforced concrete piles.

The kind of roadway paving is determined by the class and density of traffic, also by the rate of approach grades used. In case of wooden structures, fire protection of asbestos or other suitable material, such as sheet metal, should be placed over each track of the steam road.

Under-Grade Crossings—Highway Under Railroad.—An alinement through the subway continuous with that of the highway on either side is in some respects very desirable since it provides a clear view from an approaching vehicle, but the introduction of curves in the highway where necessary, allows the subway to be located at or near right angles to the railroad and thereby reduces the cost of construction. Center columns are sometimes favored since they separate the lines of traffic under the structure and there are conditions where such columns are required on account of extreme length of span. There are often instances when the introduction of columns will materially reduce the cost of elimination due to decreased floor depth necessary. The center curbs should be carried out far enough on each side of the structure to allow for proper separation of the traffic. The highway alinement and grades should be carefully studied and designed to take care of present and future requirements.

Upon further study and investigation the Committee recommends an overhead clearance of from 12 to 14 ft. On important traffic arteries without trolley tracks an overhead clearance of 13½ ft. may be required, and on important traffic arteries with trolley tracks an overhead clearance of 14 ft. may be required. The increased vertical clearance, however, adds very materially to the costs of grade separation due to the increased height of abutments and embankments. Sidewalk and center columns should be 9 to 12 in. from the curb line to allow for the overhang of vehicles.

A subway for vehicular traffic only should have a clear roadway width of not less than 18 ft. to provide for two lines of traffic. This minimum width should be increased in multiples of nine for each additional line of traffic for which provision is to be made.

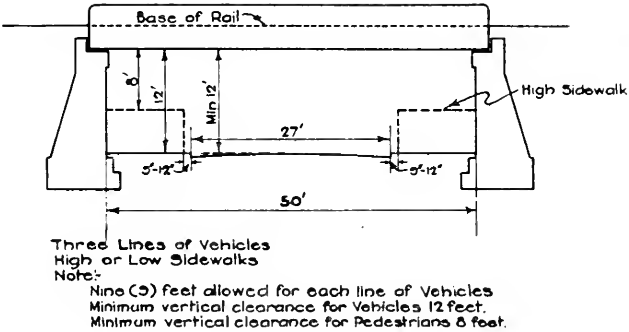
Where sidewalks are to be provided on one or both sides they may be raised above the roadway level to a minimum overhead clearance of 8 ft. In the case of street depression, raising the sidewalk above the roadway improves the sidewalk grade and provides space beneath it for underground pipes and conduits. Such a sidewalk should have a barrier on the street side for protection of pedestrians. The barrier may be a gas pipe railing or metal fence with strong wire mesh panel in the lower portion or other suitable protection. The walls supporting such sidewalks should be specially protected against bulging and failure due to overturning tendency. Good practice is to anchor them firmly to the abutment and to place the walk slab on top, or to pour the sidewalk wall and the floor of the conduit space as portions of the abutment, the reinforced top slab forming the sidewalk.

In the case of a subway under several tracks provision may be required for lighting and in all cases drainage must be provided.

The same principles apply to the approach of under-grade and over-grade crossings. The grades should be designed so as to allow for future tracks. If an important intersecting street is crossed by a heavy approach grade it is considered good practice to reduce the approach grade to about two per cent for the width of the intersecting street to provide for a safe traffic movement. The highway slopes will be dependent upon the material encountered. In city eliminations retaining walls are usually employed and stairways and driveways are sometimes required to take care of property owners affected by the elimination. A study should be made of adjoining structures and underpinning provided where necessary.

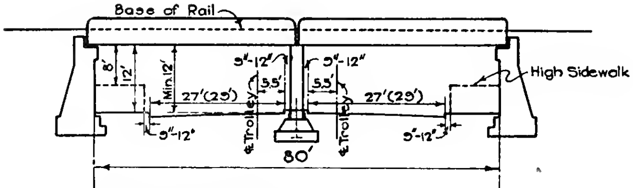
Typical illustrations of undercrossings are shown herewith.

Construction Methods.—In case of the rural overhead or undergrade project special construction difficulties are rarely encountered, but in the case of city undercrossings the work sometimes becomes one of track elevation and the problem becomes much more complex. Where conditions permit the main tracks may be shifted or detoured at their existing grade to one side or to both sides of the right-of-way far enough to allow the central part to be used for the new work to be constructed. Then traffic is turned over the new grade usually on one track at a time and the remainder of the work completed. In other instances it is possible to take one or more tracks out of service, erect a temporory construction trestle at or above the permanent grade, build the abutments on either side of the street intersections, fill in between them and widen out by side filling from the new elevation. Another method of construction is to place embankments by the use of motor dump trucks and plank roads instead of temporary trestles and dump cars. A further plan of construction that has been adopted with success is placing the filling material in the embankment by clam-shell derricks or locomotive cranes from



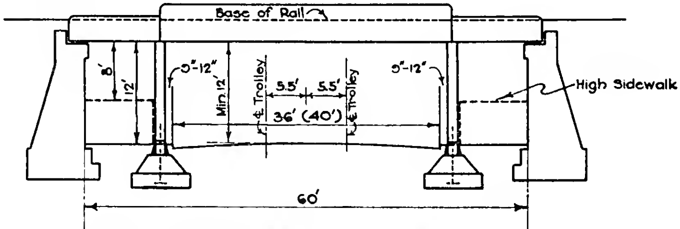
GRADE SEPARATION-CITY STREET UNDER-TYPICAL ONE SPAN BRIDGE

flat bottom cars, sufficient material being thus handled to make the dump wide enough for one or more tracks. The widening may then be completed by shifting the tracks or continuing to unload from the high level by clam. The particular advantages of the locomotive cranes are that cars can be moved and all classes of track and bridge materials can



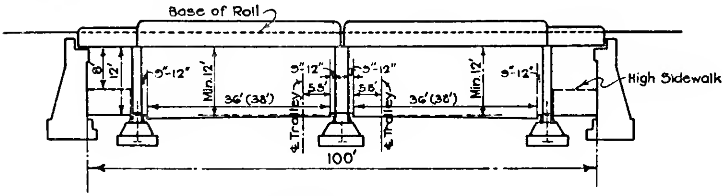
Six Lines Vehicles
Or 4 Lines Vehicles & 2 Trolley Tracks
High or Low Sidewalks
Note:-
Nine (9) feet allowed for each line of Vehicles
Eleven (11) feet for each Trolley Track
Roadway width with Trolley shown in brackets.
Curb to be located 9" to 12" back from face of column.
Minimum vertical clearance for Vehicles 12 feet
Minimum vertical clearance for Pedestrians 8 feet.

GRADE SEPARATION–CITY STREET UNDER–TYPICAL TWO SPAN BRIDGE.



Four Lines of Vehicles
Or 2 Lines Vehicles & 2 Trolley Tracks
High or Low Sidewalks
Note:-
Nine (9) feet allowed for each line of Vehicles
Eleven (11) feet for each Trolley Track
Roadway width with Trolley shown in brackets.
Curb to be located 9" to 12" back from face of column
Minimum vertical clearance for Vehicles 12 feet.
Minimum vertical clearance for Pedestrians 8 feet.

GRADE SEPARATION–CITY STREET UNDER–TYPICAL THREE SPAN BRIDGE.



Eight Lines of Vehicles
Or 6 Lines Vehicles & 2 Trolley Tracks.
High or Low Sidewalks.
Note:-
Nine (9) feet allowed for each line of Vehicles
Eleven (11) feet for each Trolley Track
Roadway width with Trolley shown in brackets.
Curb to be located 9"-12" back from face of Column
Minimum vertical clearance for Vehicles 12 feet.
Minimum vertical clearance for Pedestrians 8 feet.

GRADE SEPARATION–CITY STREET UNDER–TYPICAL FOUR SPAN BRIDGE.

also be handled by them. Each project has its own peculiar conditions and must be given careful study to determine the most economical method of construction. It is one thing to design an elimination project but quite another to build it under traffic. In order to facilitate such a study small scale plans showing stages of construction are very helpful and so essential that they should be given full consideration before the adoption of the design. These plans should show alinement, track profiles and typical cross-sections at all critical points for each stage of construction, and if properly made are of great assistance to the Engineering and Operating Departments. (Examples of such schedule plans, Stages A to G, for an elimination project on an Eastern road, are shown below.) Contractors will also be able to make a closer estimate of the cost of doing the work with this information available.

In the case of an over-grade project the work usually may be carried on from the grade elevation of the new structure without interference to operation of the steam road tracks below, except for the placing between tracks of such falsework as may be necessary.

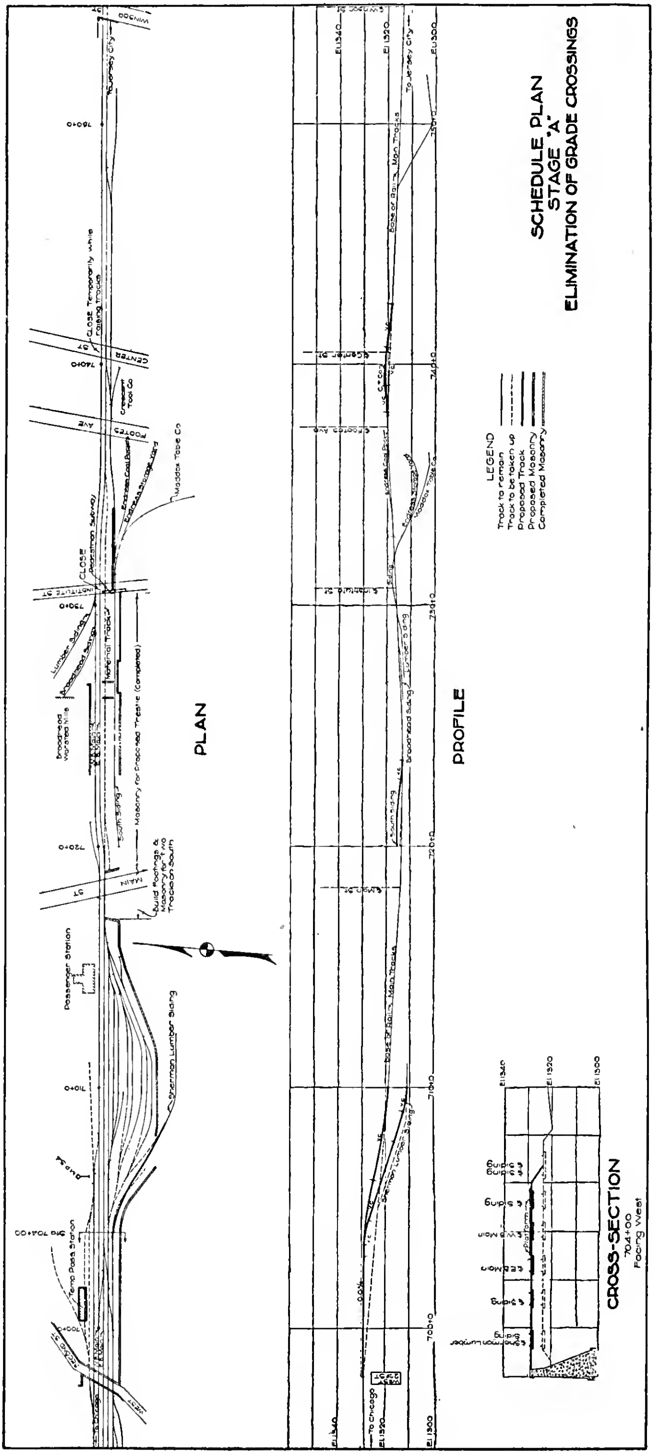
Costs.—The costs of any given grade separation project may be stated as those of construction, the capitalized additional expense of maintenance after the work is completed, and property damage. Total costs of a given project or unit costs in dollars per cubic yard of earth or concrete or per ton of metal as determined on any given project at any given time are not indicative of similar costs on another project in another location at some other time but costs in terms of man or man and machine hours may be more generally applied.

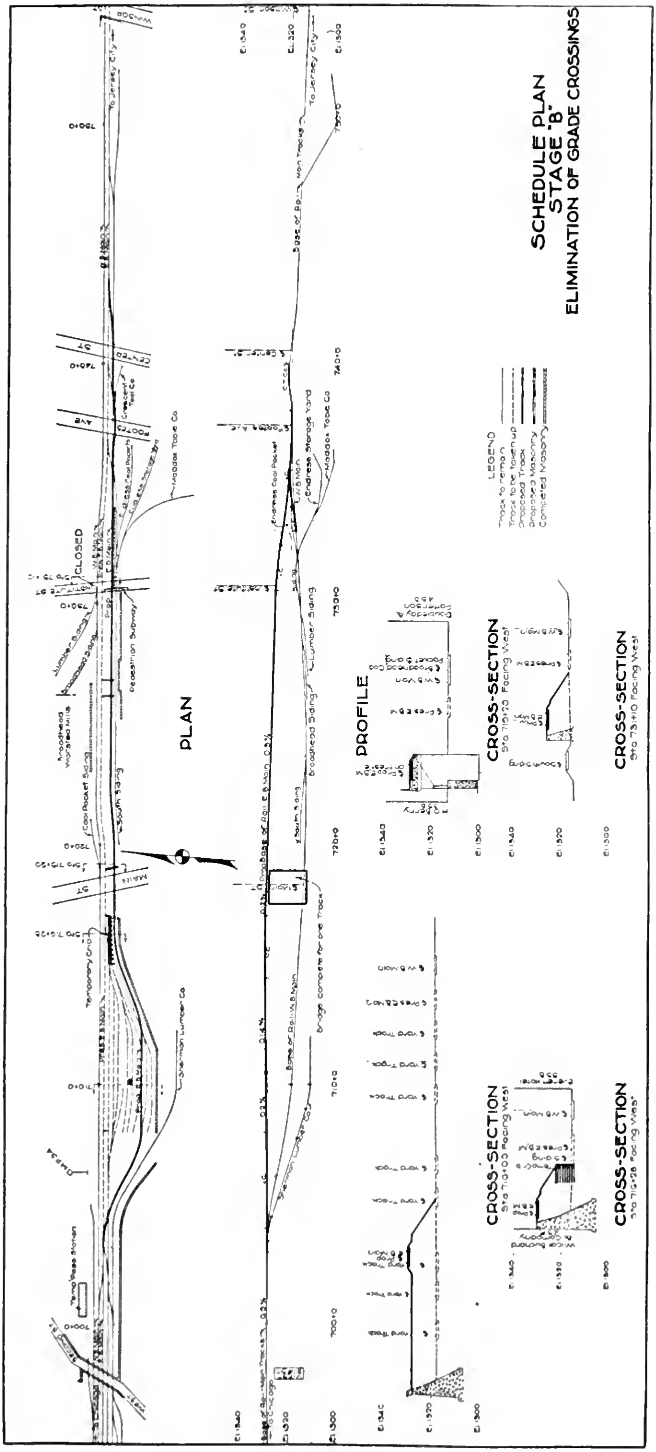
BIBLIOGRAPHY

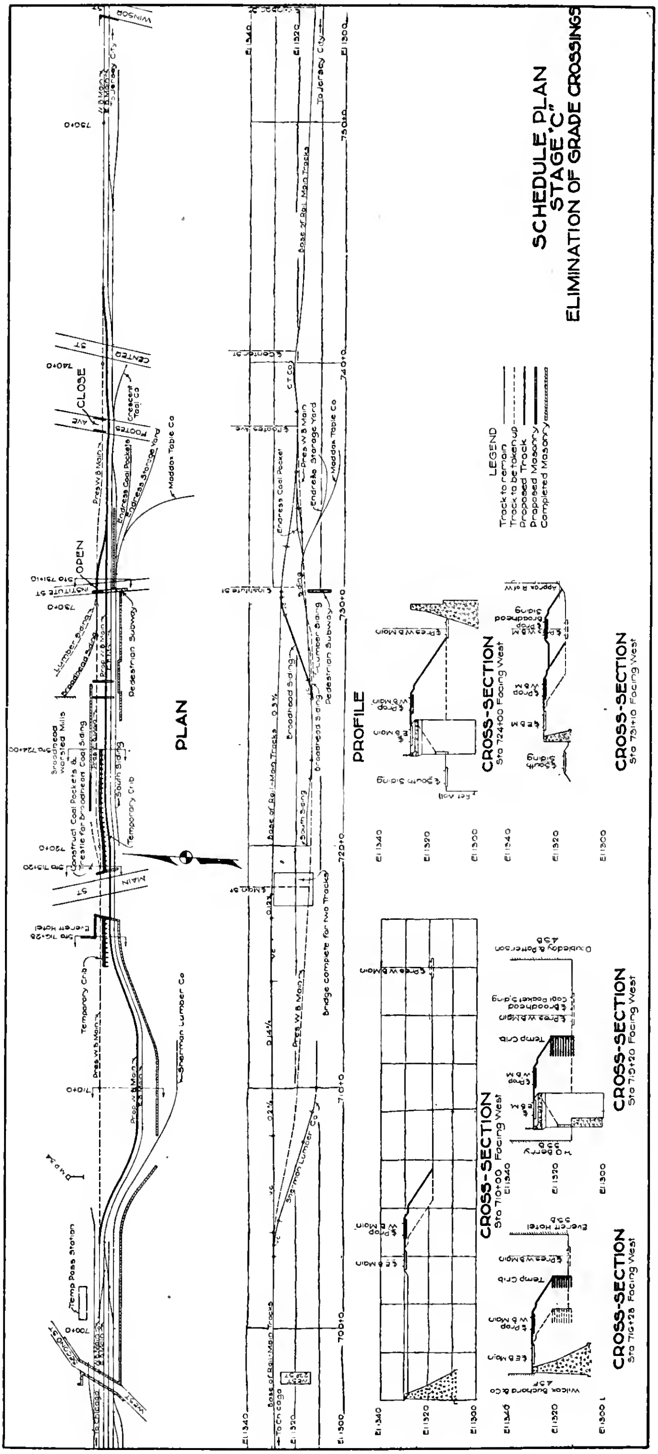
Grade Crossing Elimination.

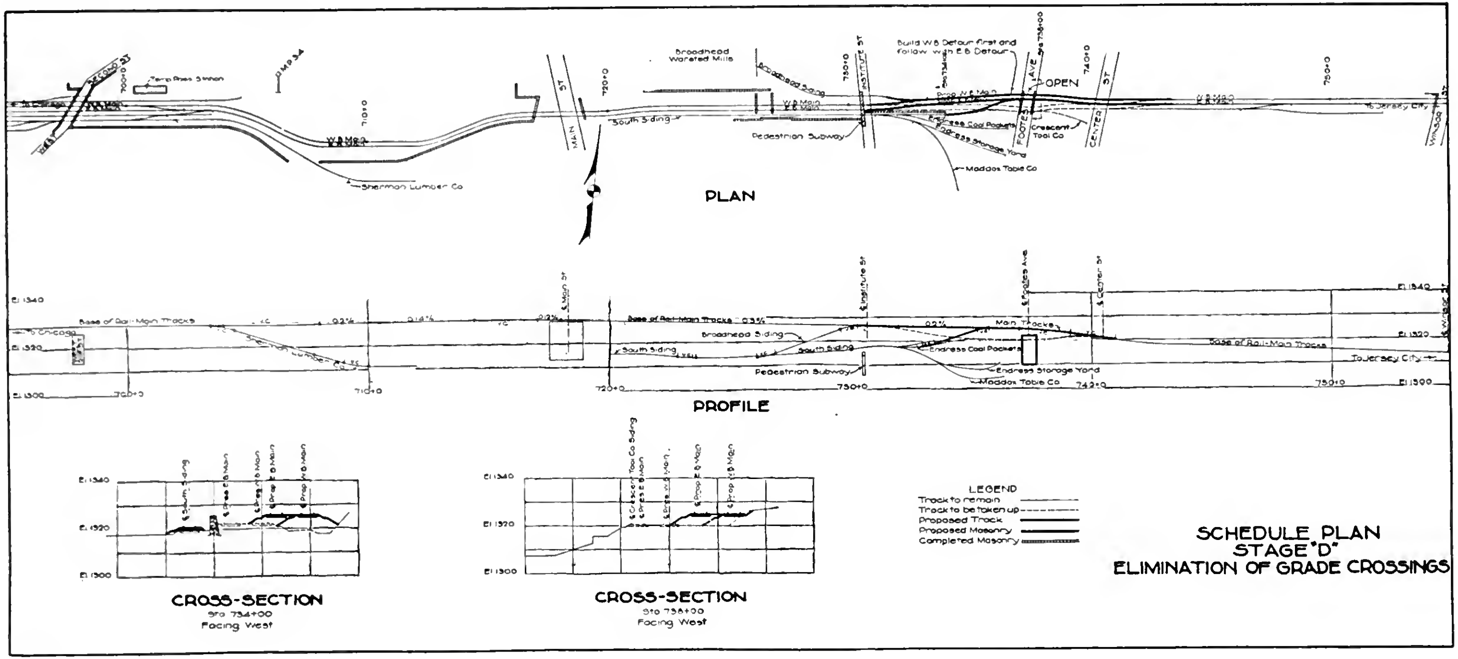
1. Apportionment of Cost.—1917 Proceedings, page 374.
2. Abolition of Grade Crossings in Massachusetts.—Paper by J. Boyles Reilly. Published in April 1915. Boston Society of Civil Engineers Journal.
3. Provisions of State laws as to over- and under-grade crossings, 1918 Proceedings, page 633.
4. Expense of Grade Crossing Elimination.—1919 Proceedings, page 88.
5. Over- and Under-Grade Crossings.—Report prepared by the Division of Grade Separation and Bridges under the direction of the Department of Public Works of Detroit. Report prepared by John W. Reid, Engineer Grade Separation, and Henry E. Riggs, Consulting Engineer.
6. Elimination of Grade Crossings.—Bibliography 1915—1920, Proceedings of 1921, page 304.
7. Elimination of Grade Crossings.—Selected Bibliography by Dagney Borge, issued by the Library Commission of the University of Wisconsin.

A

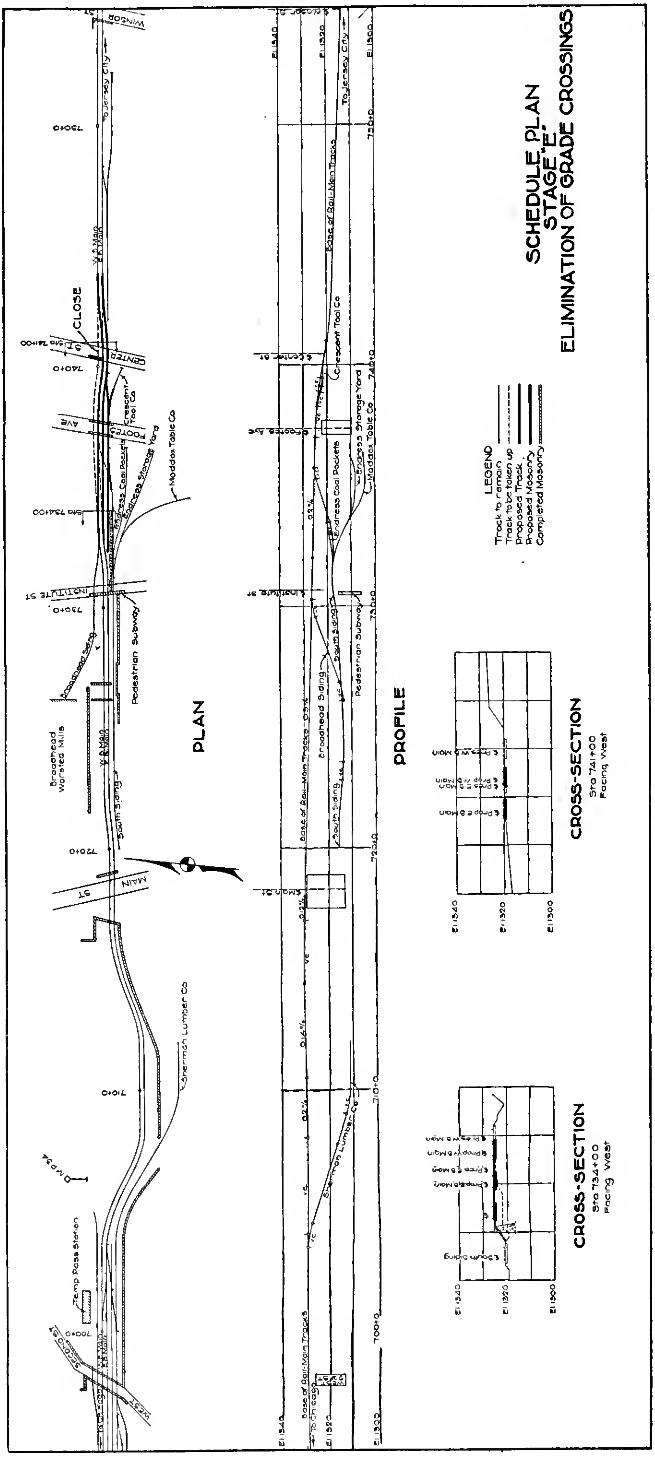

SCHEDULE PLAN
STAGE "A"
ELIMINATION OF GRADE CROSSINGS

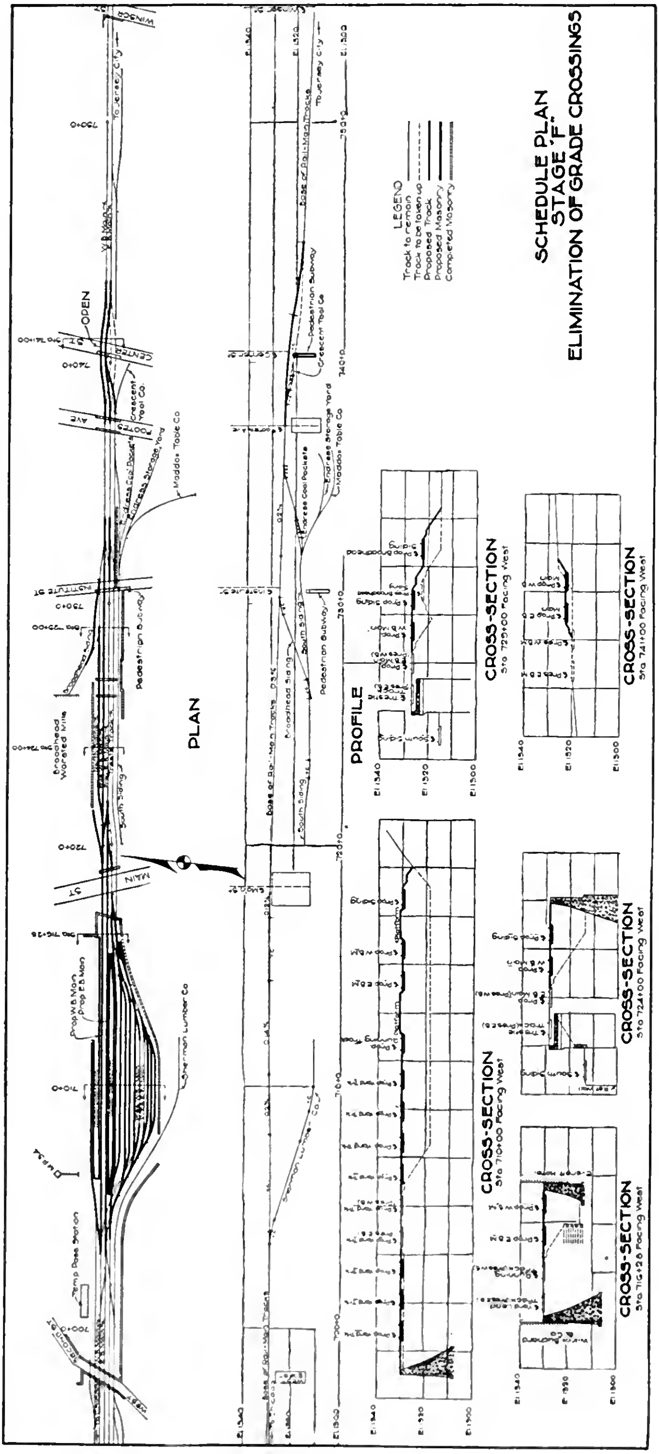

SCHEDULE PLAN
STAGE 'B'
ELIMINATION OF GRADE CROSSINGS
PLAN
PROFILE
CROSS-SECTION
Sta 710+00 Facing West
CROSS-SECTION
Sta 715+25 Facing West
CROSS-SECTION
Sta 710+50 Facing West
CROSS-SECTION
Sta 731+10 Facing West
LEGEND
Track to remain
Track to be taken up
Proposed Track
Proposed Masonry
Completed Masonry
MAIN ST
FOOTE AVE
CENTRAL ST
CLOSED
Pedestrian Subway
Lumber Siding
Broadhead Siding
Broadhead Worsted Mills
Coal Pocket Siding
South Siding
Temporary Grid
Sherman Lumber Co
Endress Coal Pocket
Endress Storage Yard
Maddox Table Co
Crescent Tool Co
To Jersey City
To Chicago
El. 1340
El. 1320
El. 1300
700+0
710+0
720+0
730+0
740+0
750+0

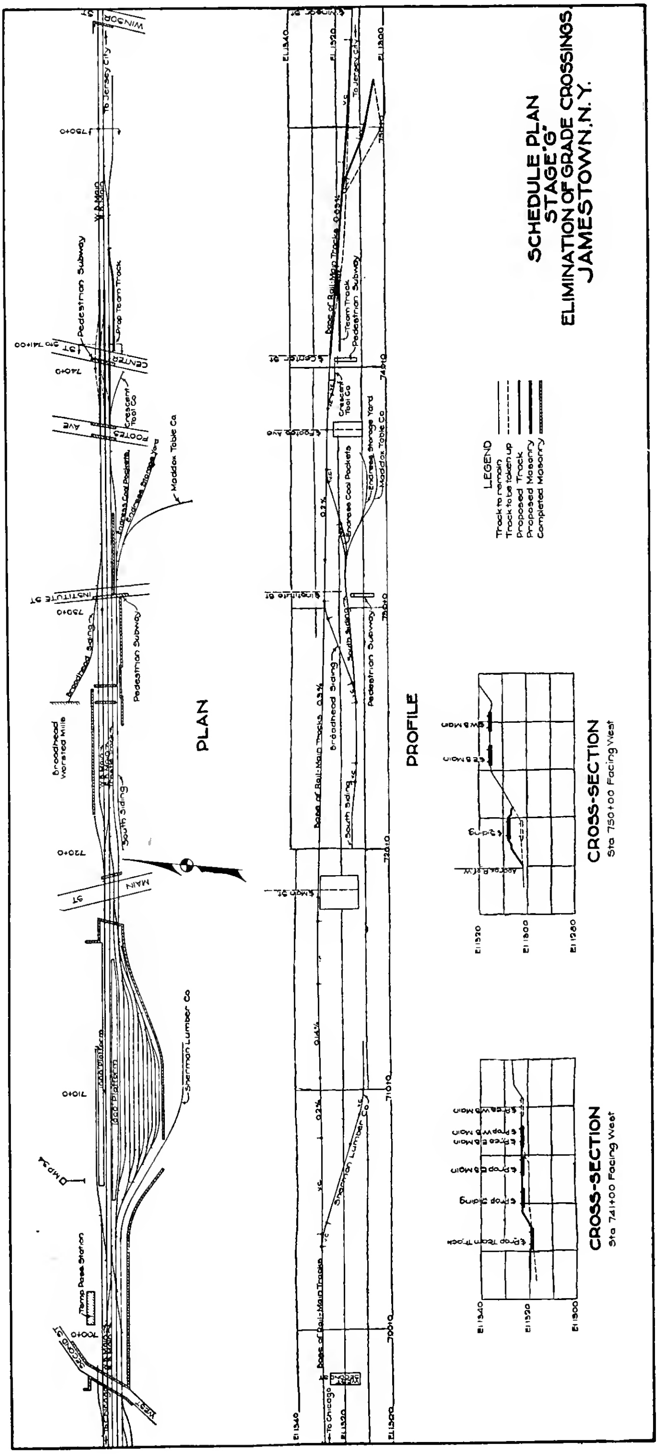

SCHEDULE PLAN
STAGE "C"
ELIMINATION OF GRADE CROSSINGS
PLAN
PROFILE
CROSS-SECTION Sta 724+00 Facing West
CROSS-SECTION Sta 731+10 Facing West
CROSS-SECTION Sta 710+00 Facing West
CROSS-SECTION Sta 719+20 Facing West
CROSS-SECTION Sta 716+28 Facing West
LEGEND
Track to remain
Track to be taken up
Proposed Track
Proposed Masonry
Completed Masonry
WINDSOR
CENTER ST
FOOTES AVE
INSTITUTE ST
MAIN ST
CLOSE
OPEN
To Jersey City
To Chicago
Temp Pass Station
Temporary Crib
Everett Hotel
Sherman Lumber Co
Pres W B Main
Prop W B Main
Lumber Siding
Broadhead Siding
Pedestrian Subway
South Siding
Temporary Crib
Broadhead Worsted Mills
Construct Coal Pockets & Trestle for Broadhead Coal Siding
Crescent Tool Co
Endress Coal Pockets
Endress Storage Yard
Maddox Table Co
Base of Rail Main Tracks
Bridge complete for two Tracks
700+0
710+0
720+0
730+0
740+0
750+0
El 1340
El 1320
El 1300



SCHEDULE PLAN
STAGE "D"
ELIMINATION OF GRADE CROSSINGS


SCHEDULE PLAN
STAGE "E"
ELIMINATION OF GRADE CROSSINGS
PLAN
PROFILE
LEGEND
Track to remain
Track to be taken up
Proposed Track
Proposed Masonry
Completed Masonry
CROSS-SECTION
Sta 741+00
Facing West
CROSS-SECTION
Sta 734+00
Facing West
WINSOR ST
CENTER ST
CLOSE
FOOTE'S AVE
INSTITUTE ST
MAIN ST
SECOND ST
WEST
To Jersey City
To Chicago
W.B. Main
E.B. Main
Crescent Tool Co
Endress Coal Pockets
Endress Storage Yard
Maddox Table Co
Pedestrian Subway
Broadhead Siding
Broadhead Worsted Mills
South Siding
Sherman Lumber Co
Temp Pass Station
Sta 734+00
Sta 741+00
700+0
710+0
720+0
730+0
740+0
750+0
Base of Rail-Main Tracks
El 1340
El 1320
El 1300
0.2%
0.16%
0.5%
Prop E B Main
Prop W B Main
Pres W B Main
Pres E B Main
South Siding


SCHEDULE PLAN
STAGE "F"
ELIMINATION OF GRADE CROSSINGS
LEGEND
Track to remain
Track to be taken up
Proposed Track
Proposed Masonry
Completed Masonry
PLAN
PROFILE
CROSS-SECTION Sta 710+00 Facing West
CROSS-SECTION Sta 716+26 Facing West
CROSS-SECTION Sta 724+00 Facing West
CROSS-SECTION Sta 729+00 Facing West
CROSS-SECTION Sta 741+00 Facing West
WINSOR ST
To Jersey City
CENTRE ST
OPEN
FOOTES AVE
INSTITUTE ST
MAIN ST
Crescent Tool Co.
Maddox Table Co
Endress Coal Pockets
Endress Storage Yard
Pedestrian Subway
Broadhead Worsted Mills
South Siding
Sherman Lumber Co
Prop W.B. Main
Prop E.B. Main
Temp Pass Station
Base of Rail-Main Tracks
El. 1340
El. 1320
El. 1300
700+0
710+0
720+0
730+0
740+0
750+0


SCHEDULE PLAN
STAGE "G"
ELIMINATION OF GRADE CROSSINGS
JAMESTOWN, N.Y.
LEGEND
Track to remain
Track to be taken up
Proposed Track
Proposed Masonry
Completed Masonry
PLAN
PROFILE
CROSS-SECTION
Sta 750+00 Facing West
CROSS-SECTION
Sta 741+00 Facing West
Winsor St
Center St
Footes Ave
Institute St
Main St
Second St
To Jersey City
To Chicago
W.B. Main
E.B. Main
Pedestrian Subway
Prop Team Track
Team Track
Crescent Tool Co
Endress Coal Pockets
Endress Storage Yard
Maddox Table Co
Broadhead Siding
Broadhead Worsted Mills
South Siding
Sherman Lumber Co
600' Platform
Temp Pass Station
Base of Rail-Main Tracks
700+0
710+0
720+0
730+0
740+0
741+00
750+0
0.2%
0.14%
El 1340
El 1320
El 1300

Appendix D

(4) IMPROVED METHODS OF PREVENTING CORROSION OF FENCE WIRE

Maro Johnson, Chairman, Sub-Committee; A. C. Mackenzie, W. H. Speirs, I. D. Waterman.

Life of Fence Wire.—Preliminary to its study of fence wire, your Committee has obtained information pertaining to the life and use of wire on thirty-eight railroads in all parts of the country. While it does not appear necessary to publish all of this information in tabular form, the following summary is offered:

The average life of wire on these roads is 16 years. The average effective life of the galvanizing on 24 of them is 10 years. The life of the wire as reported varies from about 5 years along the Gulf Coast and 6 years in mill districts, to 40 years in the desert regions of the Southwest. In general, longer life is reported on roads in the West and Central West than those along the coast or serving industrial territory. Proximity to the sea coast, coal mines, and industrial plants, nearness to the track, locations in swamps and wooded country, frequent burning of waylands, heavy snows, abuse by trespassers, and damage by live stock, are given as conditions which affect the life of the fence adversely.

One-third of the roads reporting use the Preece test for galvanizing as given in the Manual; the others order fencing by trade names and rely on the manufacturers' representations as to quality. One road reports the use of 0.15 to 0.25 of 1 per cent of copper in the steel from which the wire is drawn, and several are making tests of lead coated wire.

Tests of Fence Wire.—As part of its work for 1925 and succeeding years, your Committee contemplated some field tests of fence wire and fencing. Test fences of various grades of wire were to be put up in several locations and a check made from time to time of their condition. After some preliminary work had been done it was learned that the American Society for Testing Materials was inaugurating somewhat more extensive tests, including coated sheets and hardware, as well as wire and fencing. Under the circumstances it was felt our purposes would be fully served by keeping in touch with the A.S.T.M. tests. Through the courtesy of the Secretary of the A.S.T.M. and the Chairman of its Committee on Corrosion of Iron and Steel, J. H. Gibboney, Chief Chemist of the Norfolk & Western Railway, Committee IX now has two representatives on the A.S.T.M. Sub-Committee in charge of these tests.

Test fences are being erected at Pittsburgh; State College, Pa.; Altoona, Pa.; Sandy Hook, N. Y., and Key West, Fla. Wire with and without copper content with various weights of coating applied by several processes is to be tested. All fencing is to be attached to concrete posts, and it is hoped to have it all erected by July 1, 1926. It will be of interest to note in this connection that the Pennsylvania and New York Central Railroads have given material assistance in carrying out these tests.

Specifications for Galvanizing.—With a view to obtaining more definite specifications for galvanizing than now exist, new arrangements are being made by a committee, on which this Association is represented, under the auspices of the American Engineering Standards Committee and the sponsorship of the American Society for Testing Materials. Sub-Committees for handling the details of this work are now being formed, and it is hoped that the new specifications can be presented at the convention next year.

Appendix E

(6) THE USE OF NATURAL ROCK ASPHALT AS A SUBSTITUTE FOR PLANK IN ROAD CROSSINGS

F. D. Batchellor, Chairman, Sub-Committee; J. F. Burns, F. M. Graham,
W. O. Houston.

The subject assigned to this Sub-Committee is partly covered in the report made by Committee IX, in the Proceedings of 1922, Volume 23, page 464, it being one of the substitutes for plank crossings which were reported on at that time.

Specifications for constructing natural rock asphalt crossings were also adopted for publication in the Manual at the last annual meeting of the A.R.E.A. (See Volume 26, page 578.)

Natural rock asphalt so-called consists of sandstone or limestone rocks that have been saturated or impregnated with bituminous material, this being the residue remaining from the evaporation of petroleum formerly carried which was of paraffin or semi-paraffin base. The extent of evaporation and character of petroleum as well as the character of the rock saturated by the petroleum cause wide variation in the percentages of bituminous material found in different localities.

At the present time commercial production of natural rock asphalts for paving purposes is confined in this country to five states—Kentucky, Texas, Oklahoma, California and Alabama, named in the order of the magnitude of their respective outputs. Of the 1923 output, Kentucky produced 46 per cent, Texas 37 per cent, most of the remainder coming from Oklahoma.

Natural rock asphalts have been used for paving purposes in France, Italy and Switzerland, since early in the nineteenth century. Natural rock asphalt was imported to the United States from France as early as 1872 but has been produced in this country on a large scale only during very recent years. Its production in Kentucky was retarded by lack of adequate transportation in the vicinity of the deposits, but such production has been highly stimulated by improved river and railroad transportation and the recent tremendous increase in improved highway construction.

The process of manufacture consists of crushing the natural sandstone or limestone rock to the desired degree of fineness to permit compacting when subsequently laid and rolled. It has been found that each particle or granule of the original rock is fully coated with bitumen.

The percentage of bitumen varies widely in different quarries and even in the same quarry, so that blending is frequently necessary to produce the desired percentages. Some producers use asphalt from outside sources to bring up the percentage of bitumen to the desired amount.

Present practice indicates that the following specifications for natural rock asphalt are suitable for railroad crossings:

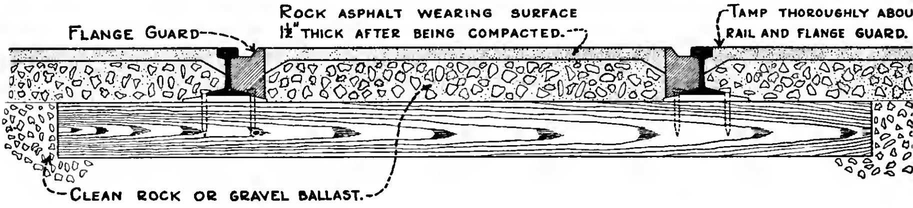
Natural Rock Asphalt.—Natural rock asphalt should contain an average of not less than six and one-half (6½) per cent nor more than nine (9) per cent of natural bitumen. Rock shall be thoroughly ground and when delivered shall contain not more than five (5) per cent of unground material; and none of the five (5) per cent of unground material shall contain pieces larger than three-fourths (¾) inch in diameter.

Test of Natural Rock Asphalt for Bitumen.—To test the natural rock asphalt for total bitumen, five (5) samples shall be taken from different parts of the car (approximately one pound in all), which shall be thoroughly mixed. From this a test sample shall be taken and weighed and the bitumen then removed by burning. The residue shall then be weighed, the difference in weight representing the total amount of bitumen.

Natural rock asphalt crossings have been used by various railroads for some time. Table "A" gives those reported.

Photographs and descriptions of typical installation at Delphos and Bradford, Ohio, on the Pennsylvania Railroad; Bedford, Ind., on the Chicago, Indianapolis & Louisville Railroad, and Louisville, Ky., on the Louisville & Nashville Railroad, are given below.

A suggested cross-section of a natural rock asphalt crossing is given below.



Suggested Rock Asphalt Crossing

Information as to the cost of natural rock asphalt crossings, gathered from different railroads, shows that the cost above top of ties and exclusive of flange guards, ranges from 13.4 cents per square foot to 35.5 cents per square foot, the majority of the crossings costing between 15.5 cents and 23.0 cents per square foot.

Cost of plank crossings, gathered in the same manner, ranges from 16.0 cents to 77.2 cents per square foot, the majority costing 35.0 cents.

Crossings placed in accordance with the specifications adopted last year (see Volume 26, page 578) should give good results, but clean gravel may be substituted where rock is mentioned in these specifications and satisfactory results obtained.

From the crossings which have been examined we believe some kind of flange guard should be used to give the best results.

In our opinion, natural rock asphalt, properly installed, will make a better highway crossing than plank for the following reasons:

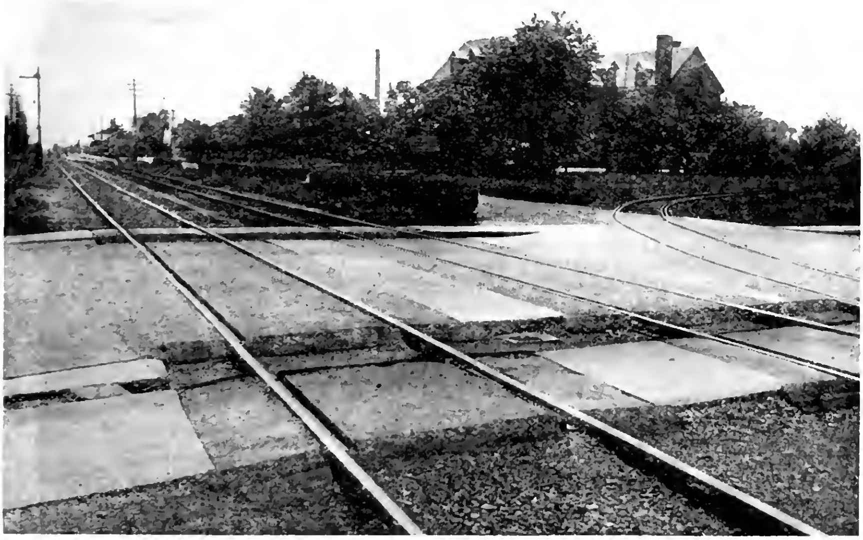
1. The first cost is less where transportation charges are not-excessive.
2. The cost of maintenance is less.
3. There is no danger of equipment being damaged from picking up plank.
4. It provides better drainage protection for tracks.
5. It does not deteriorate in stock.
6. Its use is in line with the conservation of timber.

PENNSYLVANIA RAILROAD SYSTEM

Columbus Division

Miami Avenue, Bradford, Ohio

Old ballast was removed. Ties were renewed and tie plates put on all ties. Track was ballasted with washed gravel and gravel filled in to within one inch of top of rail. 100 lb. P.S. rail was laid through this crossing. Old 85-lb. rail was used for flangeways. 1½ in. of Rock Asphalt (percentage of bitumen 7-9 per cent) was placed on top of gravel and tamped. This crossing has been in use about one year. There has been no maintenance to date and the crossing is apparently in good condition.



LOUISVILLE & NASHVILLE RAILROAD

GALT AVENUE CROSSING,

Louisville, Kentucky

Old ballast was removed and new ties inserted and thoroughly hand-tamped. C. R. S. Flangeway Guard was installed on one track and Carey Elastite Filler on the other track. Space between the rails and between the tracks was filled to within 1½ in. of the top of the rail with new ballast and thoroughly tamped with square-head tamping bars operated by pneumatic tamper. A heavy penetration oil was then sprinkled over the ballast, about 1¼ gallons to the square yard. Asphalt was then applied and it in turn thoroughly tamped with the pneumatic tamping bar.

LOUISVILLE & NASHVILLE RAILROAD

Third Street Crossing, Memphis, Tennessee

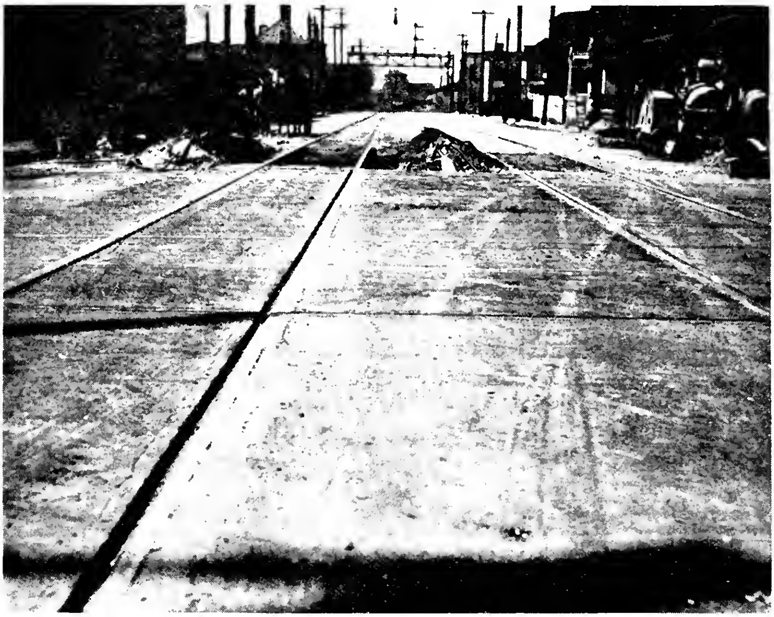
This is a crossing of eight freight tracks. City authorities permitted the street to be closed during the work. New White Oak ties were inserted and spaced 22 to 39 ft. rail, then thoroughly tamped by pneumatic

tamper. C. R. S. Flangeway Guard was applied to the rails of four tracks and Carey Elastite Filler to the rails of four tracks. The space between the rails and between the tracks was filled to within 1 in. of the top of the rail. Rock Asphalt was mixed with the ballast adjacent to the rails and the flangeway guards and fillers and the space alongside the rails and guards tamped and re-tamped with the square head tamping bars until they could make no further impression. An 8-ton steam roller was then rolled over the entire crossing. On account of sudden drop in temperature the asphalt could not be laid at the time this report was made. Before asphalt is applied, the rock asphalt surface will be sprinkled with heavy penetration oil, about 1¼ gallons to the square yard.

LOUISVILLE & NASHVILLE RAILROAD

Fourth and Gaulbert Avenue Crossing

Old ballast removed to concrete slab which is 5 in. below bottom of tie, and replaced with crushed stone, size 2 in. to ½ in. New White Oak ties put in. Rock thoroughly tamped under ties with pneumatic tamper and compressed with 4 in. square pneumatic tamps between ties to top of ties. Mixture of 1 cubic yard crushed rock and one-half gallon Headley No. 1 oil used from top of ties to within 2 in. of top of rail and 2 in. wearing coat of Rock Asphalt on top, both of these layers thoroughly compressed with the square pneumatic tamps, special attention being given to secure a good compressing along the rail and in all corners of the crossing.



PENNSYLVANIA RAILROAD SYSTEM

Main Street, Delphos, Ohio

Old ballast was removed and new crushed stone ballast and new ties put in and thoroughly tamped after the track was lined and surfaced. The flangeway rails were then placed in position and the track filled to within about 2 in. of the top of rail with stone ballast and thoroughly tamped. This was then covered with stone screenings and again tamped to shake the screenings into the voids of the stone to overcome settling as much as

possible. The crossing was then swept with a stiff broom to clean off all loose screenings, after which the Rock Asphalt was spread over the surface and raked with a garden rake until it was evenly distributed over the crossing about 1 in. above the top of rail. (Rock Asphalt compacts about one-third its thickness when loose.) Traffic was then allowed to use the crossing and a man was stationed at the crossing to rake in all the wheel tracks and add Rock Asphalt when needed until the material was thoroughly packed.

This crossing has been in service over two years, and with the exception of slight patching along the outside of rail in May, 1925, has required no maintenance. Five dollars per year will amply maintain this crossing. The life of a plank crossing in this same location is one year.

CHICAGO, INDIANAPOLIS & LOUISVILLE RAILWAY

"J" Street, Bedford, Indiana

The old ballast was removed and replaced with new crushed stone, new ties were put in where needed and new rail laid. All the track was tamped with tamping picks and bars, and after being in service a while

was surfaced and lined. Crushed stone ½ in. up to 1½ in. was then filled in within 1 in. of the top of the rail. This was then rolled with steam roller until packed solid and screenings filled in and wet down in order to give a comparatively smooth surface. Liquid asphalt was then applied along the rail to bind and seal in order to prevent the water from getting into roadbed. The old brick pavement alongside the track beyond the ties was also coated with liquid asphalt in order to act as a binder for the rock asphalt when applied, as the rock asphalt extended out over on the brick on account of the worn places in the pavement.

A 2-inch layer of Rock Asphalt was then spread over the whole and raked down before rolling so as to have an even thickness and tapered out over the brick pavement, where it came to a featheredge. The whole was then rolled with steam roller furnished by the City until it thoroughly packed. This pavement has been in service over a year and had no maintenance, but patching will be necessary this fall. Note failure next to rail, due to absence of flange-guards.

REPORT OF COMMITTEE XX—UNIFORM GENERAL CONTRACT FORMS

W. D. FAUCETTE, *Chairman;*	J. C. IRWIN, *Vice-Chairman;*
C. FRANK ALLEN,	O. K. MORGAN,
W. H. BRAMELD,	F. L. NICHOLSON,
J. B. CAROTHERS,	C. B. NIEHAUS,
CLARK DILLENBECK,	H. A. PALMER,
W. A. DUFF,	A. C. SHIELDS,
F. H. FECHTIG,	CHARLES SILLIMAN,
B. HERMAN,	E. L. TAYLOR,
F. R. JUDD,	C. A. WILSON,
J. S. LILLIE,	JOHN WORLEY,

Committee.

To the American Railway Engineering Association:

The subjects listed below were assigned to this Committee for study and report, and your Committee respectfully presents herewith the following report. In order that the result of the year's work may be read quickly, a brief outline of the work, with the action taken thereon, is presented in tabular form, as follows:

Assigned	*Action of Committee*
Revision of Manual.	No recommendations for changes.
Form of Agreement for the Purchase of Electrical Energy.	Submitted as final draft and recommended for adoption by Association.
Form of Agreement for Joint Use of Freight Station Facilities.	Submitted as final draft and recommended for adoption by Association.
Form of Agreement for Joint Use of Poles on Railway Rights-of-Way.	Submitted as final draft and recommended for adoption by Association.
Form of Agreement for Furnishing Water from Railway Water Systems to Employees and Others.	Submitted as final draft and recommended for adoption by Association.
Form of Contract for Purchase of Water.	Submitted as tentative draft for information and discussion.
Form of Maintenance Bond. Form of Agreement for Furnishing and Boarding Men.	It is the belief of your Committee that there is no occasion for the adoption of Form of Maintenance Bond or Form of Agreement for Furnishing and Boarding Men, and it is recommended that these forms be eliminated from your Committee's work.
Form of Agreement for Use of Railway Property for Public Highways.	Now under consideration.

In addition to the above work, your Committee's Chairman has been a delegate of the American Railway Engineering Association to the Joint Conference on Standard Construction Contracts, assisted by J. C. Irwin, Valuation Engineer, Boston & Albany Railroad. There have been several drafts of the proposed Standard Contract for Construction, finally resulting in a first edition, February, 1925, issued by the Joint Conference on Standard Construction Contracts. In compliance with the wishes of the American Railway Engineering Association, the name of this Association,

---

Bulletin 282, December, 1925.

together with all the other delegates, was omitted from the report. This was done on the theory that the American Railway Engineering Association did not approve or disapprove this first edition of the standard contract. The President of this Association has directed Committee XX to make a report on this first edition, and this is now under consideration by this Committee. At this meeting it is hoped that the Chairman thereof may make a report to the President of this Association.

The preamble to this first edition is printed herewith in order that members of the Association will be informed as to the basis on which it is issued (Appendix D).

Action Recommended

The report of Committee XX, as a whole, is embodied in Appendix "A," being report of Sub-Committee No. 1, J. C. Irwin, Chairman; Appendix "B," being report of Sub-Committee No. 2, Clark Dillenbeck, Chairman; and Appendix "C," being report of Sub-Committee No. 3, E. L. Taylor, Chairman.

The reports of these Sub-Committees are set forth concisely in the different appendices, and the adoption thereof, in the form presented, has been approved by your General Committee XX. These documents stand for themselves, some of which have been approved for final insertion in the Manual, and some for information and discussion. In line with the desired brevity, it is not deemed necessary to discuss the evolution of these documents in detail. It is sufficient to say that the Sub-Committees have worked diligently and with painstaking care thereon. The attendance on committee-work has been splendid.

The work of this Committee is such that its discussions cover many departments of work, and the Committee always desires criticisms and suggestions.

Recommendations for Future Work

The Committee recommends the following list from which we desire the work of next year to be selected. This list includes the unfinished work of 1925:

(1) Revision of Manual.

(2) Form of Contract for Purchase of Water.

(3) Form of Agreement for Use of Railway Property for Public Highways.

(4) Form of Construction Contract for Particular Item or Items of Work.

(5) Form of Contract for Cost-Plus Percentage Work.

For the information of anyone interested in this subject, reference is made to the following Bulletins: Nos. 242, 253, 261 and 273, which will give an historical reference to the production of some of these documents herewith presented.

Respectfully submitted,

THE COMMITTEE ON UNIFORM GENERAL CONTRACT FORMS,

By W. D. FAUCETTE, *Chairman.*

Appendix A

J. C. Irwin, Chairman, Sub-Committee; C. Frank Allen, J. B. Carothers, F. H. Fechtig, H. A. Palmer, Charles Silliman, E. L. Taylor, C. A. Wilson.

This Sub-Committee has collected data and made a study of

(1) Form of Agreement for Furnishing Water from Railway Water Stations to Employees and Others.

(2) Form of Contract for the Purchase of Water.

(3) Form of Maintenance Bond.

(4) Form of Agreement for Furnishing and Boarding Men.

(1) It recommends for adoption the following:

FORM OF AGREEMENT FOR FURNISHING WATER FROM RAILWAY WATER SYSTEMS TO EMPLOYEES AND OTHERS

This Agreement made this .... day of ...., 19..., by and between ...., a corporation organized and existing under the laws of the .... of ...., hereinafter called the Railway Company, and ...., hereinafter called the Consumer.

Witnesseth:

That in consideration of the covenants and agreements herein contained it is mutually agreed as follows:

1. The Railway Company agrees to make the connection between its water service lines and the pipe line of the Consumer at the point shown on the plan hereto attached and marked.................................... .... and hereby made a part hereof, and to provide a water meter upon the connecting line of pipe serving the Consumer.

2. The Railway Company agrees to maintain said connection and meter.

3. The Railway Company will supply water through said connection to the Consumer, not to exceed .... $\begin{array}{c}\text{gallons}\\ \text{cubic feet}\end{array}$ per day, and subject to the Railway Company's requirements.

4. The Consumer agrees to pay the Railway Company the cost of said connection and meter and of their maintenance.

5. The Consumer agrees to pay to the Railway Company for the water furnished by it at the rate of...................per $\begin{array}{l}\text{1000 gallons}\\ \text{100 cubic feet.}\end{array}$

6. Water furnished under this agreement shall be for the sole use of the Consumer and water shall not be furnished to others than the Con-

sumer through the Consumer's service line without the consent in writing of the .... of the Railway Company.

7. Bills for water furnished or other service performed by the Railway Company as herein provided shall be rendered monthly and shall be due and payable when rendered.

8. This agreement shall take effect on ...., 19...., and shall continue in force until terminated on a date specified by written notice given to either party by the other party to this agreement at least .... prior to such date of termination.

9. Upon termination, the Consumer shall pay to the Railway Company all costs of disconnecting and removing the connection between the water facilities of the Railway Company and the service line of the Consumer and all other expense incidental thereto.

10. This agreement shall not be assigned or in any manner transferred by the Consumer without the written consent of the .... of the Railway Company.

11. The Consumer agrees to indemnify the Railway Company and save it harmless from all claims and expenses that may arise or be made for loss or damage resulting to the employees or property of the Consumer or to any other persons or property, arising out of the construction, maintenance or operation of the water facilities used in furnishing water to said Consumer or the use of the water furnished, as herein provided.

12. Until terminated as hereinabove provided, this agreement shall inure to the benefit of and be binding upon the legal representatives and successors of the parties respectively.

IN WITNESS WHEREOF the parties hereto have executed this agreement the day and year first above written.

....
Railway Company

WITNESS...................

....
Consumer

WITNESS...................

(2) It submits as information and for discussion the following tentative draft:

FORM OF AGREEMENT FOR THE PURCHASE OF WATER

(Tentative Draft Submitted for Discussion)

THIS AGREEMENT, made this .... day of ...., 19..., by and between ...., a corporation organized and existing under the laws of the .... of ...., hereinafter called the Water Company, and ...., a corporation organized and existing under the laws of the .... of ...., hereinafter called the Railway Company.

WITNESSETH:

That in consideration of the covenants and agreements herein contained, it is mutually agreed as follows:

1. The Water Company agrees to supply the Railway Company with all the water it may require for..
....

at ....

2. The Railway Company agrees to pay to the Water Company, upon rendition of bills therefor, for all water consumed, at the rate of .... per $\frac{\text{1000 gallons}}{\text{100 cubic feet}}$ determined by the reading of a meter or meters to be installed and maintained by the Water Company.

3. The Water Company agrees to use its best efforts to furnish an uninterrupted supply of water to the Railway Company, but it is understood and agreed that the Water Company shall not be liable for breaks in water pipe, failure of pumping apparatus or any other causes beyond its control.

4. This agreement shall take effect as of the .... day of ...., 19...., and shall continue for .... years and thereafter until terminated by written notice given by either party to the other at least .... prior to the date of termination.

IN WITNESS WHEREOF the parties hereto have executed this agreement the day and year first above written.

....
Water Company

WITNESS...................

....
Railway Company

WITNESS...................

(3) It recommends that a proposed "Form of Maintenance Bond" be withdrawn from the Outline of Work, as investigation shows that there is no general use for such a form.

(4) It recommends that the proposed "Form of Agreement for Furnishing and Boarding Men" be withdrawn from the Outline of Work, as investigation shows that in the localities where there might be use for such a form, the State Laws and local requirements are such as would make it impractical to use a general standard form.

Appendix B

Clark Dillenbeck, Chairman, Sub-Committee; W. H. Brameld, B. Herman, J. C. Irwin, J. S. Lillie, O. K. Morgan, C. B. Niehaus.

The work assigned to this Sub-Committee was as follows:

(1) Revision of the Manual.

(2) Form of Agreement for Joint Use of Freight Station Facilities.

(3) Form of Agreement for Use of Railway Property for Public Highways.

(1) REVISION OF MANUAL

Your Sub-Committee has made careful study of the Uniform General Contract forms in the Manual, in accordance with President Fairbairn's letter of instructions of August 1st, 1925, and finds as follows:

(1) There is no matter in the Manual pertaining to Uniform General Contract Forms that should be eliminated as obsolete.

(2) It has been the policy of this Committee for many years to condense all matter as far as practicable and eliminate all needless words and verbiage. Therefore, it will not be practicable to make any further appreciable condensation of the matter to be revised.

(3) The Committee has given consideration to changes in matter that appears desirable and finds that the Form of Construction Contract should be given thorough detail study with a view of recommending revisions to bring it more fully up to present-day requirements. Also that a comprehensive study should be made of the other forms that have been adopted in the more recent years, with the view of revising paragraphs of the same meaning, but differently written in different forms, so as to have uniform standard phrases in places where there is no reason for difference. Unfortunately the Committee has been unable to complete this work and prepare recommendations before the writing of this report.

(2) FORM OF AGREEMENT FOR JOINT USE OF FREIGHT STATION FACILITIES

The "Form of Agreement for Joint Use of Freight Station Facilities" was included in last year's report of this Committee and was submitted to the Convention as a "Tentative draft for information and discussion." Requests were made for criticisms, but none have been received.

It is now submitted and attached hereto as a "Final draft submitted for approval." The Committee recommends it for adoption.

FORM OF AGREEMENT FOR JOINT USE OF FREIGHT STATION FACILITIES

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 ......"A"...... Company; and ...., a corporation organized and existing under the laws of the State of ...., hereinafter called the ......"B"...... Company.

WITNESSETH:

That, in consideration of the covenants and agreements herein contained, it is mutually agreed as follows:

Grant and Description.

1. The ....."A"..... Company hereby grants to the ....."B"..... Company the right to use, during the life of this agreement, jointly with the ......"A"...... Company and any other railway company or companies, now using or which the ......"A"...... Company may hereafter permit to use, the freight station facilities of the ......"A"...... Company at ...., in the County of .... and State of ...., described as follows:

All being substantially as shown on plan numbered................. ...., dated ...., designated as ...., signed by the ....of the respective companies, hereto attached and made a part hereof.

Scope

2. The right of joint use hereby granted contemplates and is confined to the use by the................"B"................Company of the said freight station facilities of the ...."A".............. Company for the conduct of the freight business of the ...."B"........ Company.

Employees.

3. The ...."A"............ Company shall furnish to the ...."B"............Company the joint services of the agents, clerks, telegraph operators, laborers, gatemen, watchmen and other employees of the ...."A"............ Company, whose services may be necessary for the conduct by the ...."B"............ Company of its said business at said station; and do and perform, with its own switch engines, and crews, for account of the ...."B" .... Company, such switching service over the said tracks of the ...."A"............ Company to be jointly used hereunder, as may be necessary in the premises; the ...."A"............

Company to receive cars from and make delivery of cars to the ....“B”........... Company on the interchange track hereinbefore described.

Operation and Maintenance.

4. The ....“A”........... Company shall maintain the station and appurtenances owned by it and to be jointly used hereunder; shall pay all taxes and insurances; and shall provide the necessary light, heat, water, and other accessories required for the joint use of the same; provided, however, that the ....“B”........... Company shall, at its own cost and expense, provide and furnish all stationery and printed forms which may be necessary for the conduct of its business.

Rental.

5. The ....“B”........... Company shall pay to the ....“A”........... Company, in monthly settlement, for the privilege of using said freight station facilities and for the service performed by it for the ....“B”........... Company, the following sums of money:

FOR SWITCHING

The sum of .... dollars for each and every loaded car switched by the ....“A”............. Company for the ....“B”........... Company hereunder, as aforesaid; it being understood that no charge will be made by the ....“A”.......... Company for switching empty cars hereunder, in either direction, provided they go into or come out of said facilities loaded.

FOR JOINT USE OF SAID FREIGHT HOUSE, PLATFORMS, TRACKS, ETC.

(a) Such proportion of the interest at the rate of ....% per annum upon the value of the said facilities, which for the purpose of this agreement is hereby agreed to be the sum of ...., as the number of tons of freight handled through said freight house and or over said platform by or for the account of the ....“B” .... Company, shall bear to the total number of tons of freight handled through said freight house and or over said platform, during such period.

(b) Such proportion of the expense incurred for the maintenance of said facilities, and properly chargeable under the current rules, regulations and classification of the Interstate Commerce Commission to maintenance expense, as the number of tons of freight handled through said freight house and or over said platform by or for the account of the ....“B”........... Company, shall bear to the total number of tons of freight handled through said freight house and or over said platform, during such period.

(c) Such proportion of the salaries or wages paid by ....“A” .... Company to the agent, clerks, telegraph operators, laborers, gatemen, watchmen and all other employes engaged in joint service, as the number of tons of freight handled through said freight house and or over said platform, by or for the account of the ...."B" .... Company, shall bear to the total number of tons of freight handled through said freight house and or over said platform, during such period.

(d) Such proportion of the cost of taxes and insurance, light, heat, water, telephone service and other accessories for joint use, as the number of tons of freight handled through said freight house and or over said platform, by or for the account of the ...."B"............ Company, shall bear to the total number of tons of freight handled through said freight house and or over said platform, during such period.

Bills made under paragraphs (b) and (c) of this Article will include, 10% of the cost of labor, for supervision and use of tools, and 15% of the cost of material for freight and handling.

Bills shall be rendered monthly and shall be paid within 30 days thereafter.

(See Appendix.)

Additions and Betterments.

6. In the event that any additions to, or betterments or improvements of, the facilities of the ...."A"............ Company to be jointly used by the ...."B"............ Company hereunder, shall, at any time hereafter and during the life of this agreement, in the judgment of the ...."A"............ Company, be deemed to be necessary for the joint use of the parties hereto, then and in such event, the ...."A"............ Company may, in its discretion, and without the concurrence of the ...."B"............ Company, make and construct the same, and thereafter the ...."B".......... Company shall pay additional rent for the joint use of said additions, betterments or improvements, and its additional proportion of the maintenance and operation of the same, on the basis provided in Article 5 of this agreement.

Custody of Property.

7. Cars delivered to the ......"A"...... Company by the ......"B"...... Company to be switched hereunder as aforesaid, shall not be deemed to have been regularly interchanged to the ......"A"...... Company, but the same shall remain in the records, and be considered as being in the possession of the ......"B"...... Company, and any car furnished by the ......"A"...... Company for loading on account of the ......"B"...... Company when cars of the ......"B"...... Company are not available, shall be considered as being in possession of the ......"B"...... Company beginning with the day it is placed for such loading. The ......"B"...... Company shall assume and pay its own

per diem and other expenses, and collect its own demurrage and other charges on such cars.

All cars of the ......"B"...... Company and the contents thereof, while upon the said tracks of the ......"A".... Company, as well as all freights held by or for account of the ......"B"...... Company in, upon or about the said freight house, platforms or other terminal facilities of the ......"A"...... Company so to be jointly used hereunder, as aforesaid, shall, for the purposes of this agreement, be deemed and considered to be under the control and in the custody and care of the ......"B"...... Company and the ......"B"...... Company shall carry its own insurance upon the same.

Movement of Cars.

8. The ......"A"...... Company shall provide for the movement of the freight cars of the ......"B"...... Company over its tracks as nearly as may be practicable in accordance with the wishes of the ......"B"...... Company, and shall exercise in the handling of such cars the same degree of care that it exercises in the handling of its own cars.

Deprivation of Use.

9. In case the ......"B"...... Company shall by reason of fire or other unavoidable casualty be deprived of the use of said facilities or any part thereof, a reduction of said rental shall be made to it for the time during which said deprivation shall continue, proportionate to the amount of said deprivation.

Equipment.

10. All cars delivered by the ......"B"...... Company to the ......"A"...... Company for operation over the tracks of the ......"A"...... Company hereunder, as aforesaid, shall be fully equipped with the appliances provided for in the so-called Federal Safety Appliance Acts, or in any other acts or statutes, Federal or State; it being understood that the ......"B"...... Company shall be solely responsible for the consequences of the failure on its part to so equip said cars, and that the ......"A"...... Company may refuse to receive or handle any cars of the ......"B"...... Company which may not be so equipped.

Status of Employees.

11. All employees of the ......"A"...... Company, whose services are necessary and required for the joint use of the parties hereto in the operation and maintenance for joint account of the freight station facilities of the ......"A"...... Company, shall, for the purpose of this agreement, be considered to be sole employees, in the performance, of, or omission to perform, services, the benefit or other result of which accrues to either party hereto, solely; and as joint employees, in the performance of, or omission to perform, services, the benefit or other result of which accrues to both parties hereto jointly.

Liability.

12. Liability for all loss of or damage to property and injury to or death of persons (all hereinafter collectively referred to as damage), in any manner originating or occurring upon or in connection with the operation of the property and facilities covered by this agreement, shall be governed by the following provisions:

Each party hereto shall be liable for all damage which shall be caused in any manner by or in connection with its business or traffic, when the business or traffic of the other party are in nowise involved.

Each party hereto shall be liable for all damage which shall be caused solely:

(a) By defect in its sole property or property separately used by it.

(b) By act or by the negligence of its separate employees.

Otherwise, each party shall be liable for all damage to its separate property, employees or traffic.

All other damage and costs and expenses in connection therewith, including those resulting from undetermined causes, shall be borne equally by the parties hereto.

Each party shall adjust the claims of its own employees. No settlement for which the other party is to be held wholly responsible, and no settlement in excess of Five Hundred Dollars ($500.00), for which the other party is to be held jointly responsible, shall be made without its concurrence.

In event of any suit being brought against either party hereto, for which the other party may be held liable, the party against whom such suit is brought shall at once give the other party notice in writing thereof in order that the other party may make such defense as it may deem proper, and in such case the party that is liable as herein provided shall pay all attorneys' fees, costs and expenses incurred in defending such suit, as well as damages that may be recovered therein.

Default.

13. If the ......"B"...... Company shall make default in any of the payments hereinbefore required of it to be made, or shall fail to faithfully perform any of the covenants herein required by it to be performed, then in such case, and if such default or failure shall continue for a period of .... (....) days after the ......"A"...... Company shall have given the ......"B"...... Company a written notice thereof, the ......"A"...... Company may, by a .... (....) days' notice in writing to the ......"B"...... Company declare this agreement terminated, and may at the termination of the said .... (....) days in said notice mentioned, exclude the ......"B"...... Company from the use and enjoyment of any and all of the premises and rights hereinbefore granted to it and the ......"B"...... Company shall

surrender to the ......"A"...... Company all of said premises, and shall have no claim or demand upon it by suit at law or otherwise, on account of such exclusion. Provided, that failure to make any payment or perform any covenant which is the subject of arbitration or of litigation between the parties hereto, shall not pending arbitration or litigation, be deemed a cause of forfeiture hereunder.

The ......"A"...... Company may waive any such default or failure, but no action of the ......"A"...... Company in waiving such default or failure shall extend to, or be taken to affect any subsequent default or failure, or impair its rights.

Arbitration.

14. 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.

The expense of arbitration shall be apportioned between the parties hereto, or wholly borne by either party, as may be determined by the arbitrator.

Term.

15. This agreement shall take effect on the .... day of ...., 19...., and, unless earlier terminated as hereinbefore prescribed, shall continue in force for the period of .... years from said date and thereafter until terminated on a date specified by a written notice given to either party by the other party at least .... prior to such date of termination.

This agreement shall inure to the benefit of and be binding upon the parties hereto, their successors and assigns.

In Witness Whereof, the parties hereto have executed this agreement, the day and year herein first above written.

The .... Company
By Seal
....A...
President Company
Attest:
....
Secretary

The .... Company
By Seal
....B...
President Company
Attest:
....
Secretary

Appendix.

Under section (3) ......"B"...... Company may have separate agents, etc.

Section (5) may be written in various ways, depending on conditions and the agreement of the parties. The following are suggestions for alternates:

1. For one or more paragraphs of this section:
   A flat sum .... Dollars.
2. For paragraph (a):
   One-half of the interest at .... per cent of the value of such facilities, which for the purpose of this agreement shall be taken at $...................

Should any other railway company or companies be granted by ......"A"...... Company to joint use of the aforesaid freight station facilities, then in that event the interest to be paid by ......"B"...... Company shall be that proportion which it bears to the total number of companies using the joint facilities.

3. A charge for depreciation and obsolescence may be made at the option of the parties.

(3) FORM OF AGREEMENT FOR USE OF RAILWAY PROPERTY FOR PUBLIC HIGHWAYS

The Committee has given this matter considerable study and has prepared a tentative form of agreement, which leads to discussions of many complications, more especially as applied to the construction of permanent State highways. The question arises as to whether a Railway Company can, in justice to its bondholders, grant such use of its right-of-way, and, if so granted, will they be able to get possession at some time in the future when the right-of-way may be needed for railway purposes. Then, too, can a State Highway Commission consistently construct a permanent highway on an easement grant, and then tear it up in the future and construct it elsewhere.

The political organization in charge of State highway construction varies in different states, as well as the laws. Various modifications will also be necessary in case a City, County, Borough, Town, Township or other political division of a State desires to construct a highway or road on a Railway Company's right-of-way or property.

In view of these and many other complications the Committee is not ready to submit a tentative form for publication and recommends that this subject be continued.

Appendix C

(2) FORM OF AGREEMENT FOR PURCHASE OF ELECTRICAL ENERGY

(4) FORM OF AGREEMENT FOR JOINT USE OF POLES ON RAILWAY RIGHTS-OF-WAY

E. L. Taylor, Chairman, Sub-Committee; W. H. Brameld, W. A. Duff, F. R. Judd, C. B. Niehaus, F. L. Nicholson, H. A. Palmer, A. C. Shields, John Worley.

Form of Agreement for Purchase of Electrical Energy appearing in Bulletin 273, page 509, is recommended for adoption with the following changes:

Under the title add the following note:

> Note.—This Form of Agreement is not intended to be used in connection with purchase of a large volume of electrical energy for traction purposes.

The opening paragraph to be changed so the verbiage will be consistent with other forms of agreement.

The revised form to read as follows:

FORM OF AGREEMENT FOR PURCHASE OF ELECTRICAL ENERGY

> Note.—This Form of Agreement is not intended to be used in connection with purchase of a large volume of electrical energy for 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 .... hereinafter called the Electric Company.

Witnesseth:

1. The Electric Company agrees to sell and deliver to the Railway Company electrical energy for the Railway Company's requirements for power and lighting at .... during the continuance of this agreement up to .... K.W. demand, as hereinafter provided.

2. The electrical energy supplied under this agreement shall be in the form of .... phase alternating current of .... cycles and .... volts, direct current of .... volts and shall be measured on the .... side of the .... Company's transformers.

3. The frequency and voltage at points of delivery shall be subject to the ordinary fluctuations incidental to the usual practice in generation and transmission of electrical energy, but the fluctuations incidental to the usual practice in generation and transmission of electrical energy shall not,

except under unusual circumstances, beyond immediate control, exceed a maximum variation for

> alternating current of .... cycles above or below .... cycles and of .... volts above or below .... volts.
>
> direct current of .... volts, above or below .... volts.

4. The Railway Company shall have the right to use electrical energy for lighting purposes up to .... per cent of the total connected power load.

5. The Electric Company agrees to have at all times a reserve capacity of equipment sufficient to insure continuity of supply of electrical energy up to the limit of the prevailing maximum demand of the Railway Company, against all reasonably possible failures of power generating, transmitting or converting equipment.

6. The Railway Company shall pay to the Electric Company monthly upon rendition of bills for electrical energy under this agreement:

> (a) a net fixed primary charge at the rate of .... per calendar year per K.W. of yearly maximum demand as determined by the indication of a standard instrument recording the highest average monthly demand in K.W., which demand shall be the average of the four highest demands, demand being defined as the greatest amount of power in K.W., taken simultaneously at the several points of measurement during any consecutive ...... minute period of any day of 24 hours.
>
> (b) a secondary charge of .... per K.W.H. for all electrical energy consumed, on the basis of readings of a meter or meters.

The type of measuring instruments and their location shall be mutually agreed upon and they shall be furnished by the Electric Company and installed at its expense.

The Railway Company agrees to maintain, at all times, a power factor of not less than ...... per cent. If the power factor of the Railway Company's load is less than ...... per cent, then the words "kilovolt-ampere-hours" shall be substituted for "K.W.H." in Section 6 (b); and in consideration of this penalty, if the Railway Company maintains the power factor above ...... per cent, then the Electric Company agrees to allow a discount of ...... per cent for each 1 per cent that the power factor of the Railway Company's load is above ...... per cent.

In event the Electric Company supplies electrical energy to any consumer under conditions similar to and at rates lower than those herein provided, the Electric Company agrees to charge the Railway Company such lower rates in lieu of the rates provided for herein.

A

7. It is further agreed that the prices to be paid to the Electric Company under Section 6 for electrical energy consumed by the Railway Company are based upon cost of coal oil delivered f.o.b. alongside .... of .... per ton barrel of .... pounds. gallons. If at any time during the continuance of this agreement the cost of coal oil as aforesaid is increased or decreased, the Railway Company shall pay to the Electric Company, after such increase or decrease, an additional or lesser amount for the electrical energy consumed hereunder equal to ...... mills per K.W.H. for each ...... cents of such increased or decreased coal oil cost, respectively.

8. If 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, the Railway Company is prevented, in whole or in part, from making use of the electrical energy to be supplied hereunder, or the Electric Company is unable to supply such electrical energy, then the minimum charge to the Railway Company shall be reduced in proportion to the inability of the parties to perform their respective obligations hereunder.

9. All meters shall be furnished and maintained by the Electric Company and shall be tested by approved methods by the Electric Company at its own expense during the months of .... and ...., and the Electric Company shall, where necessary, adjust or replace defective meters. The Electric Company shall give to the Railway Company at least .... days' notice when each test is to be made and representatives of both parties shall 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 2 per cent, either above or below normal, then correction in the readings of such meter shall be made for one-half of the inaccuracy found, provided the error is less than 10 per cent, and if the error is more than 10 per cent the electrical energy consumed shall be estimated by agreement between the parties, but no such correction shall be made in excess of 30 days prior to the date of the test and in no case prior to the date of the last prior test.

10. Bills shall be rendered and payable monthly and shall be subject to a ...... per cent discount if paid within .... days after rendition.

11. It is further agreed that the .... Company shall operate switches connecting the Railway Company's apparatus with the Electric Company's lines.

12. The Railway Company shall use reasonable care to prevent anyone other than the authorized employees of the Electric Company from interfering with meters or other appliances of the Electric Company.

13. 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. The expense of arbitration shall be apportioned between the parties hereto or wholly borne by either party as may be determined by the arbitrator.

14. The Electric 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 Electric Company's equipment, and, on the termination of this agreement, for the purpose of removing its property.

15. 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.

16. 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 the day and year first above written.

The .... Company

By...............................

President

(Seal Electric Company)

Witness.......................

Attest.............................

Secretary

Witness.......................

The .... Company

By...............................

President

(Seal Railway Company)

Witness.......................

Attest.............................

Secretary

Witness.......................

The Committee recommends for adoption Form of Agreement for Joint Use of Poles on Railway Right-of-Way appearing in Bulletin 273, page 512, changed at the end of Section 8, so it will read as follows:

> "in case of termination hereof by the Railway Company by notice as provided in Section 13 hereof prior to the date to which rent shall have been paid."

The revised form to read as follows:

FORM OF AGREEMENT FOR JOINT USE OF POLES ON RAILWAY RIGHTS-OF-WAY

NOTE.—This Form of Agreement is not intended to be used as a general agreement with a telegraph company operating on the lines of a railway company.

MEMORANDUM OF AGREEMENT made this ...... day of ...., 19..., between the .... Railway Company (hereinafter called the Railway Company) and the .... Company, a corporation existing under the laws of the State of .... (hereinafter called the Wire Company), for the joint use by the parties of certain poles between .... and .... in ....

In consideration of the mutual promises herein contained, the parties hereby agree as follows:

1. It is agreed that the location of all the joint poles and joint use thereof by the parties shall be as set forth in Schedule A, in accordance with plan No. ...., dated ...., designated as ...., hereto attached and made a part hereof.

2. The proportinate interest of each of the parties in the poles and the proportion of the cost of construction and maintenance to be borne by each party shall be as set forth in Schedule A.

3. The available space on each of the said poles shall be occupied by the parties hereto in the manner shown on said plan.

4. Details of construction of said poles and the wires and fixtures thereto attached and the character and voltage of electric currents employed shall be governed by specifications No.......

5. Except in case of emergency no relocation or replacement shall be made of any joint pole except upon due written notice given by the party responsible for its maintenance to the other party occupying such pole. In emergency cases verbal notice shall be immediately given and confirmed in writing as soon as practicable.

6. Each party shall, at its own expense, place and maintain its cross-arms, fixtures and wires and shall be responsible for the electric currents employed by it in the conduct of its business, for loss of or damage to property (including poles, wires and fixtures maintained under this agreement) and for injury to or death of persons due solely to the act or neglect of such party. Each party shall pay its fair proportion of any such loss of or damage to property or injury to or death of persons due in part to its act or neglect and in part to the act or neglect of the other party. In event the parties hereto cannot agree upon the fair proportion to be borne in any such case the question shall be referred to arbitration. Each party shall take reasonable precaution to prevent interference of its wires on said poles, or of its system, with the system or services of the other party.

7. The poles included herein shall be in the custody of and maintained by the party hereto indicated in said Schedule A, and the other party occupying such poles shall pay the proportion specified in said Schedule A of the expense of maintenance.

8. The Wire Company shall pay to the Railway Company as rent for the use of the latter's property and right-of-way the sum of $........ per pole per year on the .... day of every .... during the continuance of this agreement (and pro rata for a shorter period), a proportionate part of said rent to be refunded to the Wire Company in case of termination hereof by the Railway Company by notice, as provided in Section 14 hereof, prior to the date to which rent shall have been paid.

9. In event a pole tax or other similar charge is assessed by state or municipal authority upon said poles, or poles erected in renewal thereof, the same shall be treated as a maintenance expense.

10. Each party shall pay all taxes assessed against its crossarms, fixtures and wires or against its property or rights.

11. The net expense of construction or maintenance caused by a change of any pole with respect to size, character, location or otherwise, solely for the benefit of one of the parties shall be borne solely by such party and it shall have sole use of any additional space thus obtained, but if any such change is for the benefit of both of the parties the net expense thereof shall be borne by the parties in proportion to their respective benefit, and each shall have its fair share of the use of any additional space so obtained.

12. The party maintaining any pole or poles may with the consent of the other party hereto occupying said pole or poles, license the use of such poles by other parties, and a duplicate of each such license shall be filed with the other party hereto. All such licenses shall specify the terms and conditions governing such use. In case revenue is derived from the use of any pole or poles in such a license, the party granting the license shall collect such revenue and shall pay to the other party hereto its proportionate share thereof.

13. If one of the parties hereto desires to discontinue the use of any pole jointly owned hereunder, it shall give to the other party written notice of its intention so to do; and shall, within 90 days, remove its wires and fixtures and transfer all its interest in said pole to the other party if the other party desires to continue its use. It shall thereupon be paid its fair proportion of the original cost of the pole, less depreciation, and shall be released from all liability hereunder in connection with said pole except liabilities theretofore incurred. If such wires and fixtures are not so removed the other party hereto may at the expiration of said 90 days remove the same from such pole without being deemed guilty of trespass, injury or damage to the party discontinuing use of such pole, or its property or rights, and may collect all expense incurred in connection with making such removal.

14. This agreement shall take effect as of the .... day of ...., 19..., and shall continue until terminated by written notice given by either party to the other at least ...... days prior to the date of termination.

15. In event use of said poles is to be discontinued by both parties hereof, upon termination hereof each party shall at its own expense remove its crossarms, fixtures and wires from said poles and said poles shall be removed by the party responsible for the cost and maintenance thereof as indicated in said Schedule A and the net cost of removal of said poles shall be borne by the parties in the proportions applying to the cost of construction and maintenance as set forth in said Schedule A.

In Witness Whereof the parties have executed this agreement the day and year first above written.

The........................Company

By.................................

President.

(Seal Railway Company)

Witness.........................

Attest...............................

Secretary

Witness.........................

The........................Company

By.................................

President.

(Seal Wire Company)

Witness.........................

Attest...............................

Secretary

Witness.........................

Appendix D

FOREWORD

AS IT APPEARED IN THE FIRST DRAFT EDITION, STANDARD CONTRACT, OF FEBRUARY, 1925

"As a result of its first two and a half years of work, the Joint Conference, in 1924, submitted to the various national engineering and contracting associations for consideration a tentative standard contract for engineering construction. Through this document, designed as the third tentative draft, discussion was stimulated and opinion crystallized so that the best practice could be formulated.

"Criticism and comments obtained from individuals and associations with respect to the form submitted have necessarily been to some extent hypothetical, as certain principles, incorporated in it, though generally used in building contracts, are not commonly found in engineering practice. The Conference feels that this criticism and comment should be supplemented by conclusions based upon actual test of the principles. With this idea in mind, it has issued the accompanying First Edition of the Engineering Contract, with such modifications as its deliberations during the past year have shown to be advisable.

"The First Edition is issued by the Conference as an independent body and has not yet been approved by the member associations. Through actual use of this document, which it is hoped the engineering profession will encourage, there will be gained definite knowledge of its serviceability, and such defects as it may contain. This experience, together with the recommendations of the various national organizations, will in due course permit the issuance of revised editions."

REPORT OF COMMITTEE VIII—MASONRY

C. C. Westfall, *Chairman;*
J. T. Andrews,
G. E. Boyd,
T. L. Condron,
J. L. Harrington,
L. H. Hornsby,
A. N. Laird,
H. C. Libby,
R. E. Miller,
F. E. Schall,
A. W. Smith,

Job Tuthill, *Vice-Chairman;*
R. Armour,
H. M. Brown,
B. W. Guppy,
M. Hirschthal,
W. S. Lacher,
J. A. Lahmer,
J. L. Miller,
C. P. Richardson,
L. W. Skov,
G. E. Tebbetts,
J. J. Yates,

Committee.

To the American Railway Engineering Association:

Your Committee respectfully presents herewith its report covering

The Report of the Joint Committee on Standard Specifications for Concrete and Reinforced Concrete.

No report is offered on the other subjects assigned to the Committee.

Action Recommended

1. That this report on the Report of the Joint Committee on Standard Specifications for Concrete and Reinforced Concrete be accepted as information.

2. That copy of this report be transmitted through the proper channels to the Joint Committee on Standard Specifications for Concrete and Reinforced Concrete.

Recommendations for Future Work

1. Revision of the Manual.

2. Principles of design of concrete, plain and reinforced, for use in railroad structures.

3. Developments in the art of making concrete.

4. Keep in touch with the action of the Joint Committee on Standard Specifications for Concrete and Reinforced Concrete and report such to the Association.

5. Prepare specifications for foundation work, including excavation, cofferdams, piling, etc.

6. Outline of work for the ensuing year.

Respectfully submitted,

The Committee on Masonry,

C. C. Westfall, *Chairman.*

Bulletin 282, December, 1925.

Appendix A

REPORT ON THE REPORT OF THE JOINT COMMITTEE ON STANDARD SPECIFICATIONS FOR CONCRETE AND REINFORCED CONCRETE

As It Appears in Bulletin 269, September, 1924

Reviewed and Reported by the Masonry Committee Operating as a Whole

As outlined to the Association previously in reports of the Masonry Committee, the Joint Committee on Standard Specifications for Concrete and Reinforced Concrete is composed of five members from each of the following:

American Railway Engineering Association
American Society of Civil Engineers
American Society for Testing Materials
American Concrete Institute
Portland Cement Association

The Committee was organized on February 11, 1920. On June 4, 1921, tentative specifications were submitted to the constituent organizations and under date of August 14, 1924, the present report was submitted to the constituent organizations.

These specifications are, no doubt, familiar to those members who are interested in this subject. They have been presented to the different engineering bodies, the members of which have from time to time presented criticisms, but in general, these criticisms have been in the form of papers by individuals, which to many carried the impression of personal prejudice which to some extent served to offset the value of the criticism.

The Masonry Committee was charged with the review of the report, this review being presented herewith. The Committee has not attempted in its report to comment upon every part of the Joint Committee's specifications, but has called attention to those sections wherein the Committee differs with the specifications.

The Masonry Committee feels that the Joint Committee has presented a worthy report, which in many ways constitutes an advance in concrete practice. It feels, however, that in some instances the specifications call for departures from established practice which are not fully warranted by our present knowledge and for which adequate supporting data have not been presented. It recommends to the members of the Association, therefore, that in making use of the Joint Committee's specifications, they give consideration to the modifications herein presented.

In general, definite recommendations are made, but in the case of the sections on "Design," referring to Flat Slabs and Columns, the Committee does not endorse the theories presented in the Joint Committee specifications, but has no alternate recommendations to offer at this time. There are presented, however, as information, discussions by individual members of the Masonry Committee.

The Committee is not at the present time ready to present complete specifications paralleling the specifications of the Joint Committee, the present report being submitted for the guidance of the Association members in the use of the Joint Committee specifications.

The detailed discussion follows.

The Committee recommends that a footnote be appended to the title of the specifications to the effect that these specifications apply to concrete manufactured of "Portland Cement."

Definitions

ENGINEER—The Committee recommends the definition of "Engineer" should read: "The engineer in responsible charge of the work *for the owner.*"

"SLUMP"—The Committee recommends the substitution of the word "Subsidence" for *"Shortening,"* the definition to read: "SLUMP—The subsidence of a standard test mass of freshly mixed concrete used as a measure of workability in accordance with the standard method."

Paragraph 13: The Committee recommends that "Slag" described in the A.R.E.A. specifications be included in coarse aggregate permitted in the use of concrete.

Paragraph 21: METAL REINFORCEMENT—The present specifications of the A.R.E.A. do not permit twisted bars and do not permit rail steel bars. The Committee recommends that the A.R.E.A. specifications be followed.

Paragraph 28: The Committee recommends that Table 4 in paragraph 28 and the footnotes appended thereto should be changed as follows:

The words "Proportions by Volume" changed to read "Proportions by Volume, Weight."

The heading "Concrete Strength Assumed as Basis for Design, per square inch at 28 days" changed to read: "Desired Strength, pounds per square inch at 28 days."

Footnote "a"—Change the word "required" strength to "desired" strength.

Omit all of the second and third sentences in footnote "a," reading: "Where this is impracticable, Appendix 16 may be used as a guide. Appendix 16 is based on volumes of dry aggregate compacted by rodding in the measure as specified in the standard method of test for unit weight of aggregate for concrete (Serial Designation, C-29-21) of the American Society for Testing Materials. (See Appendix 15)."

"Corrections should be made in the quantities in Appendix 16 to take account of the bulking effect of moisture in the fine aggregate."

It will be noted that in the omission of reference to Appendix 16 in this footnote, the tables giving proportions for concrete of different strengths are eliminated.

In paragraph 29, under Proportioning, the Committee recommends that the words "that may be necessary" in the third sentence, be changed to read *"that he may deem necessary"* so that the sentence will read: "The Engineer shall have the right to make any changes in proportions and materials *that he may deem necessary or desirable."*

In Table 5, under paragraph 29, the Committee recommends the omission of the word "Vertical" in line (a) and all of line (c). This would provide for the same slump for thin sections and columns regardless of whether the thin sections were vertical or horizontal and would limit the maximum slump to six inches.

The Committee also recommends in connection with Table 5 and paragraph 30 that consideration should be given to the use of the flow table as a measure of workability of concrete as the present specifications refer only to the slump test.

Paragraph 76: WATER-TIGHT CONSTRUCTION JOINTS—The Committee recommends for water-tight construction joints the use of sheet lead, sheet zinc or other metal not less than 6 in. wide and extended the full length of the joint and embedded equally in the two deposits of concrete. The Joint Committee report does not provide for the use of metal in such joint.

Section 83: This section covers the depositing of concrete in sea water. The Committee recommends that the third sentence be changed to read: "The placing of concrete from *two feet below low water to two feet above high water," shall be a continuous operation,* substituting the words shown in italics for the words "between tides."

Section 84: The Committee recommends changing the words "at least" in the first and second line to "not less than," and recommends changing the third sentence to read: "Where severe climatic conditions or severe abrasions are anticipated, the face of the concrete from two feet below low water to two feet above high water, or from a plane below to a plane above wave action shall be protected by stone of suitable quality or dense vitrified shale brick as designated on the plans or as required by the Engineer, or in special cases the protection may be creosoted timber." This change adds the words "severe climatic conditions" in the first part of the sentence and lays less stress on the protection by means of creosoted timber than is done in the Joint Committee report.

Chapter 10: SURFACE FINISH.—The section on Surface Finish will be materially improved by combining with it some of the material in the A.R.E.A. Manual. Such additions, together with changes recommended in the Joint Committee report are as follows:

Paragraph 89: Substitute the following:

"The requirements in these specifications applying to forms, mixing, conveying and depositing concrete shall be followed unless modified by the plans or by the direction of the Engineer.

"The whole of an exposed surface between prescribed construction limits shall be cast in one continuous operation. Construction and expansion joints, when not shown on the plans, shall be made as directed by the Engineer, and shall be true to line with sharp unbroken edges.

"The same brand of cement and the same kind and size of aggregate shall be used throughout the whole of any exposed surface.

"For exposed surfaces the forms shall be smooth and water-tight. If of wood the boards shall be planed to a uniform thickness evenly matched with tongue and groove and tightly placed. They shall be so constructed that they can be removed without hammering or prying against the concrete. All offsets or mismatching of the boards shall be dressed to a smooth surface and all openings and cracks pointed flush with clay or plaster of Paris, to prevent leakage and the formation of fins.

"The concrete for exposed surfaces shall be so mixed, placed and worked with a spading tool, that the aggregate is uniformly distributed and a full surface of mortar brought against the form, free from air pockets and void spaces. If the finish is to be one that will expose the coarse aggregate, by either scrubbing, tooling, sand-blasting or acid treatment, then after the full surface of mortar has been worked against the form, the coarse aggregate shall be spaded against the form, to secure a uniform distribution at the face and a uniform texture of the exposed aggregate in the finished surface.

"The forms shall be removed from exposed surfaces as soon as the proper setting of the cement will permit, all fins and other projections carefully removed and offsets leveled; all voids and damaged places shall be immediately saturated with water, filled with a mixture of the same composition as the concrete and smoothed even with the surface with a wooden float or spatula. A steel trowel shall not be used for this purpose. Plastering and brush coating will not be permitted. The surface shall be finished free from streaks, discolorations and other imperfections.

"Whenever the forms are removed before the concrete has properly set, the surface shall be immediately wetted and kept wet for not less than three days."

Paragraph 93: Substitute the following:

"The wearing surface in two-course work shall be placed, if possible, within one-half hour after the base course. Where it is necessary to apply the wearing course after the base course has hardened, the latter shall first be roughened with a pick or other effective tool or if only slightly hardened, with a coarse wire brush. The roughened surface shall be thoroughly saturated with water and covered with a thin layer of neat cement paste immediately before the wearing surface is placed. The wearing course shall not be less than one inch thick."

Paragraph 96: Substitute the following:

"Immediately after the forms are removed and all voids filled, the surface shall be thoroughly wetted and rubbed with a carborundum brick, or other abrasive, to a smooth, even finish of uniform appearance without applying any cement or other coating."

Paragraph 97: Substitute the following:

"The forms shall be removed while the concrete is still green and the surface scrubbed with stiff fiber or wire brushes, using water freely, until the aggregate is uniformly exposed to the desired extent. The whole surface shall then be thoroughly washed with clean water. If portions of the surface have become too hard to scrub to equal relief, or the film of cement is not removed from the surface of the exposed aggregate, dilute hydrochloric acid (1 part acid to 4 parts water) may be used to facilitate the scrubbing. All traces of the acid shall be thoroughly removed with clean water."

Paragraph 102-a: Acid Treated Finish.—This subject is not covered in the Joint Committee Report.

"After the forms are removed and all voids filled, the surface shall be washed with commercial hydrochloric or nitric acid, diluted with water to a strength such that the bond of the cement is not broken beyond the required depth. The solution shall be applied with stiff vegetable fiber brushes and the surface scrubbed until the aggregate is exposed the desired amount. All traces of the acid shall then be quickly and completely washed off with water to prevent further action and the permanent discoloration of the surface.

"Note.—For concrete that is but a few days old, a dilution of one part acid to four parts water may be sufficient. For concrete two weeks old a dilution of one part acid to two or three parts water may be necessary."

DESIGN OF RECTANGULAR BEAMS AND SLABS

Paragraph 106: This section determines the span length of beams and slabs where brackets are provided, but states that no portion of such brackets should be considered as adding to the effective depth of the beam. The Committee questions whether it is proper to neglect the area added by the bracket in such case in considering the design of the beam.

Section 112 reads: "The distance between lateral supports of the compression area of a beam shall not exceed 24 times the least width of compression flange."

The Committee recommends that a sliding value of allowable stresses should be provided by a formula which would require a reduction in the allowable stress as the slenderness ratio increases and a suggested formula is

$$1.20 - L/50b.$$

The application of this formula would provide that when the distance between lateral supports of the compression area of the beam is ten times the least width, the full compression strength would be allowed, and where the ratio L/b is equal to 24, the formula would equal

$$1.2 - .48 \text{ or } 72 \text{ per cent}$$

which would represent the percentage of the permissible compressive stress in concrete to be used.

Section 116: The last sentence reads: "The spacing of bars shall not exceed 18 inches," referring to transverse reinforcement in the top of the slab in T-beam construction. The Committee recommends that this sentence be changed to read: "The spacing of the bars shall not exceed three times the depth of the slab and shall not be more than 18 inches."

Section 119: It is recommended that provision for reducing the allowable compressive stress be made in the case of isolated T-beams as suggested in the same manner as paragraph 112 for plain beams.

Paragraph 125: The first sentence reads: "Stirrups or bent-up bars which are not anchored at both ends according to provisions of Section 141 shall not be considered as effective as web reinforcement." It is recommended that this be changed to read "Stirrups or bent-up bars to be considered as web reinforcement must be anchored at both ends in accordance with provisions of Section 141."

Paragraph 128: It is recommended that the last clause be changed to read "In no case shall the shearing unit stress exceed .075 f'_c."

FLAT SLABS AND COLUMNS

The recommendations of the Joint Committee for the designing of flat slabs are formulated for structures that carry uniformly distributed loads, such as occur in buildings.

The Masonry Committee does not approve these recommendations for the design of flat slabs but is not prepared at this time to make any other definite recommendations regarding this feature of the Joint Committee report. The Committee, however, does submit for information a discussion of this subject, offered by one of its members, which it is felt will be helpful to engineers studying the subject of flat slab design, and suggests also a consideration of the rules adopted by the Department of Buildings of the City of Chicago, which have been used widely by designers.

Columns: The Committee does not approve of the recommendations of the Joint Committee on the design of reinforced concrete columns, but it is not now prepared to make other recommendations. There is presented, however, a discussion of this section by one of the members of the Committee which it is believed will throw some light upon the subject in so far as making a comparison between the Joint Committee's recommendations and other formulæ which are in use.

Paragraph 160: The Committee recommends that the limiting length of reinforced concrete columns be taken as 15 times the diameter or least side of the column instead of 40 times the least radius of gyration.

Paragraph 164: It is recommended that the minimum protection over the reinforcement in all columns be 1½ in. instead of 1½ in. in square columns or 2 in. in round or octagonal columns.

Paragraph 166: It is recommended that this be changed as follows:

"Where the *reinforcement is figured to carry stress,* lateral ties shall be not less than ¼ in. in diameter, spaced not more than 8 in. apart."

Paragraph 167: It is recommended that the last paragraph be given the heading (c).

Paragraph 170: It is recommended that this paragraph be changed in order to conform to the use of the expression $15D$ as the limiting length of a column instead of $40R$, formula 47, thus reading:

$$\frac{P'}{P} = 1.5 - \frac{h}{30D}$$

where D = diameter or least side of the column.

Paragraph 173: It is recommended that this paragraph be changed to read:

"The load per unit of area on soil footings shall be computed by dividing the total load on the footing by the area of the base, giving proper consideration to eccentricity."

The original paragraph neglects the weight of the footing and also neglects eccentricity.

Paragraph 175: It is recommended that this paragraph provide that the thickness of the footing above the reinforcement at the edge shall not be less than 9 in. for footings on soil instead of 6 in.

Paragraph 176: It is recommended that the words *"except where there is eccentric loading"* be added to the last clause of the first paragraph.

Paragraph 182: It is recommended that formula 49 be omitted and that the sentence immediately above the formula be changed to read as follows:

"Permissible unit stress on top of the pedestal or footing directly under the column base shall be not greater than

$$.35\, f_c'$$

the minimum distance from the edge of the column base to the edge of the top of the footing being 3 in., and the area of the top of the pedestal being at least twice the area of the column base."

SUMMARY OF WORKING STRESSES

Paragraph 187 (a): Change $40R$ to $15D$ so that this line will read "*Columns whose length does not exceed* $15D$ where D equals the diameter or least side of the column."

EXTREME FIBER STRESS IN FLEXURE

Paragraph 188: The Committee recommends

$$.325\, f_c' \text{ instead of } .4\, f_c'$$

Extreme fiber stress in flexure adjacent to supports of continuous beams: The Committee recommends

$$.375\, f_c' \text{ instead of } .45\, f_c'$$

Paragraph 189: Change to read: "Tension in concrete (a) in reinforced concrete members, None. (b) In plain concrete .025 f_c'."

Paragraph 191: (b) Beams with stirrups or bent-up bars or a combination of the two; shearing stress .075 f_c' instead of .12 f_c'.

Notations and Figures: In the explanatory paragraph it is stated that "In a few instances the same symbol is used in two distinct cases. However, there is little danger of confusion from this source."

The Masonry Committee finds that giving the same symbol several meanings resulted in considerable confusion. The Committee, therefore, recommends that the notations be revised so that distinct symbols are used in each instance.

DISCUSSION OF SECTION ON DESIGN OF CONCRETE COLUMNS OF REPORT OF JOINT COMMITTEE

By T. L. Condron, Member of the Masonry Committee

Regarding column formulas proposed by the Joint Committee on Concrete and Reinforced Concrete:

The accompanying diagrams, which were prepared in the writer's office in 1921, show several interesting comparisons with regard to column formulas proposed by the Joint Committee in 1916 and also in 1921, with corresponding column formulas of the Building Departments of New York and Chicago and the formulas proposed by the American Concrete Institute at that time.

The first diagram is a comparison of the values of the unit stresses in concrete (f_c) and vertical steel (f_s) based on concrete having an ultimate strength of 2000 lb. per sq. in. reinforced with spirals and vertical rods. In 1916 the Joint Committee's recommendation gives but one point each for concrete stress and steel stress based on 1 per cent spirals, that being the only percentage of spirals considered in that report. In the report of 1921 the working stresses are represented by straight lines between ranges of one-quarter of 1 per cent and 1¼ per cent spirals. It will be noticed that there is quite a wide difference between the Joint Committee's recommendations and the ordinance requirements of New York and Chicago.

The second diagram is a comparison of allowable loads under these several formulas on spiral columns, using 2000 lb. concrete and varying percentages of vertical reinforcement combined with six different percentages of spiral reinforcement, ranging from one-quarter of 1 per cent to 2 per cent. It will be seen that there is no relation between these different formulas and that the recommendations of the Joint Committee of 1921 do not provide for any higher stresses in columns having more than 1¼ per cent spiral, while all of the other formulas do allow higher working stresses for higher percentages of spiral reinforcing. In this connection it should be noted that an average unit working stress on the area of the column of 1,200 lb. per sq. in. may be had under the Chicago ruling for one-half of 1 per cent spiral and about 7 per cent vertical reinforcing, while none of the other formulas permits a working stress as high as 1000 lb. where one-half of 1 per cent spiral is used.

Where 1 per cent spiral is used with 4 per cent vertical reinforcing, the Chicago ruling gives a unit stress of 1030 lb., while the Joint Committee's recommendation would permit 1230 lb. and the other formulas would fall between these two.

For the case of 1½ per cent spiral combined with 4 per cent vertical reinforcing, the New York regulation permits higher stresses than any other, while the American Concrete Institute and the City of Chicago are both below the allowance under the Joint Committee.

Where 2 per cent spiral is used combined with 4 per cent vertical reinforcing, the New York regulation would permit a unit stress as high as 1560 lb., while the City of Chicago would permit only 1200 lb., and the Joint Committee would permit 1300 lb.

It would seem from this diagram that there is very great need for some uniform practice in the designing of reinforced concrete columns

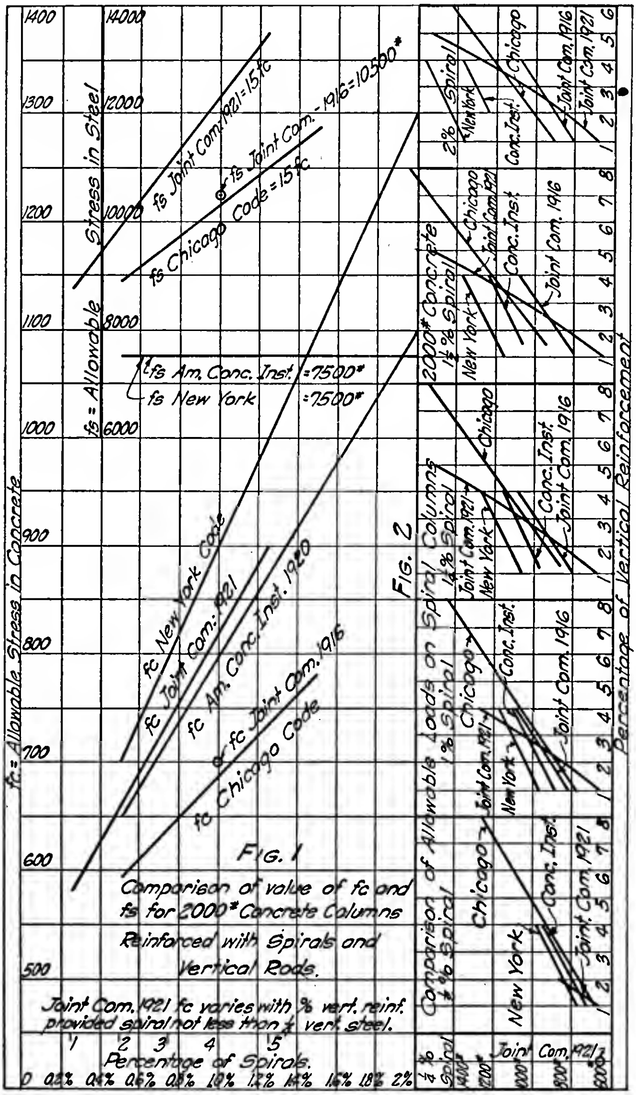


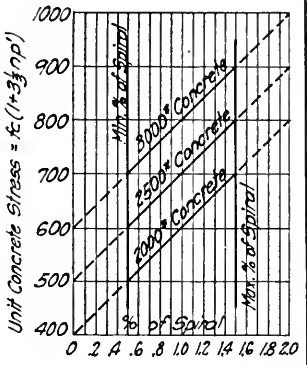
FIG. 1

Comparison of value of fc and fs for 2000# Concrete Columns Reinforced with Spirals and Vertical Rods.

FIG. 2

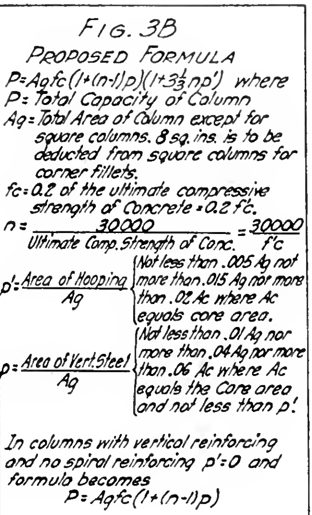
Comparison of Allowable Loads on Spiral Columns 2000# Concrete

FIG. 3A



Allowable Unit Concrete Stresses by Proposed Formulas

FIG. 3B



PROPOSED FORMULA

$P = Agfc(1+(n-1)p)(1+3\frac{1}{3}np')$ where

P = Total Capacity of Column

Ag = Total Area of Column except for square columns. 8 sq. ins. is to be deducted from square columns for corner fillets.

fc = 0.2 of the ultimate compressive strength of Concrete = 0.2 f'c.

$$n = \frac{30000}{\text{Ultimate Comp. Strength of Conc.}} = \frac{30000}{f'c}$$

$$p' = \frac{\text{Area of Hooping}}{Ag} \left\{ \begin{array}{l} \text{Not less than .005 Ag not} \\ \text{more than .015 Ag nor more} \\ \text{than .02 Ac where Ac} \\ \text{equals core area.} \end{array} \right.$$

$$p = \frac{\text{Area of Vert. Steel}}{Ag} \left\{ \begin{array}{l} \text{Not less than .01 Ag nor} \\ \text{more than .04 Ag nor more} \\ \text{than .06 Ac where Ac} \\ \text{equals the Core area} \\ \text{and not less than p'.} \end{array} \right.$$

In columns with vertical reinforcing and no spiral reinforcing p' = 0 and formula becomes

$$P = Agfc(1+(n-1)p)$$

FIG. 4

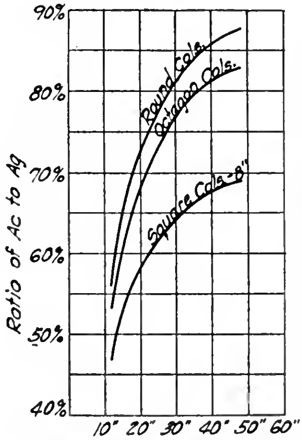
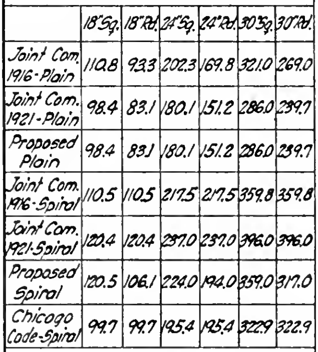


FIG. 5



	18" Sq.	18" Rd.	24" Sq.	24" Rd.	30" Sq.	30" Rd.
Joint Com. 1916-Plain	110.8	93.3	202.3	169.8	321.0	269.0
Joint Com. 1921-Plain	98.4	83.1	180.1	151.2	286.0	239.7
Proposed Plain	98.4	83.1	180.1	151.2	286.0	239.7
Joint Com. 1916-Spiral	110.5	110.5	217.5	217.5	359.8	359.8
Joint Com. 1921-Spiral	120.4	120.4	237.0	237.0	396.0	396.0
Proposed Spiral	120.5	106.1	224.0	194.0	359.0	317.0
Chicago Code-Spiral	99.7	99.7	195.4	195.4	322.9	322.9

Allowable Load in Tons assuming 1½" fireproofing.
Spiral Reinforcing = 1% of Core area.
Vertical Reinforcing = 4% of Core area.
2500# Concrete.

using spirals and it also seems that the Joint Committee recommendations should permit higher unit stresses where more than 1¼ per cent spiral is used, unless there are adequate experimental data to establish the fact that higher percentages of spiral reinforcing are not correspondingly efficient.

In the table given on these diagrams showing the allowable loads in tons for 18 in., 24 in. and 30 in. round and square columns reinforced with 1 per cent spiral and 4 per cent vertical reinforcing where 2500 lb. concrete is used, it is interesting to note that according to the 1916 Joint Committee recommendations an 18 in. square column without spiral was good for slightly larger load than an 18 in. square column with spiral, and in the case of columns smaller than 18 in., the difference was more in favor of columns without spirals, but this particular feature has been improved by the Joint Committee's recommendations of 1921 in that the allowable loads on all spiral columns 18 in. or larger are greater than for corresponding columns without spirals.

It should be borne in mind that according to the Joint Committee's recommendations of 1921, the concrete outside of the spirals for spiral columns is not figured as part of the carrying area of the column, while in the case of columns not reinforced with spirals but simply reinforced with vertical rods and ties, the entire area of the concrete is figured to carry load.

In view of the fact that the entire section of the concrete column must, of necessity, carry a load, it would seem reasonable to take this fact into account in proportioning columns and keep the allowable unit stress in the concrete within such limits that should the fireproofing outside of the spirals or outside of the ties be removed by fire or otherwise, the stress on the core within the spirals or ties would not be excessive, and to meet this idea the formulas shown as "proposed formulas" are offered for consideration. In this connection it is worth while to call attention to the fact that where reinforced concrete beams and slabs are figured to take negative moments, no deduction is ever made in the sections of these members by eliminating the concrete fireproofing below the reinforcing steel. Therefore, is it not equally reasonable to consider all of the concrete section of a column as carrying load, which is actually the case until a fire or some other cause disturbs the outer portion of the column? Whenever you are called upon to figure columns to take bending stresses, as is frequently the case, you are forced to consider the entire concrete section as resisting bending stresses as well as direct stresses.

The allowable loads under these proposed formulas are clearly shown in the tabulation of allowable loads on columns 18 in., 24 in. and 30 in. in diameter given on the diagram, and it will be seen that these allowable loads are practically the same for square columns reinforced with spirals as those recommended by the Joint Committee in 1921 for 18 in. square but are less for the 18 in. round and for the larger size columns, while the allowable loads for the columns without spirals are the same as those recommended by the Joint Committee.

The writer feels that there is a good deal of merit in the proposed formulas, which he offers for consideration in the study of column formulas.

COMMENTS ON JOINT COMMITTEE'S RECOMMENDATIONS FOR FLAT SLABS

By M. Hirschthal, Member of the Masonry Committee

In connection with the paragraphs beginning with Paragraph 142 to the end of the section on the subject of flat slabs, the writer is at variance with the method of handling and distributing the bending moments, particularly as it would apply for the condition of railroad loadings. The method of assuming an arithmetical sum of positive and negative moments and distributing this sum again in an arbitrary manner independent of the variations possible in the width and depth of column flare and drop panel is unsatisfactory and seems based on insufficient test data.

While any formula based on the moments of inertia of slab, drop panels and columns flare would be much too complicated for practical use, moments found for actual loading and properly reduced would give rational and conservative results. This reduction would be in the ratio of the squares of the shortened spans (figured between column flares) to the center-to-center-of-column spans. The column flare is not a bracket but a continuous surface, with a specified minimum thickness at the head and the clear span may well be figured between column flares as it was treated in the Chicago Building Code. In the latter the positive moment in the main bands of a square panel was figured $\frac{wl^2}{40}$ which was reached by specifying a column flare of .225 l, leaving the clear span at .775 l so that

$$\frac{wl^2}{24} \text{ become } \frac{w(.775\,l)^2}{24} = \frac{wl^2}{40} \text{ almost exactly.}$$

The method of arriving at moments in flat slabs for railroad structures may be roughly summarized as that of finding the actual moments, both negative and positive, due to locomotive loading, over the series of center-to-center-of-column spans, between expansion joints or abutments with end conditions as designed. The various maximums being found, the corresponding equivalent uniform loads are then distributed according to track centers, etc., and moments figured transversely for loading on each individual track and the maximum live load moments obtained. Moments for dead load including platforms, column and other concentrations are also found, the live and dead load moments together with impact combined to give final results. The moments thus obtained are then reduced in proportion to the squares of the spans between column flares over those of column centers. Of course, an alternative method, obviating the necessity of reducing the moments, would be to consider a series of spans consisting of the spans between column flares with the column flares themselves intervening as alternate long and short spans from expansion joint to expansion joint.

In any event, the formula in paragraph No. 142 seems to the writer to be an attempt at unjustified refinement. He would prefer to discourage the use of any figure other than ⅛ as a coefficient and would take up all the reduction with the shortening of the span, viz.:

$$M_0 = \frac{1}{8} wl \left(1 - \frac{c}{l}\right)^2$$

As stated above, the division of the moment in the table appears unjustified by any theoretical methods and there is not sufficient data based on experimental work to justify it.

Formula 37 is needlessly complicated with an appearance of exactness by the use of the various symbols in the formula while at the same time giving results inconsistent with formula 38, except for the slabs without drops. Since R is permitted to vary only .03 an average value could well be used instead of the symbol, as could also a figure for $\frac{c}{l}$ so as to give a simplified formula.

However, by using $\frac{c}{l} = .225$ (most usual design); $R = 0.54$ (given in table for 4 way); $l_1 = l$ (square panel); $b_1 = \frac{l}{6}$ (based on $b = \frac{l}{3}$) since provision is made that

$b = \frac{l}{2}$ (where no drop panel is used) there results:

$t_1 = .046\, l \sqrt{w'} + 1\frac{1}{2}$, which is more than twice the value of t_2 in 38, whereas a maximum of $1\frac{1}{2}$ times that in 38 is specified for depth of drop panel (correctly).

If b_1 is assumed equal to $\frac{l}{3}$ instead of $\frac{l}{6}$

$t_1 = .0326\, l \sqrt{w'} + 1\frac{1}{2}$, which still exceeds $1\frac{1}{2}$ times that of 38.

At the same time attention may be called to the fact that the thickness of drop panel may be governed by shear as often as by negative moment. The writer would suggest formula 38 be adopted for slabs with drop panels and thickness of drop panel limited to $1\frac{1}{2}$ times the slab thickness. Formula 38 is justified from the fact that with the usual percentage of reinforcement for positive moment in flat slabs of one-half of one per cent, internal moment

$M = 71\, bd^2$; ($t = d$ in this case)

External moment $= \frac{w\,(l-c)^2}{24}$ which for

$c = .225\, l_1 \div M = \frac{wl^2}{40} = 71\, bt^2$ from which

$t = .019\, l\sqrt{w'}$ which is close enough to .02.

Formula 37 as it stands, would give a value of

$t_1 = .026\, l \sqrt{w'} + 1\frac{1}{2}$

for a slab without drop panels, and would suggest adopting this for such condition. Moreover, the 1 in. and $1\frac{1}{2}$ in. which are added for protection of steel should be replaced by constants to allow latitude for various conditions of exposure.

PROGRESS REPORT OF SPECIAL COMMITTEE ON STRESSES IN RAILROAD TRACK

Arthur N. Talbot, *Chairman;*	W. M. Dawley, *Vice-Chairman;*
G. H. Bremner,	George W. Kittredge,
C. B. Bronson,	Paul M. LaBach,
John Brunner,	C. G. E. Larsson,
W. J. Burton,	G. J. Ray,
Chas. S. Churchill,	Albert Reichmann,
W. C. Cushing,	H. R. Safford,
C. W. Gennet, Jr.,	Earl Stimson,
H. E. Hale,	F. E. Turneaure,
J. B. Jenkins,	J. E. Willoughby,

Committee.

To the American Railway Engineering Association:

The Special Committee on Stresses in Railroad Track, cooperating with a similar committee of the American Society of Civil Engineers and the American Railway Association, presents the following report of progress:

During 1925 experimentation was directed on the rail joint in an effort to determine the intensity and distribution of the stresses in the splice bar and in the rail at the joint, the characteristics of the flexural action for different forms of splice bar, and the effect of varying conditions in the joint, such as the tension of the bolts and the fit of the splice bar to the rail. An effort was also made to learn to what extent the stresses and moments varied from joint to joint in the track and whether the joints in service behaved in accordance with assumptions quite commonly made.

The experimental work in the laboratory under controlled conditions permitted the measurement of the strains in the various parts of the angle bar or other form of splice bar under bending loads, the measurement of the tension of the bolts tightened under different degrees of torque and the effect on the corresponding flexural stresses in the splice bar, and the observation of the position of the bearing areas and the effect of the fit of the splice bar against the rail and also the effect of the vertical deflection and play of the splice bar and of its lateral bending and twisting. It has given information which it is thought will have an important bearing on the design of the form of the splice bar and on the analysis of its action under load.

Field tests were conducted on the track of the Illinois Central Railroad at Champaign, Illinois; the Delaware, Lackawanna and Western Railroad at Dover, New Jersey, and the Nashville, Chattanooga and St. Louis Railway at Bass, Alabama. The rail was 90-lb., 130-lb. and 110-lb. The joints were tested as found in the track, loads of from 95,000 to 127,000 lb. on a four-wheel truck of a freight car being applied and also in some tests lighter loads. Measurements were made of strains at certain gage

---

Bulletin 282, December, 1925.

lines on the splice bars and rails, tension in the bolts and deflections at the joints and for given distances on each side of the rail end. Although the nature and extent of the tests differed at the three locations, the following may give an idea of the variation in the conditions of the tests: tight and loose bolts, tightness of bolt obtainable by track wrench in the hands of track man, loose tie and freshly tamped tie, good and bad fit of angle bar, special forms of angle bar, and relative tension in bolts at joints where rails had been slipping with changes in temperature and at joints that had not moved under the same conditions of temperature.

Progress has been made in reducing data and preparing the material, but the work is not yet ready for presentation. It is found that the resisting moment developed in the joint under load in the track varies greatly from joint to joint and an effort is being made to learn the principal sources of this variation. As may have been expected from analytical considerations, the neutral axis of the angle bars deflects from the horizontal and the stresses at the outer edge of the flange of the angle bar are frequently very low, especially with loose bolts or poor fit between bar and rail. In several ways the results may be expected to lead to a discussion whether improvements in the design of the rail joint may be made.

The Committee has a number of other questions under consideration.

Respectfully submitted,

THE SPECIAL COMMITTEE ON STRESSES IN RAILROAD TRACK,

By A. N. TALBOT, *Chairman.*

REPORT OF COMMITTEE IV—RAIL

G. L. Moore, *Chairman;*	Hunter McDonald, *Vice-Chairman;*
E. E. Adams,	John D. Isaacs,
J. E. Armstrong,	C. W. Johns,
W. J. Backes,	R. Montfort,
A. F. Blaess,	A. W. Newton,
F. L. C. Bond,	*J. R. Onderdonk,
C. B. Bronson,	W. H. Penfield,
W. C. Cushing,	G. J. Ray,
C. F. W. Felt,	Earl Stimson,
L. C. Fritch,	F. M. Waring,
E. A. Hadley,	Louis Yager,
C. R. Harding,	J. B. Young,

Committee.

To the American Railway Engineering Association:

Your Committee on Rail respectfully submits its report to the Twenty-Seventh Annual Convention:

(1) Revision of Manual

The Committee proposes material for Manual revision as follows:

Revised Specifications for Spring Washers—Appendix A.
Recommended design for Track Bolts, including corresponding joint bar punching—Exhibit A.

(2) Design for Track Bolts

The Committee presents recommended design for track bolts, including corresponding joint bar hole, as Exhibit A. This design accords with the recommended design presented last year as a progress report, with the exception of revised dimensions and radii for the shoulder of the elliptical neck track bolt. During this year the New York Central and Pennsylvania Lines, who are the principal users of elliptical neck bolts, have agreed upon the dimensions shown in Exhibit A as satisfactory.

As now presented, the design shows optional properties for contour of shoulder, type of thread and periphery of nut. The Committee believes that this design meets conditions existing on the majority of American track for renewals and may be adopted generally for new construction.

The manufacturers of track bolts have approved the design and the American Engineering Standards Committee will adopt this as standard when ratified by the Association.

(3) Mill Practice

The Committee is gratified at the action of the Board of Directors of the American Railway Association in adopting our 1925 standard specifications for Open-Hearth Carbon Steel Rails as Recommended Practice for the Engineering Division. During this year many contracts have been closed with practically all the American steel mills for rail rolled under the pro-

---

*Died November 7, 1925.

A

visions of this specification, without change and without premium, and certain mills have adopted the specification as manufacturers' standard.

The Committee is devoting close attention to the behavior in track of rail rolled during the last three years, whose manganese content is considerably above that now specified as a maximum in our standards. Most of this rail has been made with manganese content between 1.25 per cent and 1.50 per cent with but little change in the carbon, and appears to justify belief that greater hardness is being obtained without sacrifice of toughness.

(4) Rail Failures

The Committee presents rail failure statistics for the period ending October 31, 1924, as Appendix B. The average failures per 100 track miles per year of service for all the rail reported on are given below:

TABLE 1—AVERAGE FAILURES PER 100 TRACK MILES

Year Rolled	*Years' Service*					
	0	1	2	3	4	5
1908	...	....	....	.....	.....	398.1
1909	...	....	....	.....	224.1	277.8
1910	...	....	....	124.0	152.7	198.5
1911	...	....	77.0	104.4	133.3	176.3
1912	...	28.9	32.1	49.3	78.9	107.1
1913	2.0	12.5	25.8	44.8	69.5	91.9
1914	1.2	8.2	19.8	32.9	50.9	74.0
1915	0.7	8.9	19.0	34.2	53.0	82.4
1916	1.6	11.8	29.2	47.7	70.6	105.4
1917	5.3	21.6	38.9	66.0	110.5	137.0
1918	1.6	8.9	27.6	54.0	92.8	125.4
1919	2.0	14.8	39.4	73.7	104.8	115.7
1920	3.9	14.2	32.4	63.1	84.5	.....
1921	1.6	10.9	34.9	56.9	.....	.....
1922	1.5	15.9	34.8	.....	.....	.....
1923	3.7	14.3	....	.....	.....	.....
1924	3.0	....	....	.....	.....	.....

The record of performance of the 1919 rolling follows the good showing of the 1918 rolling in presenting another marked drop in the failure rate, and it is expected that the 1920 rolling will continue in the same good course.

The Committee is again presenting in the rail failure report a chart showing the rating of mills through the use of the traffic density factor, as well as the rating by our usual method.

(5) Transverse Fissures

Data has been compiled covering approximately 16,000 fissures, complete data as to mill and track history being available on about 7000. These data will be analyzed by the Statistical Division of the American Railway Association during the next few months and presented to the conference headed by the Bureau of Standards of the Department of Commerce, as our contribution of facts toward the investigation.

Through the co-operation of the University of Illinois, specimens of rail steel representing fissured heats and heats in which no fissures have ever developed are still in process of examination for the determination of their respective elastic constants. While the work is not yet complete, the tendency of the data indicates a very interesting difference between the two classes of material, although it is doubtful whether methods can be worked out by which material with this tendency can be identified at the mills.

(6) Relation of Bolt Tension to Mechanical Strength of Joints

The Committee presents, as Appendix C, a monograph by Mr. Hunter McDonald concerning his two years' observation of a mile of test track on the Nashville, Chattanooga & St. Louis Railway. This monograph contains all the information the Committee has been able to collect this year pertinent to the subject.

It was expected that the work conducted by the Committee on Stresses in Track would continue laboratory investigation in determining the relation between bolt tensions and girder strength of joint for values of bolt tension other than the 1000 lb. and 12,000 lb. reported upon last year. This work, however, has been discontinued, and the Committee on Stresses in Track is now engaged in studying this problem by actual observation in track of stresses set up by rolling loads in joints whose bolt tension has been accurately determined.

In view of this situation the Committee on Rail desires to be relieved of further consideration of this subject, as it has largely exhausted all of its own resources.

(7) Rail Battering

The Committee reports progress on this subject in co-operation with the Committee on Track, and again calls attention to Mr. McDonald's monograph, which contains much valuable data bearing directly upon this problem.

(8) Welding of Traction and Signal Bonds

The Committee reports progress on this subject, and presents, as Appendix D, a metallurgical report on the effect of welding in changing the structure of the rail.

The Committee is not ready to make any recommendations concerning the relation of the stresses in track to the changed structure, but presents Appendix D as information.

(9) Specifications for Spring Washers

The Committee presents, as Appendix A, Revised Specifications for Spring Washers. The principal changes cover provisions for testing of elliptical springs, which are now coming into considerable use, and describes the method of testing more clearly than the present standard.

(10) Wheel Loads Upon Rail

The Committee presents, as Appendix E, a report worked out by the Engineer of Tests summarizing the work heretofore on record bearing upon this problem.

It has proven impossible for the Committee to finance a program for the accumulation of any further data, as it appears that a special track must be set aside for the work, with facilities for placing repeated rolling loads of various intensities during a considerable period of time. A very large amount of laboratory work would be necessary on specimens removed at regular intervals. It has proven impossible to work out the mechanical principles involved through work on cold rolled steel strip.

Inasmuch as the Committee can now see no avenue of furthering this research, it respectfully requests that it be relieved of further study of this subject until some new opportunity of attack may present itself.

(11) Economic Value of Different Sizes of Rail

The Committee reports progress on this subject, but has not yet succeeded in analyzing the various elements involved therein, and asks that this subject be re-assigned for continued work. It presents as Appendix F a study by the Reading Company on the structure of typical 100 lb. and 130 lb. rails as information.

(12) Specifications for Girder Rails

The Committee presents Standard Specifications for Girder Rail in Appendix G.

While Girder Rail is only used by steam railway lines in pavement through city streets and will probably never aggregate over one hundred miles, still it has seemed wise to co-operate with the American Electric Railway Engineering Association in revising their standard to conform as closely as possible with our T-rail standard in metallurgy and mechanical requirements.

This specification has been ratified by the American Electric Railway Engineering Association and adoption of it by this Association will set a common standard.

(13) Rail Canting

The Committee last year concurred in the findings of the Special Committee on Stresses in Track and recommended:

(1) Rails should be canted inward.
(2) Inclined tie plates should be used to produce the desired cant.
(3) Amount of cant should be 1 in 20.

Action upon the report was deferred at the last convention. The Rail Committee still concurs in these findings and again presents the same recommendation.

Action Recommended

1. The Committee recommends that specifications submitted with this report in Appendix A, Specifications for Spring Washers, be adopted by the Association and substituted for the corresponding specifications now printed in the Manual.

2. The Committee recommends that the design of Track Bolts, submitted with this report as Exhibit A, Design for Track Bolts, be accepted

as an American Railway Engineering Association standard and printed in the Manual.

3. The Committee recommends that Appendix G, Specifications for Girder Rails, be adopted as an American Railway Engineering Association standard and printed in the Manual.

Recommendations for Future Work

1. Revision of Manual.
2. Continue the study of details of mill practice and manufacture as they affect rail quality.
3. Continue the study of rail failures.
4. Continue the study of transverse fissures.
5. Continue the study of cause and prevention of rail battering.
6. Continue the study of gas welding of propulsion and signal bonds.
7. Study the economic value of different sizes of rail.

Respectfully submitted,

THE COMMITTEE ON RAIL,

G. L. MOORE, *Chairman.*

Appendix A

(1) REVISED SPECIFICATIONS FOR SPRING WASHERS

E. E. Adams, Chairman, Sub-Committee; W. J. Backes, C. F. W. Felt, L. C. Fritch, E. A. Hadley, Hunter McDonald, R. Montfort, W. H. Penfield, Earl Stimson, L. Yager, J. B. Emerson.

SPECIFICATIONS FOR SPRING WASHERS

(I) GENERAL SCOPE

1. These specifications cover rail joint spring washers of two types: (a) Elliptical springs exerting unit tensions on two bolts of the joint, (b) Helical springs exerting tension on individual bolts. Two classes of Helical springs are covered: B1—High Spring Pressure and B2—Low Spring Pressure. The purchaser shall specify under which class inspection shall be made.

(II) MATERIALS

2. Material shall be of a carbon steel or an acceptable alloy steel, manufactured either by the Basic or Acid Open-Hearth, the Electric Furnace, or the Crucible Process.

(III) CHEMICAL REQUIREMENTS

3. The chemical composition of the spring washers manufactured from each melt of steel shall be within the following limits:

Phosphorus—not to exceed 0.05 per cent.
Sulphur—not to exceed 0.04 per cent.

(IV) PHYSICAL REQUIREMENTS

Testing Machine

4. Test specimens shall be interposed between the platens of a compression machine of approved design, equipped with a deflection instrument calibrated to .0001 inch and located so that readings are recorded from approximately the center point of platens, and shall be subjected ten successive times to the preliminary loads.

(A) Physical Requirements for Elliptical Spring Washers

Preliminary Load

5. The preliminary load shall be 30,000 lb., and the distance between the platens measured after the tenth application.

Reaction

6. The spring shall then be subjected to a load of 20,000 lb. at which point the distance between the platens shall be at least $\frac{1}{32}$ inch (.03125) greater than a similar distance measured under a load of 30,000 lb.

Hardness

7. The test specimens shall show hardness on Brinell scale of between 321 and 418.

(B) PHYSICAL REQUIREMENTS FOR HELICAL SPRING WASHERS

Spring Pressure, Method of Determination

8. After the application of tenth preliminary load, the distance between platens of testing machine shall be measured. Load shall then be released and reapplied and again distance between platens measured. These two distances shall not vary by more than .001 inch.

Test specimens shall then be removed from testing machine, micrometered, and maximum thickness of material recorded in .001 inch. To each figure thus obtained shall be added a reserve factor of .02 inch, and the resultant figure shall be called the test height.

The platens of testing machine shall then be brought together so that when they are in full contact the deflection instruments register zero. The platens shall then be released and test specimens placed approximately at center of lower platen. Test load as given in the table below shall then be applied and distance between platens as recorded on deflection instrument shall be equal to, or greater than, the test height as above defined.

Spring Washer Number	*For Diameter of Bolt in Inches*		*Low Spring Pressure*		*High Spring Pressure*	
	Body	*Thread*	*Preliminary Load in Lb.*	*Test Load in Lb.*	*Preliminary Load in Lb.*	*Test Load in Lb.*
1	3/4	13/16	Down to Solid	750	15,000	7,500
2	13/16	7/8	Down to Solid	850	17,500	8,500
3	7/8	15/16	Down to Solid	1,000	20,000	10,500
4	15/16	1	Down to Solid	1,250	25,000	11,500
5	1	1 1/16	Down to Solid	1,500	28,000	12,000
6	1 1/16 1 1/8	1 1/8	Down to Solid	2,000	36,000	15,000
7	1 1/4	1 1/4	Down to Solid	.....	45,000	18,000

Hardness

9. The test specimens shall show hardness on Brinell scale of between 402 and 477.

(C) PHYSICAL REQUIREMENTS COMMON TO BOTH ELLIPTICAL AND HELICAL SPRINGS

Fracture Test

10. When test specimens are nicked and broken, the structure at the fracture must be of fine grain, homogeneous, or of uniformly silky structure.

Proportion of Tests

11. (a) Tests shall be made from specimens selected by the inspector at random from lots of not over 15,000 pieces of finished helical spring washers and not over 7500 pieces of elliptical spring washers offered for inspection. Two specimens shall be selected for each test (pressure, fracture, and hardness), and if both meet the requirements of the specifications, the lot will be accepted. If one of the specimens fails, a

third shall be selected and tested, and if it meets the requirements of the specifications, the lot will be accepted. If, however, the third test piece fails, the lot will be rejected.

(b) When required, the manufacturer shall furnish samples from a preliminary lot before proceeding with the fulfillment of the order and give sufficient notice in advance of the date when they will be ready for inspection.

Temperature of Test Specimens

12. The temperature of the specimens at time of test shall be between 60 and 110 deg. Fahr.

Reheat Treatment

13. (a) If the results of the physical tests do not conform to the requirements specified, the manufacturer may reheat-treat such lot, but not more than three additional times, unless authorized by the purchaser, and retests shall be made as specified in Section 11.

(b) No lot which has failed to pass the tests shall be offered for further test until after the spring washers in that lot have been re-treated.

(V) DESIGN AND TOLERANCE

Design

14. Spring washers shall be made in accordance with the standard sizes, dimensions and forms, as specified by the purchaser.

Tolerance

15. The weight of finished spring washers per thousand lot shall be at least 97 per cent of the theoretical weight, the weight of a cubic inch of steel being taken as 0.2833 lb.

(VI) MANUFACTURE

16. (a) Previous to offering any lots of spring washers for inspection, each individual piece shall have been subjected as a part of the routine manufacturing process to shock or pressure sufficient to eliminate permanent set and any individual pieces defective through seams, quenching cracks, etc.

(b) Heat treatment shall conform to the best known methods for securing the desired physical properties.

(c) All spring washers must be clean, smooth, without burrs or rough edges, of uniform size and cross-section, free from injurious mechanical defects, and be finished in a first-class, workmanlike manner.

(VII) INSPECTION

Place of Tests

17. All tests and inspection shall be made at the place of manufacture prior to shipment, unless otherwise agreed, except that check tests may be made at any other place selected by the purchaser without holding the

manufactured articles at the mill awaiting the results of the check tests, and shall be so conducted as not to interfere unnecessarily with the operation of the mill.

Access to Works

18. Inspectors representing the purchaser shall have free entry at all times, while the contract is being executed, to the works of the manufacturer, and shall have all reasonable facilities afforded by the manufacturer to satisfy them that the spring washers are furnished in accordance with the terms of these specifications.

Defects Found After Delivery

19. Spring washers to the extent of five per cent or more of the order which show injurious defects subsequent to their acceptance at the place of manufacture or sale will be returned to the manufacturer, who shall pay the freight charges both ways and replace the defective spring washers with new ones fulfilling the requirements of the specifications.

(VIII) SHIPMENT

Packing and Branding

20. (a) Finished Elliptical spring washers shall be packed in bundles of twenty-five (25), securely fastened with wire. Finished Helical spring washers shall be packed in quantities of one thousand (1000) or fifteen hundred (1500) in securely hooped kegs or well-fastened boxes. Containers shall be left open until the inspection is completed.

(b) All containers or bundles shall be marked by the manufacturer as follows:

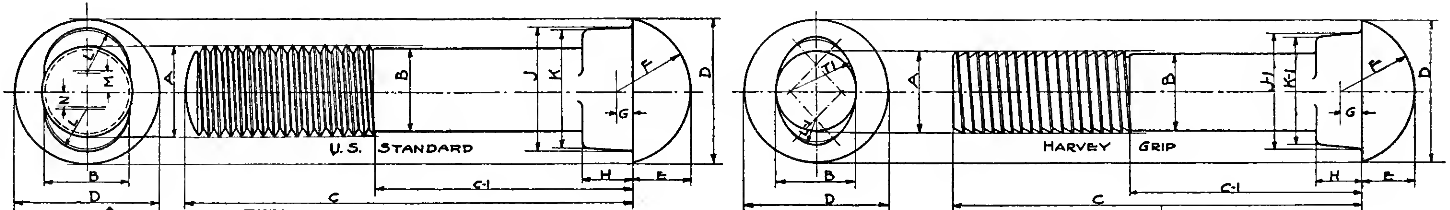
Elliptical Spring Washers

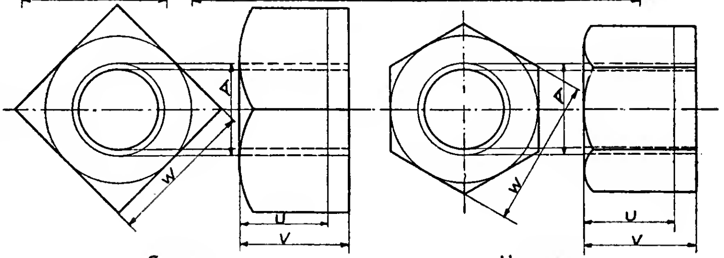
1. Name of Manufacturer.
2. Name of Railroad and drawing number showing joints on which springs are to be used.
3. Bolt hole centers.
4. Short diameter of holes.
5. Rail section.
6. Label—"HIGH PRESS. ELL. SPG. WASHERS."

Helical Spring Washers

1. Name of Manufacturer.
2. Size (nominal bolt diameter).
3. Number of spring washers.
4. Label—B-1—"HIGH PRESS. HEL. SPG. WASHERS"; B-2—"LOW PRESS. HEL. SPG. WASHERS."

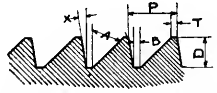
Exhibit A





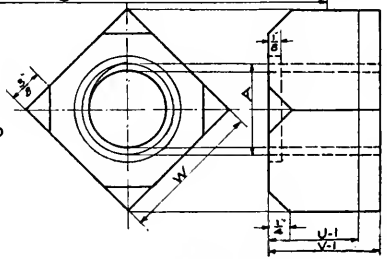
SQUARE

HEXAGON

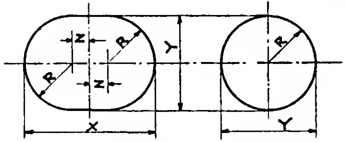


HARVEY GRIP BOLT THREAD ENLARGED

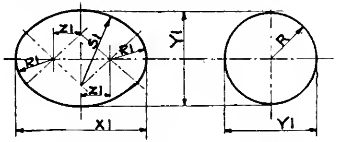
Size of Bolt	Dimensions of Thread					
	A	X	P	D	B	T
¾"	45°	MAX. 10°	.1000"	MIN. .065"	.0118"	.0018"
⅞"	45°	MAX. 10°	.1111"	MIN. .072"	.0132"	.0132"



IDEAL RECESSED



OVAL BAR PUNCHING



ELLIPTICAL BAR PUNCHING

A		B	C	D	E	F	G	H	J	K	L	J-1	K-1	M	N	U	V	W	X	Y	Z	X-1	Y-1	C-1	U-1	V-1	L-1	R-1	Z-1	S1	T1
Threads		Body		Head				Shoulder								Nut			Bar						Ideal Nut		Radius	Radius	Rad Ctr.	Radius	Radius
Diam Max.	Per In.	Shank Dia	Length Unq Hd	Diam.	Thick.	Radius	Rad Ctr	Depth	Spread Max.	Spread Min.	Radius			Rad Max.	Ctrs. Min.	Thickness Common	Thickness Treated	Width Flats	Punching Length	Punching Width	Rad Ctr.				Thickness Common	Thickness Treated					
¾"	10	11/16"	AS PER ORDER OIL QUENCHED TO BE ⅛" LONGER THAN COMMON	1-¼"	15/32"	21/32"	3/16"	3/16"	1-1/16"	1-1/32"	11/32"			3/16"	11/64"	¾"	1"	1-¼"	1-⅛"	13/16"	5/32"			AS PER ORDER	⅞"	1-⅛"	¼"	9/32"	9/32"		
13/16"	10	¾"		1-11/32"	33/64"	11/16"	11/64"	13/32"				1-⅛"	1-3/32"			¾"	1"	1-⅜"				1-⅛"	⅞"		⅞"	1-⅛"	19/64"	11/32"	7/16"	21/32"	43/64"
⅞"	9	13/16"		1-7/16"	9/16"	47/64"	11/64"	½"				1-3/16"	1-5/32"			⅞"	1-⅛"	1-7/16"				1-3/16"	15/16"		1"	1-¼"	21/64"	⅜"	7/16"	11/16"	45/64"
15/16"	9	⅞"		1-17/32"	39/64"	25/32"	11/64"	15/32"	1-13/64"	1-11/64"	7/16"			27/128"	25/128"	⅞"	1-⅛"	1-7/16"	1-5/16"	1"	⅛"				1"	1-¼"	11/32"	⅜"	9/32"		
1"	8	15/16"		1-⅝"	21/32"	53/64"	11/64"	9/16"	1-⅜"	1-11/32"	15/32"			7/32"	13/64"	1"	1-¼"	1-⅝"	1-7/16"	1-1/16"	3/16"				1-⅛"	1-⅜"	⅜"	13/32"	5/16"		
1-1/16"	8	1"		1-23/32"	45/64"	⅞"	11/64"	19/32"	1-29/64"	1-27/64"	½"			29/128"	27/128"	1"	1-¼"	1-¾"	1-½"	1-⅛"	5/32"				1-⅛"	1-⅜"	13/32"	7/16"	3/16"		
1-⅛"	7	1-1/16"		1-13/16"	¾"	59/64"	11/64"	⅝"	1-17/32"	1-½"	17/32"			15/64"	7/32"	1-⅛"	1-⅜"	1-13/16"	1-⅝"	1-3/16"	7/32"				1-¼"	1-½"	7/16"	15/32"	11/32"		
1-¼"	7	1-3/16"		2"	27/32"	1-1/64"	11/64"	11/16"	1-11/16"	1-21/32"	19/32"			¼"	15/64"	1-¼"	1-½"	2"	1-¾"	1-¼"	¼"				1-⅜"	1-⅝"	15/32"	½"	⅜"		

(2) DESIGN FOR TRACK BOLTS

CORRESPONDING OVAL AND ELLIPTICAL BAR PUNCHING. THREE TYPES. ALTERNATING STANDARD NUTS AND TWO TYPES ALTERNATE THREADS

Revised, September 28, 1925

Appendix B

(4) RAIL FAILURE STATISTICS FOR 1924

By J. B. Emerson, Engineer of Tests, Rail Committee

This report deals with the rail failure statistics for the year ending October 31, 1924, and continues the method adopted as standard last year of basing the failure rate by mile years of service in track.

The rollings for 1919 and succeeding years are embodied in these statistics. The tonnage and track miles represented are as follows:

Year Rolled	*Tons*	*Track Miles*
1919	884,805	5,913.86
1920	1,060,750	7,271.00
1921	1,048,771	6,857.55
1922	1,093,960	6,974.38
1923	1,514,717	9,501.95
1924	714,676	4,519.04

The average results are shown in Table 1, together with the results taken from previous reports. The 1919 rollings, whose period of observation is now concluded, exhibit another substantial drop in the curve, following the drop recorded last year from the peak of the 1917 record. The four-year record of the 1920 rollings justifies a further drop at least equal in amount next year, and it would seem that the low record of the 1914 rollings will be attained during the next three years.

Fig. 1 shows diagrammatically the general average results.

Table 2 presents a summary from twelve years' reports showing track miles and total failures in addition to the failures per 100 track miles shown in Table 1. The average results of the rails from each of the mills for the rollings since 1908 are given in Table 3 and the results are shown diagrammatically as Fig. 2.

Table 4 presents the performance of the rails rolled at each of the mills in recent years and averages for the rollings from 1919 to 1923, inclusive, are shown for each mill. The average results weighted by the mileage are presented diagrammatically in Fig. 3. Inland shows the lowest relative figure, but this may rise when these rails have undergone full five years' service. Carnegie displaces Illinois, the last year's record holder, with a figure of 9.66.

Table 4 again rates the relative performance of the various mills from the same data used for Fig. 3, except that a traffic density element has been introduced into the final computations, based on the average ton miles of revenue freight per mile of track of the various railways into whose tracks the output of each mill was placed. A similar chart was presented last year as information and is presented again this year for the same purpose.

Table 5 presents the average weight of the rails rolled at all mills. It will be observed that the average weight has dropped considerably below the last year's figure of 101.5. This, however, is probably due to the failure of some roads who use large section rail to submit statistics for this last year.

TABLE 1—AVERAGE FAILURES PER 100 TRACK MILES

Year Rolled	YEARS SERVICE 0	1	2	3	4	5
1908	-	-	-	-	-	398.1
1909	-	-	-	-	224.1	277.8
1910	-	-	-	124.0	152.7	198.5
1911	-	-	77.0	104.4	133.3	176.3
1912	-	28.9	32.1	49.3	78.9	107.1
1913	2.0	12.5	25.8	44.8	69.5	91.9
1914	1.2	8.2	19.8	32.9	50.9	74.0
1915	0.7	8.9	19.0	34.2	53.0	82.4
1916	1.6	11.8	29.2	47.7	70.6	105.4
1917	5.3	21.6	38.9	66.0	110.5	137.0
1918	1.6	8.9	27.6	54.0	92.8	125.4
1919	2.0	14.8	39.4	73.7	104.8	115.7
1920	3.9	14.2	32.4	63.1	84.5	
1921	1.5	10.9	34.9	56.9		
1922	1.5	15.9	34.8			
1923	3.7	14.3				
1924	3.0					

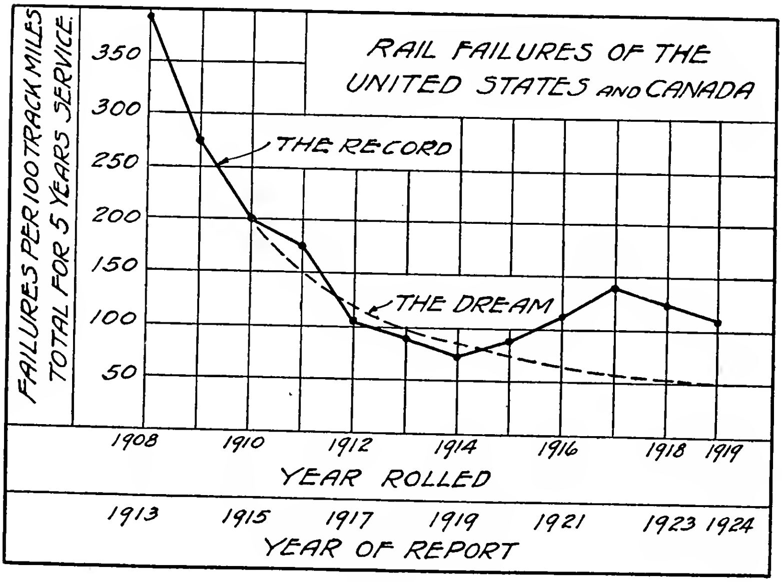


FIG. 1

Table 2—Summary from Twelve Years' Reports Showing Track Miles, Total Failures and Failures per 100 Track Miles.

Service	Five Years			Four Years			Three Years			Two Years			One Year			Several Months		
	Trk Mls Of Rail Laid	Failures		Trk Mls Of Rail Laid	Failures		Trk Mls Of Rail Laid	Failures		Trk Mls Of Rail Laid	Failures		Trk Mls Of Rail Laid	Failures		Trk Mls Of Rail Laid	Failures	
		Total	Per 100 Trk Mls		Total	Per 100 Trk Mls		Total	Per 100 Trk Mls		Total	Per 100 Trk Mls		Total	Per 100 Trk Mls		Total	Per 100 Trk Mls
From 1913 Report																		
Year Rolled		1908			1909			1910			1911			1912			1913	
Totals-	3201.36	12746	398.1	6340.54	14208	224.1	9860.18	12227	124.0	6536.05	5030	77.0	7105.74	2050	28.9	5848.64	118	2.0
From 1914 Report																		
Year Rolled		1909			1910			1911			1912			1913			1914	
Totals-	6697.39	18605	277.8	10024.85	15309	152.7	6096.48	6354	104.4	7610.60	2431	32.1	8775.44	1096	12.5	4768.34	56	1.2
From 1915 Report																		
Year Rolled		1910			1911			1912			1913			1914			1915	
Totals-	11587.43	22981	198.5	7980.75	10635	133.3	10374.18	5119	49.3	10668.59	2756	25.8	7061.24	584	8.2	4286.26	31	0.7
From 1916 Report																		
Year Rolled		1911			1912			1913			1914			1915			1916	
Totals-	7969.41	14052	176.3	10260.93	8100	78.9	11335.41	5076	44.8	7505.24	1483	19.8	7381.29	656	8.9	5352.71	87	1.6
From 1917 Report																		
Year Rolled		1912			1913			1914			1915			1916			1917	
Totals-	10778.68	11546	107.1	12526.00	8706	69.5	7819.79	2576	32.9	7344.65	1395	19.0	8532.53	1004	11.8	4713.67	261	5.3
From 1918 Report																		
Year Rolled		1913			1914			1915			1916			1917			1918	
Totals-	11882.57	10924	91.9	7752.27	3948	50.9	7072.23	2414	34.2	8347.44	2439	29.2	7384.26	1596	21.6	3262.43	53	1.6
From 1919 Report																		
Year Rolled		1914			1915			1916			1917			1918			1919	
Totals-	7917.26	5855	74.0	7280.51	3862	53.0	8407.55	4013	47.7	7615.46	2962	38.9	6354.44	568	8.9	4272.96	85	2.0
From 1920 Report																		
Year Rolled		1915			1916			1917			1918			1919			1920	
Totals-	7346.50	6057	82.4	8062.10	5691	70.6	7334.40	4844	66.0	6658.80	1837	27.6	6676.60	986	14.8	6064.20	197	3.9
From 1921 Report																		
Year Rolled		1916			1917			1918			1919			1920			1921	
Totals-	7820.14	8248	105.4	7025.25	7765	110.5	6313.98	3414	54.0	6271.82	2477	39.4	7341.71	1044	14.2	4797.22	79	1.6
From 1922 Report																		
Year Rolled		1917			1918			1919			1920			1921			1922	
Totals-	6945.43	9533	137.0	6117.93	5681	92.8	6402.43	4719	73.7	7550.63	2448	32.4	7421.29	806	10.9	5130.65	78	1.5
From 1923 Report																		
Year Rolled		1918			1919			1920			1921			1922			1923	
Totals-	5756.11	7221	125.4	6388.57	6697	104.8	7200.83	4545	63.1	7338.52	2568	34.9	7116.16	1135	15.9	4819.63	183	3.7
From 1924 Report																		
Year Rolled		1919			1920			1921			1922			1923			1924	
Totals-	5913.86	6845	115.7	7271.00	6146	84.5	6857.55	3905	56.9	6974.38	2429	34.8	9501.95	1363	14.3	4519.04	139	3.0

Table 3—Failures for Various Ages of Rail per 100 Track Miles

Year Rld	Years Service						Years Service					
	0	1	2	3	4	5	0	1	2	3	4	5
	Algoma						Bethlehem					
1908						482.9						503.7
1909					203.7						466.1	
1910				431.0		13.8				174.0	245.0	330.9
1911			219.7						113.3	195.3	251.7	329.8
1912		124.0						11.9	32.0	52.1	83.2	106.8
1913							1.6	13.4	26.9	52.6	77.3	99.5
1914		19.0	43.2	67.1	67.9	321.4	0.0	3.8	6.9	16.0	21.6	33.0
1915	1.4	7.1	11.8	22.9	39.1	84.0	0.0	17.1	24.5	41.0	65.0	92.4
1916	4.3	22.7	42.1	63.4	96.8	139.9	4.5	17.7	42.4	75.2	110.9	152.0
1917	135.5	2.0	2.0	9.1	29.7	62.9	12.1	39.0	59.2	94.8	127.7	157.5
1918							11.0	19.6	57.7	78.4	91.5	133.7
1919		7.3	26.6	55.8	82.9	36.7	3.1	31.2	72.3	105.0	160.7	213.9
1920	0.0	2.6	16.5	41.0	278.5		0.8	10.5	57.5	56.5	84.5	
1921	0.9	4.6	13.4	27.0			2.2	12.9	63.4	88.4		
1922	4.2	17.4	51.7				.9	55.6	77.3			
1923		30.3					7.7	7.4				
1924							10.4					
	Cambria						Carnegie					
1908												
1909					244.8	326.6					104.1	137.1
1910				98.5	136.4	201.0				98.9	112.9	101.1
1911			73.7	126.1	227.7	257.2			71.5	108.9	123.1	165.6
1912		17.1	41.8	74.3	108.9	140.9		12.3	30.9	55.3	78.4	98.8
1913	7.1	26.7	49.5	78.3	106.2	120.1	2.5	8.9	19.4	33.8	62.9	80.8
1914	1.7	15.8	37.7	61.9	64.3	137.7	0.8	5.5	11.9	16.6	25.4	48.8
1915	1.0	6.3	19.5	34.1	58.7	111.5	0.3	1.8	8.6	16.9	29.2	43.7
1916	5.4	7.3	25.9	33.7	73.7	157.6	0.4	4.9	13.2	26.8	45.6	69.7
1917	14.3	23.9	38.9	112.9	311.6	394.2	1.5	6.1	19.5	39.3	73.3	92.2
1918	0.0	32.9	95.5	248.0	369.7	507.4	1.4	6.2	41.6	50.2	73.7	125.5
1919		33.3	75.2	82.6	103.2	152.7	1.6	8.5	35.9	36.5	46.5	60.5
1920	16.9	37.6	44.2	96.8	158.5		2.9	7.0	15.1	34.4	59.4	
1921	8.4	13.8	43.2	101.2			0.5	3.3	8.6	23.6		
1922	3.4	16.1	43.9				.7	8.4	20.4			
1923	6.9	12.6					.4	4.1				
1924							2.2					
	Colorado						Dominion					
1908						45.5						
1909					22.4	34.2						
1910				19.6	23.4	60.9						
1911			15.8	31.0	52.6	84.3						
1912		18.3	40.9	55.6	91.3	117.6						
1913	1.2	3.9	11.0	26.0	46.6	82.1						
1914	1.0	3.7	7.6	14.1	27.3	42.0						
1915	0.2	4.6	7.7	15.1	34.4	80.3						
1916	1.0	5.8	15.7	34.5	53.6	78.1						
1917	0.7	5.4	12.5	38.7	51.5	42.6						
1918	0.0	6.5	13.1	39.7	109.0	184.8			60.0	149.0	420.9	482.7
1919	1.9	5.0	18.5	32.9	65.2	90.2		5.7	102.3	185.9	298.3	396.00
1920	0.7	9.3	27.6	75.0	96.5							
1921	0.0	9.2	31.7	50.6			7.2	60.9				
1922	2.5	12.0	27.1				0.0					
1923	1.3	7.0										
1924	.6											
	Illinois						Inland					
1908												
1909					151.9	219.7						
1910				88.4	136.8	206.2						
1911			67.5	94.0	107.7	178.6						
1912		7.4	23.2	39.2	64.6	100.0						
1913	1.1	10.0	21.9	44.0	62.1	91.5						
1914	1.0	11.6	30.0	47.3	83.6	98.3						
1915	0.1	10.7	21.9	40.9	56.1	78.8						
1916	0.8	11.1	26.0	43.9	70.7	97.3						
1917	0.7	9.1	19.9	46.3	75.5	107.7						
1918	0.2	2.5	10.8	18.5	45.4	50.3						
1919	0.6	11.5	26.8	43.7	77.1	107.1						
1920	0.9	5.4	13.3	36.9	55.6							
1921	0.5	4.2	16.2	27.0								
1922	0.1	5.0	11.2						19.00			
1923	1.0	6.6						7.69				
1924	2.3						0.0					

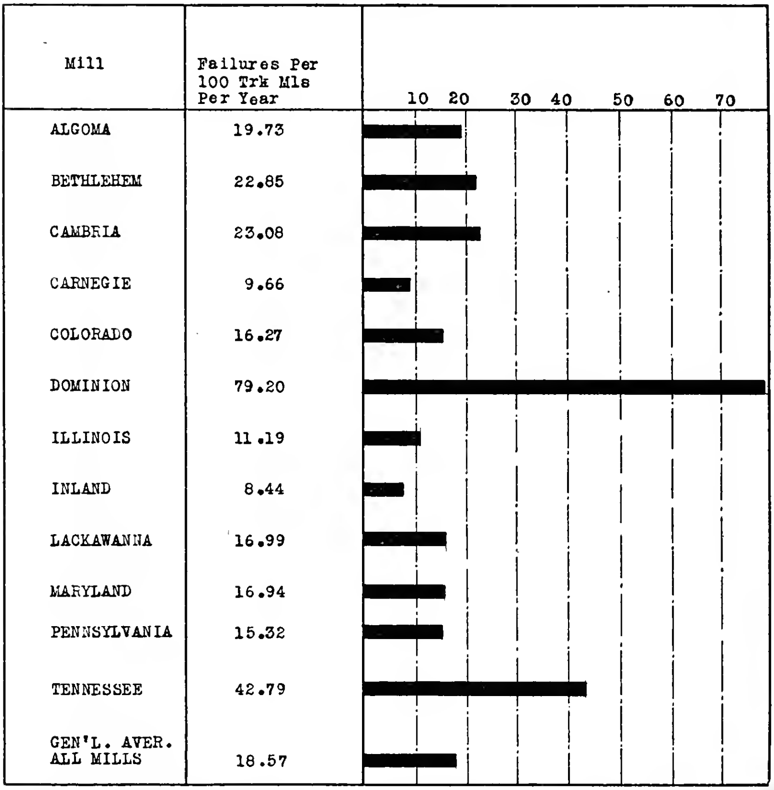
TABLE 3—CONTINUED

Year Rld	Years Servi e						Years Service					
	0	1	2	3	4	5	0	1	2	3	4	5
	Lackawanna						Maryland					
1908						143.5						
1909					100.1	117.8						
1910				42.7	90.3	148.9				69.6	104.8	163.7
1911			29.5	57.1	108.6	162.5			32.9	49.5	58.5	67.4
1912		4.8	20.1	39.6	67.1	88.6		11.3	5.8	18.1	8.6	110.8
1913	2.3	17.2	31.4	51.9	74.0	115.3	0.9	28.6	74.1	88.4	117.0	159.7
1914	0.3	1.8	10.0	24.5	49.3	78.7	1.1	13.3	25.2	31.4	36.2	62.9
1915	0.2	10.5	23.8	38.1	57.3	73.1	8.3	24.5	60.2	99.6	138.1	231.4
1916	2.4	8.9	25.5	40.1	58.0	76.9	1.6	30.7	61.8	92.6	96.6	180.3
1917	0.8	16.8	31.6	46.6	78.3	104.5	49.1	160.5	214.2	360.5	425.5	445.5
1918	2.1	7.4	23.7	43.8	65.5	93.2	6.9	23.7	59.2	113.6	139.1	210.2
1919	2.5	22.8	51.9	77.4	86.7	153.0	10.8	34.2	52.8	60.8	90.8	106.9
1920	5.1	14.5	27.1	50.6	74.1		0.0	0.0	2.3	11.9	11.9	
1921	1.2	3.8	19.0	41.3			0.0	0.0	7.2	25.3		
1922	0.3	4.0	13.6									
1923	5.0	18.6										
1924	9.1						3.2					
	Pennsylvania						Tennessee					
1908						72.9						86.5
1909					86.3	101.4					11.1	83.7
1910				81.4	110.9	123.8				32.4	47.8	55.2
1911			34.6	79.6	119.0	145.2			14.9	25.1	40.8	61.7
1912		5.3	15.6	27.5	46.8	60.4		7.3	32.9	43.9	64.5	83.2
1913	1.1	9.6	21.0	34.7	47.2	71.2	1.5	5.7	16.5	24.5	41.6	57.3
1914	2.5	8.2	21.1	29.4	38.0	49.7	1.7	7.5	16.6	29.0	44.2	60.8
1915	0.0	6.3	18.1	27.9	48.4	59.6	1.3	6.0	16.0	30.5	48.0	70.9
1916	0.0	35.6	46.1	94.2	136.1	171.7	2.3	15.6	37.1	61.1	82.2	123.4
1917							3.2	17.3	35.7	58.2	102.5	109.5
1918	0.0	2.4	9.2	20.7	50.6	76.0	1.6	16.4	34.6	79.9	143.1	145.3
1919	11.1	46.9	79.6	139.8	175.1	235.8	2.2	14.1	54.2	100.7	132.3	79.7
1920	1.8	56.3	38.5	73.2	96.7		12.1	39.9	83.1	149.3	189.8	
1921	0.0	4.9	12.2	25.9			8.1	37.5	84.9	149.7		
1922	0.0	10.3	18.7				5.1	42.7	106.7			
1923	0.0	10.0					12.9	42.4				
1924	3.2						5.1					

All Mills

Year Rld	Years Service					
	0	1	2	3	4	5
1908						370.5
1909					163.6	198.5
1910				81.3	107.1	154.0
1911			53.0	83.5	111.2	161.9
1912		26.3	28.9	46.0	74.2	102.7
1913	1.8	11.5	24.8	43.3	68.5	90.3
1914	1.1	8.0	18.9	30.8	47.4	74.0
1915	0.8	8.8	19.0	33.8	53.0	82.4
1916	1.7	11.7	27.9	47.7	70.6	105.4
1917	5.4	21.8	38.9	66.0	110.5	137.0
1918	1.5	8.9	27.6	54.0	92.8	125.4
1919	2.0	14.8	39.4	73.7	104.8	118.7
1920	3.9	14.2	32.4	63.1	84.5	
1921	1.6	10.8	34.9	56.9		
1922	1.5	15.9	34.8			
1923	3.7	14.3				
1924	3.0					

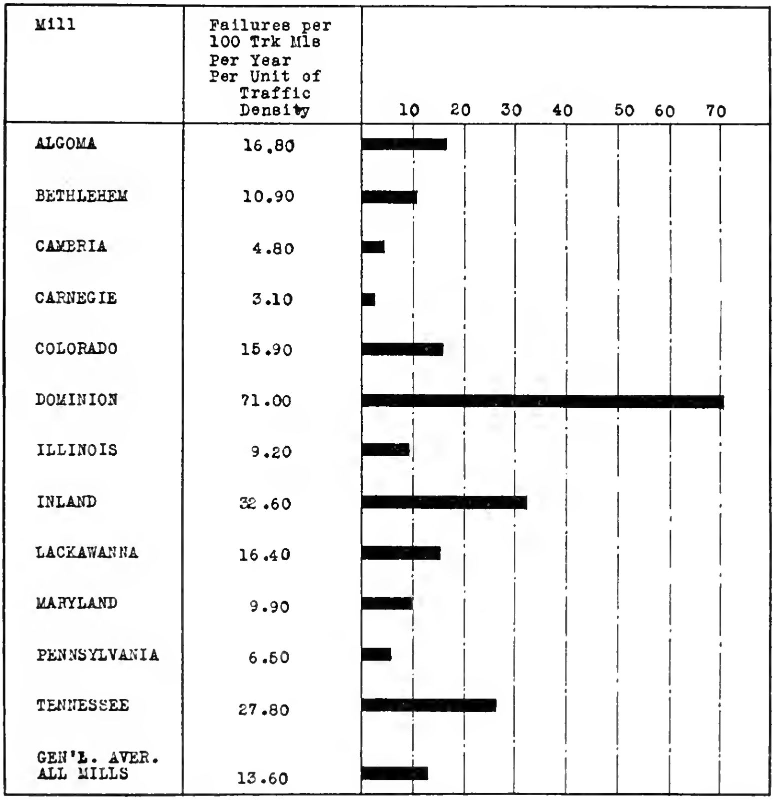
Diagram Showing Mill Ratings for Five-Year Period Compiled by Usual Method



Mill	Failures Per 100 Trk Mls Per Year
ALGOMA	19.73
BETHLEHEM	22.85
CAMBRIA	23.08
CARNEGIE	9.66
COLORADO	16.27
DOMINION	79.20
ILLINOIS	11.19
INLAND	8.44
LACKAWANNA	16.99
MARYLAND	16.94
PENNSYLVANIA	15.32
TENNESSEE	42.79
GEN'L. AVER. ALL MILLS	18.57

Fig. 3—Average Failures Classified by Mills for the Rollings From 1919 to 1923, Inclusive

Diagram Showing Mill Ratings for Five-Year Period as Altered by Use of Traffic Density Factor.



Mill	Failures per 100 Trk Mls Per Year Per Unit of Traffic Density
ALGOMA	16.80
BETHLEHEM	10.90
CAMBRIA	4.80
CARNEGIE	3.10
COLORADO	15.90
DOMINION	71.00
ILLINOIS	9.20
INLAND	32.60
LACKAWANNA	16.40
MARYLAND	9.90
PENNSYLVANIA	6.60
TENNESSEE	27.80
GEN'L. AVER. ALL MILLS	13.60

Fig. 4—This Diagram Is Presented for Information Only and Shows Ratios Changed From Those Presented in Fig. 3

Failures per 100 Track Miles—Total for Five Years' Period

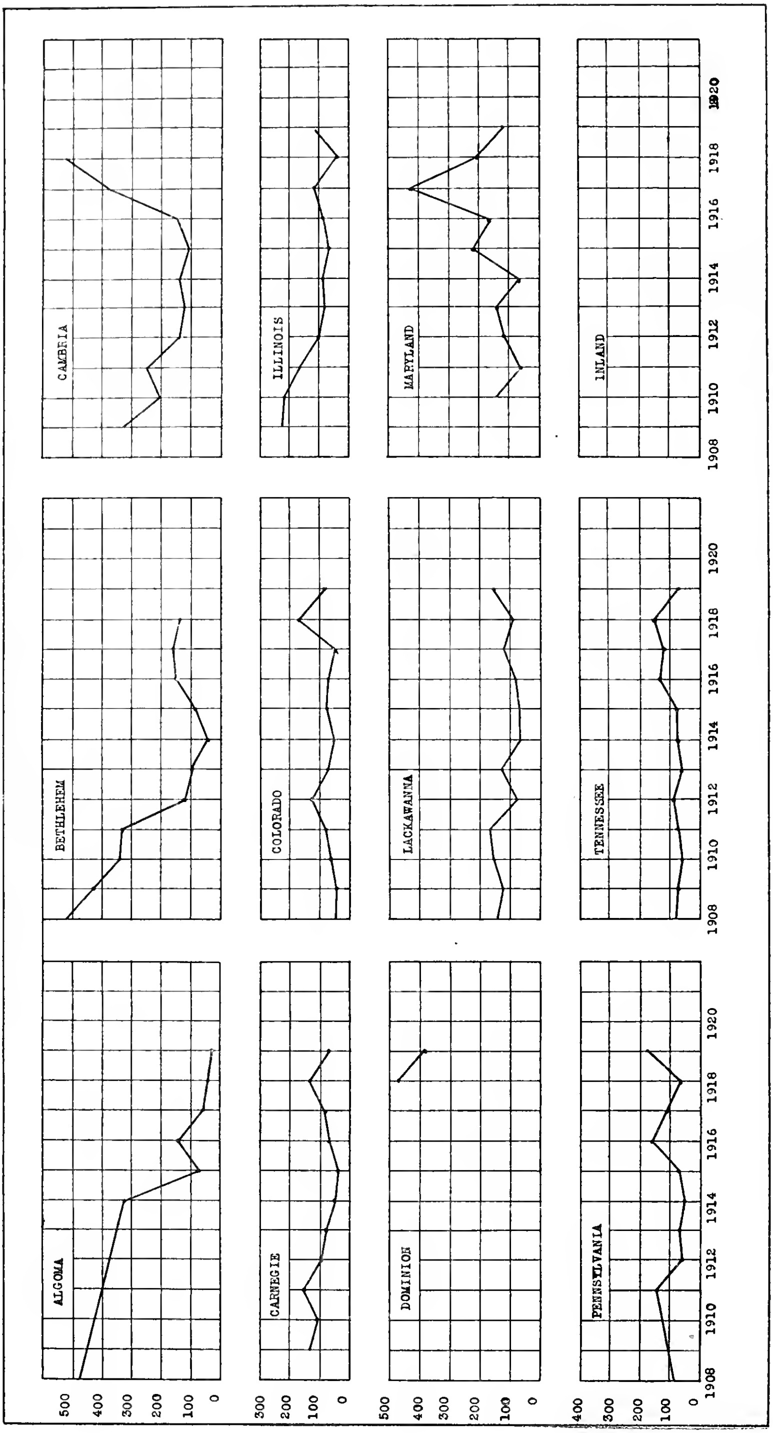


Fig. 2—Record of Failures per 100 Track Miles for Five Years' Service for Rollings From 1908 to 1919

Table 4—Recapitulation—Totals and Averages Grouped by Mills—Track Miles Represent Quantity Originally Laid; Failures to Date Computed by Mile Years of Rail in Service

Year	Track Miles	Total	Failures to Date Per 100 Track Miles To Date	Failures to Date Per 100 Track Miles Per Year	Track Miles	Total	Failures to Date Per 100 Track Miles To Date	Failures to Date Per 100 Track Miles Per Year
			Algoma				Bethlehem	
1919	136.26	49	36.74	7.35	604.13	1306	213.94	42.79
1920	28.88	81	278.64	69.63	284.67	261	84.55	21.14
1921	605.82	164	27.09	9.03	498.13	637	88.44	29.46
1922	363.39	188	61.71	25.85	295.99	213	77.31	38.66
1923	424.93	129	30.36	30.36	1270.52	69	7.49	7.49
Totals	1559.27	611		19.73	2953.44	2486		22.66
			Cambria				Carnegie	
1919	42.56	68	152.70	30.64	464.97	307	60.63	12.11
1920	130.88	251	158.51	39.63	1145.02	529	59.44	14.86
1921	56.86	201	101.27	33.76	800.71	227	23.63	7.88
1922	281.26	104	43.91	21.95	905.70	150	20.44	10.22
1923	271.95	34	12.65	12.66	1126.57	42	4.18	4.18
Totals	783.51	658		23.06	4442.97	1255		9.66
			Colorado				Dominion	
1919	818.95	741	90.27	16.05	1.27	4	396.00	79.20
1920	577.39	561	96.69	24.15				
1921	525.60	266	50.61	16.87				
1922	556.99	151	27.14	13.57				
1923	517.97	40	7.01	7.01				
Totals	2996.90	1759		16.27	1.27	4		79.20
			Illinois				Inland	
1919	2018.69	2139	107.19	21.44				
1920	2337.82	1333	55.68	13.92				
1921	2512.66	685	27.06	9.02				
1922	1757.33	209	11.21	5.60	267.76	55	19.00	9.50
1923	2592.77	164	6.64	6.64	405.73	31	7.69	7.69
Totals	11219.27	4530		11.19	673.49	86		8.44
			Lackawanna				Maryland	
1919	601.17	859	153.01	30.60	184.48	207	106.95	21.39
1920	1467.87	1056	74.19	18.55	41.90	5	11.90	2.97
1921	512.92	216	41.30	13.77	27.60	7	25.36	8.48
1922	971.64	130	13.61	6.81				
1923	654.33	108	18.66	18.66				
Totals	4207.83	2369		16.99	253.98	219		16.94
			Pennsylvania				Tennessee	
1919	180.91	458	233.82	48.45	860.48	677	79.74	15.95
1920	241.59	231	96.73	24.18	1014.98	1848	169.88	47.47
1921	264.88	68	25.90	8.63	1046.37	1534	149.74	49.91
1922	498.97	97	18.76	9.38	1076.45	1132	106.75	53.38
1923	717.08	65	10.60	10.60	1520.10	660	42.49	42.49
Totals	1903.43	919		15.32	5518.38	5851		42.79

All Mills

Year	Track Miles	Total	Failures to Date Per 100 Track Miles To Date	Failures to Date Per 100 Track Miles Per Year
1919	5913.86	6845	115.74	23.15
1920	7271.00	6146	84.53	21.13
1921	6857.55	3905	56.94	18.98
1922	6974.38	2429	34.82	17.41
1923	9501.96	1363	14.34	14.34
Totals	36518.74	20688		18.57

Table 5—Average Weights of Rails Compiled from Tonnages Used in This Report

Mill	1919	1920	1921	1922	1923	1924
Algoma	98.4	92.9	100.4	100.9	99.4	
Bethlehem	109.2	100.6	104.2	112.3	105.1	92.9
Cambria	105.4	120.6	119.0	118.5	112.7	
Carnegie	102.4	101.7	107.2	110.1	106.2	121.7
Colorado	90.4	90.8	90.0	90.0	90.9	94.6
Dominion	85.0					
Illinois	92.3	95.2	95.9	96.1	97.9	96.4
Inland				94.5	97.6	91.1
Lackawanna	95.7	97.6	97.4	90.2	97.2	96.6
Maryland	91.6	85.0	85.0			103.0
Pennsylvania	102.0	119.6	107.1	108.7	119.5	119.3
Tennessee	88.7	89.1	87.9	91.4	94.6	95.1
Average	95.2	92.2	97.3	99.8	101.5	95.1

Diagram Showing Failures per 100 Track Miles by Mills and Years for Periods Ending October 31, 1924

Mill	Year Rolled	Failures Per 100 Trk Mls
ALGOMA	1919	36.74
	1920	278.54
	1921	27.09
	1922	51.71
	1923	30.36
BETHLEHEM	1919	213.94
	1920	84.55
	1921	88.44
	1922	77.31
	1923	7.49
CAMBRIA	1919	152.70
	1920	158.51
	1921	101.27
	1922	43.91
	1923	12.65
CARNEGIE	1919	60.53
	1920	59.44
	1921	23.63
	1922	20.44
	1923	4.18
COLORADO	1919	90.27
	1920	96.59
	1921	50.61
	1922	27.14
	1923	7.01
DOMINION	1919	396.00
INLAND	1922	19.00
	1923	7.69
ILLINOIS	1919	107.19
	1920	55.68
	1921	27.06
	1922	11.21
	1923	6.64
LACKAWANNA	1919	153.01
	1920	74.19
	1921	41.30
	1922	13.61
	1923	18.66
MARYLAND	1919	106.95
	1920	11.90
	1921	25.36
PENNSYLVANIA	1919	233.82
	1920	96.73
	1921	25.90
	1922	18.76
	1923	10.60
TENNESSEE	1919	79.74
	1920	189.88
	1921	149.74
	1922	106.75
	1923	42.49
GEN'L AVER. ALL MILLS	1919	115.74
	1920	84.53
	1921	56.94
	1922	34.82
	1923	14.34

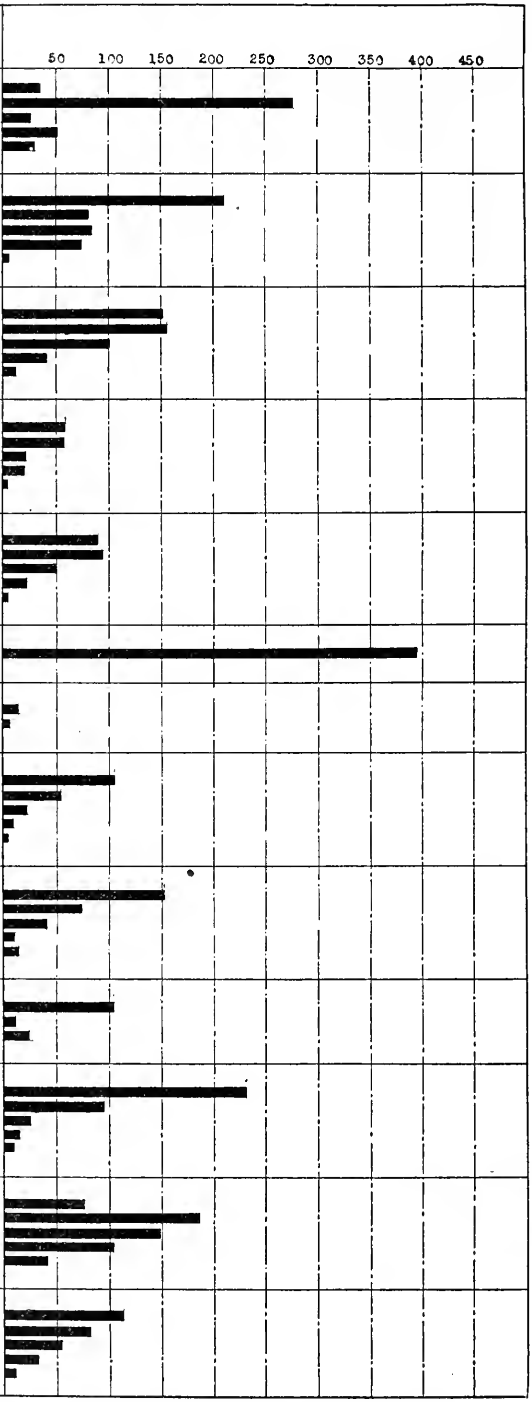


FIG. 5—ACCUMULATED FAILURES FOR ROLLINGS FROM 1919 TO 1923

Appendix C

(6) EFFECT OF VARIOUS BOLT TENSIONS ON MECHANICAL STRENGTH OF JOINTS

(7) CAUSE AND PREVENTION OF RAIL BATTERING

E. E. Adams, Chairman, Sub-Committee (3)

MONOGRAPH

By Hunter McDonald

Past-President; Vice-Chairman, Committee IV—Rail; Member of Sub-Committee (3)

ACKNOWLEDGMENT

The field observations on the sections of test track on the Chattanooga Division herein referred to have been under the general direction of Mr. J. L. Fergus, Division Engineer. Measurements in the field and notes on track conditions were made by Mr. W. H. Lord, Assistant Engineer.

In the assembly and plotting of the data, Mr. A. F. Ganier, Assistant Engineer—Design, in the office of the Chief Engineer, had general direction. He was ably assisted in the development of graphs, study of comparative data, etc., by Mr. L. D. Rankin, Structural Designer.

Mr. B. M. Cheney, of the firm of Laughlin & Cheney, Inc., of Chicago, formerly Inspector of Maintenance for the Chicago, Burlington & Quincy Railroad, has carried out some interesting experiments on bolt tensions at Western Avenue in the suburbs of Chicago on the Burlington Railroad. He furnished copies of his report on October 1st on these tests to Mr. Emerson, Secretary of the Rail Committee. Reference will hereafter be made to the results which he obtained.

EXHIBITS

It is intended that the Exhibits accompanying this paper will tell the most of the story. However, this cannot be completely done by the use of illustrations and figures. The list is as follows:

List of Exhibits

Exhibit	*Description*	
A	Log of data, from observations (110-lb R.E. Section Rail)	M.P. 105-106.2
B	Supplemental notes on above Log	M.P. 105-106.2
C	Graph of Joint Gaps, Rail Creep and Rail Batter	M.P. 105-106.2
D	Chart, influence of Alinement on Joint Gaps and Batter	M.P. 105-106.2
E	Chart, showing relation between Joint Gaps and Batter	M.P. 105-106.2
F	Chart, showing relation between Batter and Ingot Position	M.P. 105-106.2
G	Chart, showing relation between Batter and location of Ties under Joints	M.P. 105-106.2

H	Chart, showing relation between Batter and Carbon Content	M.P. 105-106.2
I-a	Chart showing relation between Batter and Heat Numbers	M.P. 105-106.2
I-b	Data on 12 Joints where Batter was excessive	M.P. 105-106.2
J	Data on 34 rails where Batter was at minimum	M.P. 105-106.2
K	Photos, showing effect of Brine Drippings on Bolt Tension, with descriptive data.	
L	Photos, showing a type of chipping at Joints, with descriptive data.	
M	Instruments developed for taking measurements of Joint Gaps and Batter.	
N	Proposed Expansion Tables and Expansion Shims.	

INTRODUCTORY

Assignments.—Shortly after the writer was made a member of the Rail Committee in 1922, he suggested as a fitting subject for study: "The movement of contiguous rails through standard bolted joints."

This subject was reported to the Board of Direction and in Bulletin 256 of June, 1923, the Board announced as Subject No. 4 of the Rail Committee the following:

> "The movement of contiguous rails through standard bolted joints, with especial reference to the force necessary to produce movement and the effect of lubricated contact surfaces between rail and joints."

The writer, being about to begin the laying of 110-lb. rail on single track without slot spiking and with rail anchored in each direction, undertook for the Committee to make observations on this rail which might throw light on the subject.

In Bulletin 256, June, 1923, the Board of Direction announced, for the Rail Committee, among others, the following subjects:

> (7) "The advisability of lubricating the contact surfaces between joints and rails, together with the effect of various bolt tensions on the mechanical strength of joints and the resistance to slip."
>
> (9) "The cause and prevention of rail battering, with a discussion as to principles of rail joint design, collaborating with the Committee on Track."

In Bulletin 276, June, 1925, the Board announced, for the Rail Committee, among others, the following subjects:

> (6) "Continue the study of the effect of various bolt tensions on the mechanical strength of joints."
>
> (7) "Continue the study of the prevention and cause of rail battering."

Test Track.—On page 1289 of Proceedings for 1924 will be found the first progress report made by the writer on the subject of "Movement of rail through joint bars," and for convenience in describing the stretch of track under observation the first two paragraphs and a portion of the third of this progress report are here quoted:

> "The stretch of track, 1 and 22/100 miles long, selected for the test, lies along the edge of a creek bottom. The grades are

> undulating, having three summits, in clay and limestone cuts. The gradients are one per cent. There are three level stretches. The embankments will average seven feet in height. One-half mile of the track is on tangent; 2,000 feet on 3 deg. curve to the right and 1,750 feet on 4 deg. curve to the left, the curves reversing on a point but having short spirals.
>
> "The track is well balanced; ballast not shouldered; underlying soil, clay; ties in good condition; rail 110 lb. per yard; rolled by Tennessee Coal, Iron & Railroad Company at Ensley, Ala., in April, 1923, and laid in June, 1923. Hipower nutlocks were used and joints wrenched up in the usual way, no special effort being made to secure uniform bolt tension. Joints consist of angle bars heat treated and oil quenched, with heat treated rolled thread bolts—1 inch diameter. The track is tie-plated throughout with 7 by 10¼ plates canted 1 in 40. No spikes were driven in slots and ties were not respaced to provide for suspended joints. Rail anchors were applied throughout, 6 to each rail, 3 facing in each direction. Expansion allowance was made in accordance with the A.R.E.A. standard. The temperatures were taken on the rail with a rail thermometer.
>
> "Reference hubs were set on each side at intervals of 1000 feet and in such a way that by stretching a cord any creeping could be accurately determined."

Maintenance.—At this point it will be appropriate to add something with respect to the manner in which the track in this test section has been maintained and operated. For sketch map of alinement, superelevation, allowable speed, daily traffic, etc., see diagram at the top of Exhibit D.

During the years 1920, 1921 and 1922, the entire stretch of track was overhauled with an average raise of 4 inches on limestone ballast without shoulder above the bottom of the ties, white oak ties being inserted north of Joint 292. The ties south of this joint were creosoted red oak put in out of face in 1920. The ties under the 90-lb. rail at the time of overhauling were respaced and spikes driven in slots for suspended joints. Ballast shoulders were added in 1923 after the 110-lb. rail was laid. Two hundred and forty white oak ties have been patched in north of Joint 292 since December, 1922. The labor cost for Mile 106 of patching in ties, lining, surfacing, wrenching bolts from July, 1923, to October, 1925, inclusive, was $1300.

Observations.—Eleven sets of joint gap observations were made at various periods between June 27th, 1923, and October 26th, 1925, but unfortunately for this investigation the lowest average temperature obtained for any set of observations was 25.5 deg. The highest average temperature for which observations were made was 118.5 deg. Each set of observations is plotted (Exhibit C) above the base line, in a distinguishing symbol. Horizontal spaces represent rails 33 feet long.

Rail Batter.—During the course of the observations on this test track and of 110-lb. rail laid at other points, it was noted that rail batter was proceeding with apparently unusual rapidity, and it was concluded to be desirable to plot the rail batter on the same chart upon which the joint gap data for various dates was plotted, in order that the two phenomena might be studied in connection with each other.

This course was suggested to the Rail Committee by the writer and met with its approval. Accordingly, two sets of observations were taken for joint batter, the first, March 5th, 1925, and the last October 26th, 1925. These are plotted on Exhibit C under the respective joints and below the base line from which the joint gaps above the line were plotted.

The vertical lines under a joint represent the ends of the rails forming the joint. The short horizontal lines on each side of the vertical lines represent the extent of the batter below the base line. Where only one horizontal line appears, the two readings for the different dates were identical.

Joint Support.—The upright and inverted V's on Exhibit C represent respectively suspended and supported joints as defined by diagram at the top of the Log, Exhibit A. Where neither of these symbols appears the joint is termed "Neutral."

System of Numbering.—On Exhibit A will be found a diagram illustrating the system of numbering the joints and rails. The even numbers refer to the east rail, and the odd numbers to the west one. The number of a rail is the same as the joint number at its north end. For instance, rail No. 1 is on the west side of the track and between Joints 1 and 3.

Second Progress Report.—Reference is made to the progress report submitted by the writer at the Convention in 1925 while the report of the Rail Committee was under discussion. (See page 1420 of Proceedings for 1925.)

Various Weights of Rail.—In addition to the special sources of information above described, advantage has been taken of an intimate and extensive knowledge on the part of the writer of the life history of the rail, and the traffic over it, on various parts of the system on which he has charge of the maintenance, ranging in dates of manufacture from 1876, and of various weights.

Methods of Observations.—In the earlier days of this investigation, it was thought desirable to measure not only the depth of batter at the joint gap but the extent of the battered area measuring back from the joint gap. The measurements were taken under a steel straightedge about eight inches long applied at the end of the rail but not spanning the gap. The length of the battered area was determined by inserting a feeler gage of .0015 inch in thickness, pushing it away from the joint gap under the straightedge until it could be moved no farther. The distance from the joint to the far edge of the feeler gage was measured. The average length of battered area for single track on 110-lb. rail was found to be 1.276. The measurement of the extent of the battered area was subsequently abandoned, as not being worth the trouble. The depth of the batter was measured between the straightedge and the top surface of the rail with thickness gages, a series of blades being selected to fit the space in question. The thickness gage was one-half inch wide; one edge coincided with the end of the straightedge and rail and the other was one-half inch back from the end. The batter reading was, therefore, at a point one-half inch from the end of the rail. After the first readings, March 5th, were taken it was recognized that the batter was considerably greater at the edge of the joint than at the point one-half inch back, but in order to get comparable readings it was necessary to take the October 26th readings in the same way as those of March 5th. The batter slopes off rapidly as the joint is approached and extreme actual batter is, therefore, greater than the amounts shown on the Exhibit. At just what point the actual reading should be taken is a question.

Instruments Developed.—A special taper gage in two leaves was developed for measuring joint gaps and later a micrometer screw reading to 1000ths inch, combined with a straightedge, for measuring batter. These instruments are illustrated on Exhibit M. With the micrometer screw it would be possible to take the reading at any point but if end overflow is present, care is necessary in order to secure uniformity in measuring.

Double Track.—On account of the fact that the proportion of double track on the Nashville, Chattanooga & St. Louis Railway is somewhat small and it is a common practice to operate trains in both directions on both tracks in order to pass fast-moving trains around slow ones, especially on mountain grades, no formal study of rail movements through joints or of rail batter for double track has been made.

Cropped, Resawed or Clipped Rail.—A small amount of 90-lb. A.R.A. Section "A" "cropped" rail, taken from the main track of the Chattanooga Division and relaid again in the same track under the same character of traffic as that moving over tracks in the vicniity of Anderson and Bass has been studied with respect to end overflow and chipping.

Bolt Tensions.—The effect of brine drippings tending to reduce tension in bolts has been observed and reference is made to Exhibit K.

The following is quoted from the progress report for 1925, page 1420 of Proceedings:

> "It is hoped that when the amount of bolt tension necessary to maintain the maximum strength of a joint has been determined experimentally, some practicable means may be found to avoid unnecessarily high bolt tension."

Observations by Prof. Talbot's Party.—On page 1245, paragraph No. 4, of the Proceedings of 1925, under the heading of "Other Tests," Prof. A. N. Talbot, Chairman of the Special Committee on Stresses in Railroad Track, and under the auspices of the Committee on Track, reports progress on laboratory tests on bolted up joints of various sections of rail and the longitudinal pressure required to cause the rail to slip in the joint for different conditions, such as varied tension in bolts, etc. He states:

> "It is planned to carry further the investigation on rail joints. It is hoped that an instrument may be devised to measure strains in the splice bars at the top, bottom and middle of bar under condi-

tion of support of rail found in track. Tests in other lines are also under consideration."

On November 7-12, inclusive, Prof. Talbot's party, under the direction of his assistant, Mr. E. E. Cress, made observations on a number of the joints on the test mile 106 which included bolt tensions and stresses in the splice bar. These measurements were made by very ingenious instruments especially devised for the purpose. The writer is advised by Prof. Talbot that similar observations have been made on other railroads and the results will be forthcoming whenever the data collected can be properly arranged and studied and conclusions announced.

Further Investigations.—Conclusions following are, of course, to be considered as individual expressions of the writer, and unless qualified they are to be considered as final as such. However, the data herein presented has for its principal object the offering of some suggestions for further investigation of each of the subjects by those who are interested in it and who may have better laboratory facilities, a better equipped organization and a superior knowledge of the technique of investigations in metallurgy than has been at the disposal of the writer. The limited time between the completion of the observations and the preparation of this report has precluded exhaustive study of and deductions from the data submitted.

It is fully recognized that before the Committee can be in position to announce definite conclusions, much more data and information must be accumulated on both subjects, which will require time and the expenditure of considerable money.

The writer intends this paper as the conclusion of the results of his investigations, but sincerely hopes that the assignment may be continued and the subject studied by appropriate committees until the Association is in position to announce its final conclusions.

Plan of Discussion.—In what follows an effort will be made to discuss the two subjects covered by the assignment under separate headings, but, on account of their intimate relationship and interdependence and for convenience in understanding and reference, it may be necessary at times to refer to each subject in the same paragraph.

SUBJECT (6) "EFFECT OF VARIOUS BOLT TENSIONS ON MECHANICAL STRENGTH OF JOINTS"

Desirable Length of Rail.—At the Convention in 1924, Chairman Lem Adams, of Sub-Committee No. 3 of the Rail Committee, in presenting the report, made reference to the possibility of the investigation which the writer was making throwing light on this question. This possibility arises from the fact that where rails are tightly bolted together, they have a tendency to act in conjunction with each other over long distances, producing movement only at joints where least resistance is offered. The following is quoted from an introduction of this subject appearing in the first progress report of these observations on page 1290, Proceedings for 1924:

> "Considering joints showing a total movement of $\frac{1}{16}$ inch or less between extremes of temperature as 'frozen' or so tightly bolted as not to admit of movement, the following single and 'multiple' rail lengths were observed."

Then follows the data as to "the number of single rails and number and length of composite rails" with the result that an average length of 40 feet was obtained for the rails on the east side of the test track and of 44 feet for those on the west side.

A corresponding calculation was made as of October 26th, 1925, with results as follows: Average length of single and multiple rails: East rail, 45 feet; West rail, 50 feet. Slightly different results might be obtained on any different day when conditions as to bolt tensions may have been altered by operations in tightening up bolts or by relaxing of tension from various causes. However, it tends to confirm the writer's belief that 45 feet is the most desirable standard length for rails.

RAIL CREEPING

Restraint of Rail Creep.—The following statement in the first progress report: "That it is entirely practicable to prevent rail creeping on single track by anchoring in both directions"—has been amply confirmed, and the total amount of such creeping in both directions may be safely set down as about one inch. It is not possible to confine creeping within closer limits on account of the fact that there is always some lost motion between the rail anchor and the side of the cross-tie and between the side of the cross-tie and the ballast. In some instances, on track anchored in both directions, a creeping of one inch has been observed in one direction after the passage of a train and corresponding creep in the other direction by the passage of another train in the opposite direction. Such changes also take place as a result of temperature changes, but this condition obtains more constantly on double track than on single track. The ideal condition is that which confines rail creeping to a single rail, but, on account of the lost motion above referred to, and the small expansion gaps required at higher temperatures, this ideal can never be attained.

Tests with Calibrated Spring Washers.—Mr. Cheney, as a result of his experiments with calibrated Verona spring washers at Western Avenue and at Riverside on the Burlington on double track line, has reached the conclusion that for freedom of movement of rail through joints, bolt tensions should not exceed 15,000 lb. and that for necessary strength of joint the minimum tension should be 10,000 lb. His experiments do not support the latter conclusions but certainly there is a minimum beyond which the tension should not be permitted to relax.

Types of Nuts and Length of Wrenches.—Mr. Cheney's tests were made on both the so-called "free turn" bolts and "wrench fit" bolts. With the "free turn" bolts a wrench 36 inches long was used by which a tension of 20,000 lb. was secured. On the "wrench fit" bolts with a 36 inch wrench a tension of 10,000 lb. was secured; with a 42 inch wrench, 12,500 lb., and with a 48 inch wrench, 20,000 lb.

Secretary Emerson, in transmitting Mr. Cheney's report to the members of the Rail Committee, wrote as follows:

> "I may say that the feature of this investigation surprising me most was the considerably increased power necessary to pull the nuts up to a given pressure when our standard track bolt was used as against the amount of power necessary to produce the same pressure when using the Burlington standard "free turn" threads. After several pulls, it appeared to me that at least a quarter less effort was necessary on the Burlington threads."

It is to be regretted that space will not admit of the insertion of Mr. Cheney's full report.

Prof. Talbot's Measurements.—With a view of comparison with Mr. Cheney's findings, a study has been made of the bolt tension and movement of rails through the joints upon those joints where Prof. Talbot's party measured the bolt tensions. The results are listed in the table below. It is a fact that the rail movement in a joint takes place only through one-half of the joint unless all bolts are quite loose and it might be expected that wherever the average tension of bolts (3) and (4) is considerably higher than that of bolts (1) and (2) or vice versa, movement would take place through that portion of the joint which showed the lowest average tension.

				Condition as to Movement, October 26, 1925				
Jt.	Average Tension 1 and 2	Average Tension 3 and 4	Average Joint Gap 64ths In.	Joint Tested	First Joint South	Second Joint South	First Joint North	Second Joint North
5	15500	19750	1.1	Fr.	N. R. fr. S. R. mo.	Fr.	N. R. fr. S. R. mo.	Fr.
14	5500	14200	9.4	S. R. fr. N. R. mo.	Fr.	Fr.	Fr.	Fr.
33	....	25500	17.6	S. R. fr. N. R. mo.	Fr.	Fr.	S. R. fr. N. R. mo.	N. R. fr. S. R. mo.
54	21250	14250	5.7	Fr.	Fr.	Fr.	Fr.	Fr.
55	17000	21500	5.0	S. R. fr. N. R mo.	S. R. fr. N. R. mo.	Fr	Fr.	Fr.
56	4500	11500	11.2	Fr.	Fr.	Fr.	Fr.	Fr.
57	22100	17500	16.6	Fr.	S. R. fr. N. R. mo.	S. R. fr. N. R. mo.	Fr.	Fr.
66	15750	7500	13.1	N. R. fr. S. R. mo.	Fr.	Fr.	Fr.	Fr.
68	16500	12750	8.5	Fr.	N. R. fr. S. R. mo.	Fr.	Fr.	Fr.
80	16250	7500	10.4	N. R. fr. S. R. mo.	Fr.	Fr.	Fr.	Fr.
89	9500	15500	11.1	Fr.	Fr.	S. R. fr. N. R. mo.	Fr.	Fr.
94	16250	14750	12.7	Fr.	S. R. fr. N. R. mo.	Fr.	Fr.	S. R. fr. N. R. mo.
105	16100	11000	9.0	Fr.	Fr.	Fr.	Fr.	Fr.
106	10250	10500	5.9	Fr.	Fr.	Fr.	Fr.	Fr.
126	18500	12000	9.3	Fr.	Fr.	Fr.	Fr.	Fr.
141	15500	15500	3.0	Fr.	Fr.	Fr.	Fr.	Fr.
158	3800	16750	12.8	Fr.	Fr.	Fr.	Fr.	Fr.
209	19500	11750	2.1	Fr.	Fr.	Fr.	Fr.	Fr.
229	7750	16500	15.0	S. R. fr. N. R. mo.	Fr.	Fr	Fr.	Fr.
281	22250	8000	0.7	Fr.	Fr.	Fr.	Fr.	Fr.

Attention is called to the fact that odd and even numbers are in the West and East rails respectively and that only in the cases of Joints 54 and 56, 55 and 57 and 66 and 68 are any of the above joints contiguous.

Joints having average bolt tensions above 10,000 lb. but showing movement ....1—No. 55
Joints having average bolt tensions above 10,000 lb. but frozen.......... ....10—Nos. 5, 54, 57, 68, 94, 105, 106, 126, 141, 209
Joints having average bolt tensions on one side below 10,000 lb., moving ....5—Nos. 14, 33, 66, 80, 229
Joints having average bolt tensions on one side below 10,000 lb., frozen ....4—Nos. 56, 89, 158, 281

It appears that 75 per cent of these cases tend to confirm Mr. Cheney's findings, while 25 per cent are abnormal.

The condition as to movement of two joints on each side of the ones under consideration is shown, but this does not explain the abnormality except in the case of No. 89—carrying it further might do so.

Definite conclusions as to the maximum bolt tension which will admit of movement of the rail in the joint might be reached if measurements were taken on a much larger number of joints in continuous stretches of track anchored in both directions.

"Nutlocks."—In his reply of July 27th, 1925, to a questionnaire issued last July by a Sub-Committee of the Track Committee on the subject of nutlocks, the writer stated as follows:

> "A mere nutlock or a device which simply prevents a nut from turning is not a proper appliance to put on a rail joint . . . . This principle has been recognized by the Rail Committee and it has recommended the adoption of the term spring washer in lieu of nutlock on specifications for such appliances applicable to rail joints. Any spring washer should be capable of maintaining for a reasonable length of time the necessary tension in the bolt to produce the proper strength of the joint. In maintaining such tension it must take up and compensate for wear of the bearing parts."

In his reply of September 3rd on this same subject, Mr. C. F. W. Felt, Chief Engineer of the Santa Fe Railway System, very aptly described the function of a spring washer for a track bolt as follows:

> "To store energy exerted in screwing the nut onto the bolt and delivering same as surfaces of rail, joint, bolt and nut wear, thus tending to retain high pressure within the joint."

Spring Washers.—The ideal spring washer should satisfactorily perform the functions outlined in the above quoted replies to the questionnaire and should, therefore, possess the greatest possible range of reaction and the power to retain this range for the greatest length of time.

Spring washers which flatten permanently under bolt tensions required to retain the desirable strength of joint are an unnecessary appendage, inasmuch as the labor of wrenching the bolt to take up the wear after the spring washer has flattened is just as great as it would be with no spring washer used. The only excuse for the use of such washers is as a filler.

The forces tending to reduce the tension in the bolt are: (1) The giving way and gradual adjustment of the rough surfaces between the bolt head and the splice bar; (2) The sidewise moving and twisting of the angle bar under traffic; (3) The wearing into the nut of the sharp corners of spring washers; (4) The wearing of the fishing surfaces between the splice bars and the rail, and (5) The effect of brine drippings on the bearings of the bolt at each end and on the fishing surfaces of rail and splice bars.

The brine drippings operate principally on the outside of the rail and it is desirable, therefore, that the spring washers be applied on the inside in preference to the outside.

A spring washer which operates on two bolts and tends to maintain uniformity of tension in each pair of bolts is preferable to any device which is applied singly to each bolt because uniform tension is more readily maintained and therefore requires less labor.

Rail Anchors.—The ideal rail anchor should not depend upon contact with the tie plate for its effectiveness but should have its contact with the cross-ties at a considerable distance below the bottom of the tie plate in order to avoid reliance upon the spikes for effective anchorage. It should be capable of being taken off and reapplied a number of times without injury. The grip on the rail should be from the inside in order to decrease the damage to the base of the rail through contact of wheel flanges of derailed equipment and that the grip on the rail may receive the least injury from brine drippings.

Where traffic is unbalanced, preponderance being in the direction of the ascending grade, reliance cannot be placed in the gradient to prevent rail creeping. This was found to be true on a 1 per cent grade five miles long where 110-lb. rail laid without slot spiking or rail anchors against the grade had crept. The creeping was checked but it was impracticable to eliminate or correctly redistribute the excess expansion acquired through the original omission.

Slot Spikings.—This is not objectionable where sufficient anchors are used to prevent rail creeping in either direction and may take the place of one pair of rail anchors. Results of recent experiments seem to forecast the abandonment of the flaring bottoms to rail joints and a return to some form of the old fishplates. Should this take place, slot spiking would be eliminated, "a consummation devoutly to be wished."

Beginning of Rail Anchoring.—It was not until 1923 that the practice of anchoring newly-laid rails in both directions and paying closer attention to expansion allowances was begun on the Nashville, Chattanooga & St. Louis Railway. The tendency towards excessive gap openings and rail creeping was present with all of the rails laid prior to this date.

Brine Drippings.—On Exhibit K there appear photographs of some specimens of bolts taken from the track and split through the axis with a view of showing the difficulties, due to brine drippings, of maintaining tension in track bolts. On the page opposite the Exhibit will be found descriptive matter relative to each figure. Traffic producing brine drippings is usually in one direction and the drippings generally fall on the outside of the rail and their destructive effect on joints and rail adjacent to and included therein is greatest at the receiving end. Through the effect of air currents, the salt spray is distributed not only over the surface of the rail and joints but penetrates behind the splice bars, attacking the fishing surfaces, and the shank of the bolt on the inside; it also affects the washer and bolt head contacts with the outer surfaces of the splice bars. It will be observed that for the "wrench tight" threads the brine drippings have not affected the threads within the limits of the nut. These thread surfaces are usually found bright. With a "free turn" nut it is important that the brine drippings be sealed out of the interior of the nut by the application of grease. Unless the bolt ends and nuts are protected from corrosion the nuts usually become frozen and extraordinary force is required to move them. Where such is the case, sufficient force should be exerted to tighten them and if it results in twisting the bolts in two, new ones should be promptly supplied.

Track Walkers.—These are generally of the older and more experienced type of employees and when charged with the duty of tightening bolts, frequently do not possess the physical strength to do so when nuts have become frozen. Under such conditions, nuts are usually left untightened.

Lubrication and Track Oiling.—Prof. Talbot, in his laboratory experiments, developed the fact that the use of oil on contact surfaces did not aid the movement of the rail through the joint after the bolt tension had gotten above 3,000 lb.

Even if it were of value, it has not been found feasible to get a useful amount of oil on the contact surfaces between the joint and the rail, either by the method of applying it with an oil can or with a device which sprays the oil on the rail under air pressure.

It will be noted from Exhibit B that some recent applications of Gre Dag, which is understood to be a combination of graphite and heavy grease, have been made on some of the joints on Mile 106. In all cases as the bolt was tightened the grease squeezed out. The real value of such lubrication, in admitting of the maintenance of high bolt tensions, and at the same time permitting of movement of the rail through the joint, cannot be determined except as a result of numerous carefully carried out experiments.

The spraying of the track with a heavy asphaltic oil applied about twice a year will most likely operate to exclude brine drippings from the threads of the bolts and diminish their effect on contact surfaces. With this done, no lubrication of the interior of the nut, other than that resulting from the processes of manufacture, will be required. It is highly desirable that heavy oil be applied to the interior of the joint on both sides. The writer has made some experiments with a hand-operated oil spraying device, spraying the oil behind the splices from each end. Some such method is essential in order to prolong the life of the joints, bolts and rail itself, especially on the bottom contact surfaces.

Expansion Allowances.—It has been the writer's observation that the tendency to lay rail too open has been almost uniformly the case on American railroads. "Sun kinks" or "bucking track" have not been often produced by the general laying of rail too tight, but by permitting it to drift after laying, depending alone on slot spiking and without the application of rail anchors in both directions. Theoretically, when the temperature of the rail reaches 100°, all joints in a mile should be tight. The writer has observed temperatures in rail during the past summer of 135°, but, even with such extreme temperatures, all of the joints in the rail have not been closed up. By confining the expansion spaces, correctly allowed in rail laying, within distances where creeping in either direction is not likely to exceed 1 inch, no fear of sun kinks need be entertained even at extreme temperatures.

The ends of rail which have not been milled in manufacture generally have rough saw marks which prevent the actual laying of the rail close up. Through pressure and attrition, these saw marks gradually give way and admit of greater expansion spaces than would be available if the ends of all of the rails had been milled. This circumstance no doubt accounts in a large measure for the excessive joint gaps found to exist in rail laid in the past, but carelessness, the use of makeshift shims, delayed application of rail anchors in both directions, too early removal of expansion shims as rail laying progresses and the use of an interval of 24° in our tables for expansion are the chief causes.

Expansion Table.—The writer has given considerable attention to a table of expansion allowances for the several lengths of rail now in use, which will provide for changes of shims at intervals of 10° rather than 24° and at the same time admit of the use of shims which increase in thickness at the uniform rate of 1/16 inch. He believes that rails should not be laid at temperatures below zero inasmuch as the wider the necessary joint gap, the greater chance there is for error in securing the proper width, which becomes a very important matter when the rail attains the extreme high temperatures. In addition to this, extremely cold weather is not conducive to economical work. The table suggested by the writer is shown on Exhibit N.

Expansion Shims.—On Exhibit N there also appears an illustration of an expansion shim which the writer has devised and which he has found to give excellent results from actual trials in the field. It is in the form of the ordinary cotter pin except that it is ½ inch wide. It is inserted on the outside of the rail and sufficiently below the top to prevent interference by traffic. It can be extracted when desirable before the rail has cooled by the use of the ordinary pointed short-handled wrench, which the joint men have always with them to adjust the holes in the splice bars to those in the rail when applying the bars. The point of the wrench is inserted in the eye of the shim and the upper end pressed toward the center of the track. This brings the shim to an inclined position which admits of further penetration of the pointed wrench handle and the attainment of a fulcrum by means of which the shim may be withdrawn. Being made of tough steel, the shims may be used a number of times. For the expansion table suggested, only four thicknesses of shims are required. See sketch at bottom of Exhibit N.

Rail Thermometer.—The writer has seen rail thermometers designed to show the temperatures on the left and instructions as to the thickness of shims to be used for varying temperatures on the right. This plan is practicable only for one length of rail unless a very cumbersome design of thermometer is used. He thinks that reliance, therefore, should be placed only in the temperature readings. In using the thermometer, care should be taken not to press it on the rail, as very slight pressure affects the surface of the bulb which is in contact with the rail and produces the appearance of a decided increase in temperature which will lead to considerable error.

Importance of Bolts.—A necessary condition toward the attainment of the ideal is that of uniformity of bolt tension adjusted and maintained to approximately the amount of tension necessary to develop the full strength of the joint.

There is no feature of track maintenance which yields a larger return for the labor expended than properly adjusted track bolts. Bolts which become loose set up movements in the joint which tend to induce excessive batter and destroy the supporting power of the cross-ties and ballast. On the other hand, swinging ties under or near a joint induce loose bolts, thus forming a "vicious circle" which if permitted to enlarge its radius becomes destructive and dangerous. The loosening of bolts can be detected before it has gone too far by tapping the heads of the bolts with a small hammer; bolts which are too tight can be detected in the same manner. Regular inspections should be made with the hammer and the heads of bolts requiring tightening marked with yellow crayon for the notice of the trackmen. The desirable length of the wrench handle will depend on the type of nut used, whether "free turn" or "wrench tight." Whatever length may be adopted finally after the desirable length has been determined as a result of further investigation should be rigidly adhered to and the use of gas-pipe extensions prohibited, except where nuts are frozen and help is not available.

SUBJECT (7) "CAUSE AND PREVENTION OF RAIL BATTERING"

Rails of Earlier Manufacture.—For years prior to, and especially since this study was undertaken, the matter of rail batter and end overflow has received special attention on the part of the writer.

The reports and discussions of this Association and the pages of the technical press have contained for years expressions of opinion from the railroad men who have charge of maintenance matters that the lighter sections of rail are superior in quality to the heavier.

In 1892, the writer presented a paper to the Engineering Association of the South, which was published in its Proceedings for 1893, entitled "The Depreciation in Quality of our Steel Rails." In this paper, comparisons were made between 52.6-lb. steel rails rolled by the Cambria Iron & Steel Company, 58-lb. rail rolled by the same company, laid opposite each other in the same track, and 68-lb. rail rolled by the Edgar Thompson Steel Works. The first named was laid in 1880, the second in 1884, and the third in 1890. The carbon content of the first was .302, of the second .414 and of the third .405. The approximate tonnage over No. 1 was 35,600,000, No. 2—25,640,000, No. 3—8,326,000. The estimated loss per yard in pounds per 10,000,000 tons was No. 1—.42, No. 2—.58 and No. 3—.289.

Unfortunately, the photographs taken of fractured specimens of each rail were not reproduced in the paper, but their description is quoted:

> "No. 1 had a fine close grain almost white, indicating considerable working and perhaps at a low temperature. No. 2 showed a somewhat more crystalline formation and was quite bright, indicating less work at a higher heat. No. 3 showed a very coarse, bright crystalline texture, indicating the same thing, only a little more so."

Other quotations are as follows:

> "It will be noted that No. 1, the oldest and apparently the hardest rail, showed the least carbon, while the newest and softest shows the most. The other ingredients being almost the same, I am led to the conclusion that variation in the chemical composition of rails, within certain limits, has not so much effect as the manner of treating the ingot after it is made. Carbon is usually supposed to be a hardener, but it seems to have had the opposite effect in this case.
>
> "An inquiry for the description of the manufacture of samples 1 and 2 elicited substantially the following: 'Owing to the loss of a large portion of our records by the disaster of 1889, we are unable to locate the work. We are decidedly of the opinion that the difference in the wear of the rails is largely controlled by the difference in the standard of carbon. Some of the phenomena connected with the wear of steel rails are hard to explain, the same chemical composition giving under some differences of manufacture —so slight as to be unnoticeable—quite different results. The chemical composition of our rails has been maintained the same, within working variation. On smaller sections, as both rails are produced from the same sized ingots, there is slightly more work—whether enough to produce noticeable after results, it is difficult to say."

Bessemer and **Open-Hearth.**—In the *Railway Age,* of August 29, 1925, there was published a paper by Mr. W. C. Cushing, Engineer of Standards, Pennsylvania Railroad System, entitled "Is Rail Being Improved?" This is a very illuminating and valuable article. It is referred to here for the purpose of calling attention to one of the expressions used therein. In discussing the toughness in resistance to abrasion of rail containing from 10 to 14 per cent more manganese than is ordinarily used, he states:

> "It is strong and tough but the hardness is not superior to that of Bessemer steel and, consequently, the resistance to batter at the ends of the rails is not altogether satisfactory."

From this statement it might be inferred that Mr. Cushing is of the opinion that the batter is due to the Bessemer process, but it is the view of the writer that the process of manufacture as between Bessemer and Open-Hearth is not conclusive as to superior resistance to batter shown by the lighter sections of rail in comparison with the heavier. He believes that lighter sections of Open-Hearth rail are more resistant to batter than are the heavier sections.

Recent Notes on Old Rails.—In October last, having been particularly struck with the performance of some 56-lb. rail which was originally laid new in place in 1890 and is still in that position, inquiry was made of the Bethlehem Steel Company for some description of the process of manufacture. The reply of Mr. E. F. Kenney, Metallurgical Engineer of that company, is quoted below:

> "In 1890 the art of rail-making was probably quite different from what it is today, and from what I can understand, records were not kept to any such degree as is the custom to-day. All I have been able to find is an old book showing the carbon and manganese in each blow of steel. All the rails were Bessemer, and during the 1890 period shown in this record, the carbon varied from .42 per cent to .56 per cent and the manganese from .69 per cent to 1.32 per cent.
>
> "A little later in 1891, they started to record the weekly average of silicon, sulphur and phosphorus, which varied as follows:
>
> Silicon .... .029 — .065
> Sulphur .... .089 — .130
> Phosphorus .... .079 — .099
>
> "While there is no record of copper analyses, I believe these early Bessemer rails had a considerable content, probably one-half to one per cent.
>
> "I trust that this small amount of information will be of some service, and regret that we are not able to furnish more."

Space will not admit of reproducing all of the memoranda which have been made recently on the tendency to batter and overflow and chipping of rail laid at different times in the tracks of the Nashville, Chattanooga & St. Louis Railway, but the following are selected as being illustrative of what the writer believes to be a persistent tendency.

52.6 lb. rail rolled by the Edgar Thompson Steel Company under the Bessemer process in 1876 was originally laid in the main line of the Chattanooga Division. It was subsequently transferred to the main line of the Nashville Division. In 1911 some of it was taken from the main track of the Nashville Division and laid in the main track and sidings in the yard at Hickman, Ky., the remainder being sold. It is safe to say that this rail has carried much more than 200,000,000 tons. All types of cars and loads now pass over it in the course of a year, except that the locomotives are of medium weight.

The rails still left in the track are almost without exception free from end overflow, chipping and battering.

56-lb. rail rolled in 1890, the same as that referred to in the letter above quoted from Mr. Kenney, shows after examination of about fifty miles laid on different branch lines and which have carried about 40,000,000 gross tons of ordinary traffic, although handled with medium weight engines, while sometimes kinked, show remarkable freedom from rail batter, and overflow and chipping.

58-lb. Cambria steel, rolled in 1890 and laid originally in place where it is still being operated, shows almost complete freedom from rail batter, end overflow and chipping but is somewhat kinked. The gross tonnage over this rail with ordinary traffic with comparatively light engines has been about 30,000,000 tons. It is almost entirely free from end overflow, batter and chipping.

60-lb. rail, rolled in Carnegie mills in 1890 laid new on the P. T. & A. Railroad and subsequently transferred to the Columbia Branch, shows almost entire freedom from end overflow, rail batter and chipping and has carried approximate gross tonnage of ordinary traffic, moved with medium weight engines, of about 30,000,000 tons.

In 1890, the laying of 68-lb. Bessemer steel rail was begun on the Chattanooga Division and by 1899, almost the entire main line had been laid with this weight of rail. About 1899, this rail began to be replaced with A.S.C.E. 80-lb. rail, the 68-lb. rail being taken up and laid generally on the Nashville Division where much of it remained in the track until 1911, when its replacement began with relay 80-lb. rail from the Chattanooga Division, where new 85-lb. rail of the A.S.C.E. section was being laid in its stead.

The 68-lb. rail was generally scattered over the branches, where much of it is still in use. It shows generally a somewhat greater tendency to curve wear but the absence of joint batter, chipping and end overflow is quite apparent. The gross tonnage over what remains of this rail must have exceeded 200,000,000 tons.

Beginning in 1903 and 1904, the 80-lb. rail on the principal Divisions was gradually replaced by 85-lb. rail of the A.S.C.E. section. Only a small mileage of this 80-lb. rail was manufactured by the Bessemer process, this at Sparrows Point, Md., while the remainder was made by the Open-Hearth process at the mills of the Tennessee Coal, Iron & Railroad Company at Ensley, Ala. Much of this 80-lb. rail has carried more than 200,000,000 tons and both types of Bessemer and Open-Hearth appear to be equally free from end overflow, rail batter and chipping, but not so free as the lighter sections above described.

Much of the 85-lb. Open-Hearth rail of the A.S.C.E. type, the laying of which was begun in 1907, is still in use under main line traffic, at high speed. While it shows a tendency towards an increase of chipping, excessive batter and end overflow is generally absent.

In 1912, the use of 90-lb. rail, A.R.A. Section "A" was begun, 26 miles being laid on the Chattanooga Division and 23 miles on the Nashville Division. This rail shows an increased tendency to chip and end overflow and batter over the 85-lb. rail.

It is fully recognized that these old rails which are still in use represent survivals of the fittest, but it is remarkable how general is their very fit condition. Their toughness must have been largely due to the larger proportion of manganese to carbon than obtains to-day in rail manufacture. Their comparative freedom from corrosion was no doubt influenced by the scarcity of brine drippings, but their reputed copper content must have been also an agency for preservation. The resilience of the lighter rail and absence of rigid support from ballast must have also contributed to the good wearing qualities at the joints.

90-lb. A.R.A. rolled at Gary in 1910, cropped and rebored and laid with old continuous joints, shows very little tendency to overflow in the joint gap and only moderate batter and chipping. This rail has carried about 5,000,000 tons gross with large and small engines in its present position. It was originally laid on the lines of the Chicago, Burlington & Quincy Railroad.

85-lb. A.S.C.E. T.C.I. rail rolled in 1912 was cropped and laid in main track at P. & I. Junction, near Paducah, Ky. It was taken from the Chattanooga Division about 1922. This rail was Open-Hearth. Gross tonnage passing over it since it was laid new was about 125,000,000. This rail now has tonnage of both P. & I. and P. & M. Divisions over it, the gross for the period being about 18,000,000 tons, in addition to a considerable amount of switching movement. All open joints show evidence of batter and end overflow.

Maryland Steel Company's 80-lb. Bessemer rail, rolled in 1904, laid first on the Chattanooga Division and subsequently removed to the P. & M. Division, where it was relaid without clipping, but new angle bars applied, shows very little batter and no overflow into the joint gap. It has carried a gross tonnage of perhaps more than 200,000,000.

More Recent Rail.—The Illinois Steel Company's 90-lb. A.R.A. section "A" rail laid at Metropolis Bridge, rolled in 1916, shows at some joints $\frac{1}{16}$ inch batter and only a small amount of end overflow at any joint. It has carried about 15,000,000 gross tons.

New 90-lb. Open-Hearth rail laid in the track of the P. & M. Division, manufactured by the Illinois Steel Company in 1923, shows heavy end overflow and a decided tendency to batter. This rail has carried about 7,000,000 gross tons of ordinary traffic handled with large engines.

90-lb. A.R.A. section "A" Open-Hearth rail rolled by T.C.I.Co. and laid on the P. & M. Division near Mercer in 1923 shows heavy overflow in joint gaps, considerable tendency to rail batter and chipping. It has carried approximately 8,000,000 gross tons with large engines.

Manner and Rate of Battering.—It is, of course, apparent that the length of the battered area will increase with the depth, also that on double track the length of the battered area on the receiving rail is greater than on the delivering rail. End overflow has been observed on both the receiving and delivering end of rail, but that on the receiving end may be caused by traffic in the reverse direction as heretofore referred to.

Battering of rail at the joints on any kind of track is, of course, facilitated by the fact that the metal has three directions in which to flow.

The increasing depth of batter as the end of the rail is approached has already been referred to and the rate of such increase is not uniform. A standard method of measurement will have to be adopted and a very large number of observations made and plotted before curves of the rate of batter can be deduced and used for comparison between different rails and different weights of rails.

Studies of Recent Observations.—A number of studies have been made from the accumulated data with a view of establishing, if possible, probable causes of rail battering and chipping, but findings which might be regarded as conclusive are generally absent.

Batter Proportional to Width of Joint Gap.—The only fact which seems to have been established beyond reasonable controversy is that rail battering is directly proportional to the width of the joint gap. This is shown on Exhibit E, where relationships between batter and width of gap on the east rail and the west rail, together with a line representing the average results, appear.

This result is again shown on Exhibit I-b, covering twelve joints showing excessive batter, and on Exhibit J, covering 34 rails showing minimum batter. On the former the average opening is 10½/64ths inch with an average batter of .041 inch, while those on the study for minimum batter show an average opening 5.63/64ths inch with an average batter of .0125 inch. The average joint gap for 393 joints is 8.19/64ths inch, while the average batter for these same joints was .020 inch.

Chemical Content.—Exhibit H shows an attempt to establish some relationship between the amount of batter and the carbon content. In plotting this chart the per cent of carbon for A and B rails was reduced .05 for A rails and .02 for B rails, the intention being to compensate approximately for the lower carbon on the outside of the heads of these rails due to segregation. The results are plotted graphically, the data for the east rail appearing above the horizontal line and that for the west rail below. If carbon has played any part through greater proportions in different rails it has not been possible to prove it. On Exhibit I-b, a study of rails where joints have shown excessive batter, the manganese and carbon content have each been taken into consideration but the presence of both is in average quantities with the general content of all heats represented in this test mile.

Ladle Analysis.—It should be borne in mind, however, that ladle analyses are not conclusive as to the chemical content of any rail. Actual analysis of the rail at the point under observation is the only way that any valuable lessons from chemical content can be drawn.

Ingot Position.—Exhibit F shows an attempt to bring out the relation between batter and ingot position. The results are plotted graphically and the number of rails involved in each plotting is shown in figures, batter for the east rail appearing above the horizontal line and that for the west rail below.

The D rails appear to be subject to the greatest amount of batter, with the C rails showing the least. The much maligned A and B rails show less batter than the E, F and G, while the C rails show the least.

Tie Support.—Exhibit G is an attempt to show the relation between batter and the location of ties under the joints. This information is again plotted with the east rail above the line and the west rail below and is expressed in figures as well as graphically. The chart indicates that there is little choice between the three methods of support and that so far as rail batter is concerned, the hit or miss method of laying the rail is as good as any. More extended observations are needed, however.

Influence of Heats.—Exhibit I-a is an attempt to show the relation of the heat to batter, the percentage of rails in each heat and for each depth of batter increasing at the rate of .005 inch, being plotted. Three heat numbers only appear in the line of minimum batter of .010 inch. All of them appear on the line for batter of .020 inch. Heat Nos. 10087 and 40483 show the greatest percentage, which is 55.5 in the first case and 55.0 in the second. On the .025 inch line for batter, Heat No. 40482 shows the highest percentage, which is 33. For the line of .03 inch, Heat No. 10887 shows the highest percentage, which is 22.5. For a batter of .035 inch, Heat Nos. 40483 and 53416 show a maximum, the percentage of the former being 15 and the latter 14½.

Rails Showing Excessive Batter.—Exhibit I-b presents a study of twelve joints where rail ends are in very bad condition, so far as batter is concerned. The ingot letter on the north and south side of each joint is shown. Heat No. 53416 appears three times, being paired once with D and B rails. Heat No. 30558 appears only once with a D rail. Heat No. 80710 appears twice, the first time with an A rail, the last time with a B rail. Heat No. 10889 appears once with a C rail. Heat No. 61813 appears once with an A rail. Heat No. 40483 appears twice, but in one case both ends of the same rail are involved. Heat No. 10885 appears six times, two G rails, two E rails, one C rail and one B rail. Heat No. 30560 appears once with an E rail. Heat No. 61811 appears once with an F rail. Heat No. 70600 appears three times with E rail, F rail and B rail. Heat No. 30562 appears once with a D rail. Heat No. 70601 appears once with a C rail. The small number of A rails in this list is conspicuous. The list shows two A rails, four B rails, three C rails, five E rails, four D rails, two F rails and three G rails. The E rails predominate, showing five with a percentage of 22.

Rails Showing Minimum Batter.—Exhibit J is a study of 34 rails showing minimum batter. In this list the B rails lead with 8 or 23 per cent, the E rails next with 7 or 21 per cent, and the A rails next with 6 or 17 per cent. It will be noted that the average carbon content is 68.6, whereas the average carbon content for the 393 rails in this stretch of track is 68.2. This result seems to confirm the previously mentioned investigation shown on Exhibit A, to the effect that the carbon has not definitely influenced the extent of rail batter.

At the bottom of this chart is plotted the number of rails of each ingot letter found among the 34 which exhibited minimum batter. This is shown by the bottom line. The top line shows the number of rails of each ingot letter appearing in the entire stretch of track. The result of this plot is that the position of a rail in the ingot does not appear to bring about minimum batter.

Curve and Tangent.—Exhibit D presents four graphs. A shows that the average opening is greatest on curves; B, that the average batter is greatest on curves; C, that the average opening is greatest on the low rail of the curve, and D, that the average batter is greater on the low rail than on the high rail.

Chipping.—It has been strongly advocated by a number of Chief Engineers, and particularly by the Robert W. Hunt Company Inspection Bureau, that one of the prime causes of chipping and, incidentally, of rail batter, is the fact that the ends of the rails are not milled.

The mills charge a premium for this milling and the railroads are reluctant to pay it. Some rail mills are compelled to mill between 20 and 50 per cent of all rails on one end in order to secure proper length of rails and to remove projecting fins above the surface of the rail which are otherwise usually rolled back on the surface under the action of the cambering machine.

Mr. A. F. Blaess, Chief Engineer of the Illinois Central Railroad, under date of October 21st, wrote a number of members of the Rail Committee with regard to trouble which he has observed on 110-lb. rail recently purchased and laid in his track, on account of chipping the top surface of the ends of the rail. He expressed the opinion that the trouble is evidently due to the folding back of a top fin on the front end of the rail in passing through the cambering machine. The fin on the 110-lb. rail being much larger than that on the 90-lb. rail formerly used forces attention on a feature which had not been particularly noticed on 90-lb. rail on account of its apparent insignificance. The above is the substance of his letter; the following is quoted:

> "The most careful job of filing that can be done will not correct this trouble because a portion of the fin is pressed into the top surface of the rail while hot and filing cannot remove it."

Mr. W. C. Cushing, Engineer of Standards, Pennsylvania Railroad System, answered Mr. Blaess, under date of November 4th, as follows:

> "We do not experience the trouble quoted in your letter of October 21st, 1925, in the case of our 130-lb. P.S. rail. It may be because this section requires very little camber in the cambering rolls and hence there is not this pressure on this fin which might be the case with rails of other sections."

Mr. G. J. Ray, Chief Engineer, Delaware, Lackawanna & Western Railroad, answered Mr. Blaess, under date of October 31st, from which I quote as follows:

> "Our experience at the mill developed the fact that this condition is brought about by the way rail is delivered to the hot saws. If the rail is sawed with the base toward the saws, this will deposit a hot fin on the head of the rail and unless care is taken to remove this fin before the rail passes through the cambering rolls it will embed itself in the head of the rail and thereafter the depression cannot be removed.
>
> "In rolling our rails, the inspectors must see that the head of rail is placed toward the hot saw, thus putting the fin on the base of rail."

Mr. G. L. Moore, Engineer Maintenance of Way, Lehigh Valley Railroad, wrote under date of November 16th:

> "We do not experience a great amount of trouble on account of chipping at the ends of our rails. This is probably due in part to the fact that the mills furnishing our rails have so arranged the operation of their cambering machine that it does not fold back the saw fin on the head of the rail. This is accomplished by an adjustment of the roller that bears against the head of this rail whereby this roller which ordinarily rolls the fin back on the rail does not touch the extreme end of the rail as it enters the cambering machine but comes in contact with the rail about one foot back from the end. The ends of the rails are thus free of the conditions complained of and consequently can be readily chipped, leaving them clean and smooth."

The writer's investigation of the matter with respect to mill practice at the T.C.I.Co.'s mill at Ensley, Ala., brings out the fact that for various reasons in actual practice one end of a considerable number of rails is milled; that their saws are so arranged that it is not practicable to have it enter the rail at the head, thus transferring the fin to the base where it can do little harm; that to change their plan so as to provide for the saw entering the rail at the head would cost a very large sum of money.

An effort has been made to identify some of the rails which have been milled and already laid in our track. It is believed that several have been so identified, but chipping in these cases is about equally distributed.

It is the writer's view that the presence of these fins rolled into the surface of the head of the rail is not the prime cause of chipping; in fact, that they have very little to do with chipping. He believes that chipping is principally brought about by the action of rails which have overflowed at the ends upon each other tending to wedge out pieces of the top surface of the rail. Whether the tempering of the metal, due to water from the hot saws, has the effect to embrittle it or whether such embrittlement is brought about by cold rolling of the top surface of the rail under traffic, is a matter upon which he is not yet informed. In his observations on 110-lb. rail, he has noted that chipping has so far occurred only at the joints. It is true that where the fin is rolled back and embedded in the surface of the rail, a slight depression occurs, but the effect of this is to set up rail battering rather than chipping. Where end overflow has taken place and the rails subsequently come together, each projection operates on the other and in turn they lift each other up and break backward from the joint. While the writer approves the general practice of milling rails, he does not feel that this will remedy the trouble of chipping.

Mr. Armstrong, President of the Rail Joint Company, wrote the writer under date of December 9th, 1924, as follows:

> "In conversation I mentioned the fact that the Union Pacific and Southern Pacific in laying new rail have been using end posts 1/8 inch thick. They have followed this practice for a number of years, and it insures keeping the rail ends apart, and in case of flowing, the thin steel bridging the gap, lipping, and starting the cause of battered rail. By keeping the ends apart, if they do flow, it permits the trackmen to saw off these thin pieces before they lip and break. In conversation with some of the officials, I have understood that this method has been followed successfully and most of the trouble of the flowing had occurred during the first year.
>
> "Mr. E. E. Adams, of the Union Pacific, and Mr. W. H. Kirkbride, of the Southern Pacific Company, could give you full information in the matter."

This matter was followed up with Mr. Kirkbride and Mr. Adams, and one paragraph of the writer's letter of December 12th to these gentlemen is quoted:

> "I can well understand how if these strips were placed in between the joints and left there permanently they would prevent the rail from coming together, but I fail to understand how this can be done without seriously encroaching upon the spaces left for expansion, and, if Mr. Armstrong has clearly described the operation, I would appreciate information on this point."

Mr. Kirkbride, under date of December 26th, replied as follows:

> "About three years ago, when we purchased some manganese rail, the manufacturers recommended that we use 1/16 inch fiber end posts between the rail ends, the purpose being to prevent any slight flowing of metal of one rail reaching the adjacent rail. The use of these fiber end posts, however, proved a failure through being crushed and becoming useless before any effort was made to saw off any of the flowed metal fins.
>
> "During the past year or so we have resorted to the practice of sawing off the flowed metal in the top of ball on the ends of carbon rail, which in some cases develops soon after the rail is laid. Instructions to our track forces are that the fins must be sawed off with hack saw before they develop appreciably and flow over the adjoining rail. Our experience has been that one man with a hack saw can saw off about 100 rails as an average per day of 8 hours.
>
> "You will understand, of course, that these flowed fins are sawed off as soon as the rail shows any tendency to flow and before the fin has reached the adjoining rail. Generally speaking, the maximum flow of the metal of the top of the rail into the gap from the original end of the rail will probably not exceed 1/8 inch and the depth below the original top of the surface will not exceed 1/32 inch. Additional sawing after the initial cutting off is sometimes necessary; however, after the rails have been sawed once or twice it is our belief that the cold rolling effect of traffic, or hardening of the surface of the rail, will have developed that will materially reduce any tendency of the rail to batter.
>
> "Our experience, while only covering a short period of time, seems to indicate and point to the fact that this sawing off of flowed fins is justifiable and to a certain extent will prevent some battering, which in the past originated from metal on top of one

> rail flowing on to top of adjacent rail, resulting in chip breaking out of top of the rail and in due time developing a battered rail.
>
> "We have no cost figures available; the work is not very severe on hack saws and the average work per man per day will give you some idea of what the cost would be on your lines."

Mr. Adams replied, under date of December 15th, in substance that the cutting off of end overflow was practiced only on his system in connection with insulated joints; that fiber shims cut to the true rail templet for relaying rail on the Union Pacific Railroad proper have been used but not on the other three units of the system.

> "We do not depend upon the shim for complete expansion even though a fiber is somewhat elastic, but use in addition thereto a finely milled hardwood lath that would give slightly more than one-half normal expansion for our rail and I think is doing some good, at least in the protection against rail ends chaffing and lipping over, which, as you know, results in the chipping of joints when the rail again contracts.
>
> "The prevention of rail batter from the above causes prompted us to introduce this practice in all rail laying but we now find that the equalization of expansion that we secure with a fiber shim is much more important to us than the separation of the rail ends. The expense is very slight, therefore I think that the practice is well justified.
>
> "Answering the last paragraph of your letter, wish to advise that we use $\frac{1}{16}$ inch shims almost exclusively and these are applied in multiples when laying in cool weather and a single shim is placed even in the hottest weather."

An effort has been made on Exhibit L to show by photographs and descriptions accompanying same just how end overflow operates to bring about chipping at the joints, which is a potent aid in rail battering.

Whether the high point on the right-hand rail in No. 6 as revealed by the straightedge is due to the metal being forced upward as a result of the battering at the joint or is one of the characteristic bumps which became apparent in practically all of this rail shortly after it was laid, is a question which has not been determined.

Welding Up Battered Joints.—While the writer has not had very much experience with this method of prolonging the life of rail, he is satisfied from the good results already obtained that the plan is economical and wise.

To be most successful it should be resorted to just as soon as a tendency toward excessive battering is exhibited. The following with respect to success in welding is quoted from a report of a maintenance of way committee on the Pennsylvania System on the matter of reconditioning rail:

> "We find that the battering of the welded rail ends has been but slight and this by no means general, and the wearing qualities of the steel, as far as battering is concerned, are apparently as good as those of the adjoining original steel. The failures which have occurred have come about chiefly through chipping out of the welded steel and this chipping has invariably been gradual and progressive, usually beginning at the extreme end of the rail and not at the line of connection between the welded steel and original

> steel; that is to say, it does not begin where the welded steel is the thinnest. In no case has there been a clean separation nor a large separation of the welded metal from the original surface of the rail head.
>
> "The length of weld applied at the joints at each of the above locations was about eight inches—three inches on end of leaving rail and five inches on end of receiving rail. After seven months of service only one of the above welds has entirely failed.
>
> "At both places the joints were so battered that it was impossible to hold even fair riding conditions, and even with frequent and thorough working the surface would break in two days. After the building-up work was done and the joint bars were renewed on some of these joints, no greater difficulties were experienced in maintaining surface on these stretches of track than on others laid with rail of the same age under similar conditions, where the rails were not battered."

With regard to the battering of welded joints, the following is quoted from the report above referred to:

> "At this point it should be stated that it has been found that chipping out of the welded steel is greatly reduced by cutting off the weld at the rail end with a chisel immediately upon finishing the welding operation, so that none of the applied metal extends over the end of the rail and into the space between the rail ends, where, due to expansion or creeping of rails, it might be crowded out by the adjoining rail."

The practice on the Nashville, Chattanooga & St. Louis Railway is to saw off the rough edges on the welded ends of the rail with a hack saw.

Clipped or Cropped Rail.—Reference has been made in the early part of this paper to cropped rail.

It has been the writer's belief that cropped rail would tend to overflow more rapidly than would new rail on account of the fact the top cold-rolled surface of the rail being under compression would have greater tendency to push over the ends after having been sawed.

The following is the result of the examination of a carload of cropped rail which was taken from the track of the Chattanooga Division, cropped and relaid under the same traffic and removed again:

85-lb. rails rolled in March, 1912, were cropped during February, 1923, and laid on the Chattanooga Division, Mile 111. They were taken up in November, 1924, and replaced by 110-lb. rail.

An examination of 82 of these rails at one end showed overflow on 16 rails varying from $\frac{1}{64}$ inch to a maximum of $\frac{1}{16}$ inch and on 21 rails at the south end of the car the overflow varied from $\frac{1}{64}$ inch to a maximum of $\frac{3}{32}$ inch. The overflow measured across the head of the rail varied from ½ inch to 1½ inch. No chipping was observed.

These rails being inspected on the car, it was not possible to tell whether the overflow occurred on both ends of any rail.

Except as mentioned above, no overflow appeared on any rail.

The following on this subject is quoted from the previously mentioned report of a maintenance of way committee of the Pennsylvania Railroad System:

> "All the cropped rail used on the Pennsylvania Railroad System has given very good service up to this time and has shown no greater tendency to batter or chip, or for the metal to overflow at the rail ends, than is found in new rail. It has been found that if proper care is taken in calipering, matching, loading and distributing the rail for relaying, very good riding track can be obtained."

Prevention of Rail Battering.—No rail which has been under observation by the writer in these tests has been found to be free from battering. Quite a number show excessive battering. On the other hand, a considerable number show a minimum amount of battering. End overflow is usually also missing on rail and joints of such minimum batter. In the writer's opinion, the best course to be pursued in prevention of rail battering or reducing its intensity is to study carefully the heat treatment and metallurgy of those rails which show the least tendency to batter and when the conditions which bring about this quality of minimum batter are discovered, some method of manufacture which will bring the output of the mill up to point of producing rails of that or even better quality should, if possible, be devised and put into practice. The price to be paid for such improved rail cannot be appropriately discussed here further than to say that it should be agreed on by the manufacturers and purchasers. There can be no question but that tremendous economies can be effected in maintenance of way expenses by improving the quality of the rail.

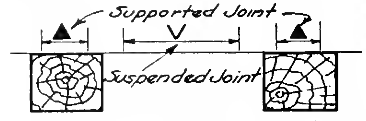
Exhibit A

A

LOG OF DATA FROM OBSERVATIONS ON RAIL JOINTS FOR BATTER, JOINT GAPS, CHIPPING, OVERFLOW, ETC.

N.C. & ST.L. RY. — M.P. 105-106.2, CHATTANOOGA DIV.

FOR NOTES ON BATTER, CHIPPING, OVERFLOW, JOINT GAP, ETC. SEE EXHIBIT "B."



TYPES SHOWING POSITION OF JOINTS CLASSIFIED AS SUPPORTED OR SUSPENDED

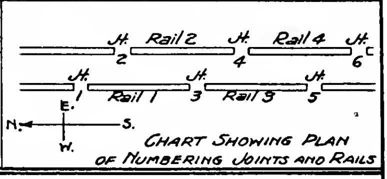


CHART SHOWING PLAN OF NUMBERING JOINTS AND RAILS

No. Joint (or Rail)	Kind of Joint	Av Carbon	Ingot Letter	Batter Measurements Oct. 26 '25		Measurements of Joint Gaps Showing Date & Temperature		
				North Rail	South Rail	Maximum	Minimum	Average
1		69	E	.015	.015	20/64" - 12·29·24 - 26°	0 - 10·1·23 - 107° 11·1·23 - 57°	6/64"
2	▲	70	B	.015	.015	25/64" - 12·29·24 - 26°	0 - 7·26·23 - 118° 10·1·23 - 107°	6/64"
3	▲	67	E	.020	.015	28/64" - 12·15·23 - 27°	2/64" - 6·23·24 - 114°	15/64"
4		64	D	.025	.015	10/64" - 12·15·23 - 27° 1·7·24 - 19°	0 - Read 4 times	3/64"
5	▲	69	G	.010	.020	8/64" - 6·27·23 - 75°	0 - Read 7 times	1/64"
6	▲	76	B	.015	.020	28/64" - 12·15·23 - 27°	0 - 10·1·23 - 107°	10/64"
7		70	F	.015	.015	30/64" - 12·29·24 - 26°	0 - Read 3 times	7/64"
8		76	G	.015	.015	22/64" - 1·7·24 - 19°	2/64" - 6·23·24 - 114° 8·23·24 - 115°	9/64"
9	V	70	B	.010	.010	16/64" - 1·7·24 - 19°	1/64" - 7·15·25 - 100°	9/64"
10		70	B	.015	.020	11/64" - 12·29·24 - 26° 7·15·25 - 100°	0 - Read 3 times	4/64"
11	V	63	F	.015	.010	12/64" - 8·27·23 - 76°	0 - Read 6 times	4/64"
12	▲	70	B	.015	.015	12/64" - 1·7·24 - 19°	0 - 7·26·23 - 118°	4/64"
13	V	69	G	.015	.015	21/64" - 1·7·24 - 19°	0 - Read 3 times	6/64"
14		69	E	.020	.015	21/64" - 7·15·25 - 100°	0 - 7·13·23 - 94° 8·23·24 - 115°	9/64"
15	V	69	G	.015	.015	16/64" - 1·7·24 - 19°	0 - 8·23·24 - 115°	5/64"
16	▲	69	B	.010	.010	9/64" - 6·26·23 - 75°	0 - Read 6 times	1/64"
17		69	E	.010	.015	15/64" - 1·7·24 - 19°	0 - 7·26·23 - 118°	4/64"
18		69	D	.015	.015	30/64" - 12·15·23 - 27°	0 - 7·26·23 - 118°	9/64"
19	V	70	D	.015	.015	15/64" - 8·27·23 - 76° 12·15·23 - 27°	0 - 10·1·23 - 107°	7/64"
20		70	G	.015	.020	14/64" - 1·7·24 - 19°	0 - Read 4 times	5/64"
21	V	69	G	.020	.020	26/64" - 1·7·24 - 19°	1/64" - 7·26·23 - 118°	12/64"
22	▲	69	F	.020	.020	21/64" - 12·29·24 - 26°	0 - 6·23·24 - 114° 8·23·24 - 115°	6/64"
23	V	69	G	.020	.020	31/64" - 12·15·23 - 27° 1·7·24 - 19°	5/64" - 8·23·24 - 115° 7·15·25 - 100°	17/64"
24		69	D	.025	.015	34/64" - 7·15·25 - 100°	0 - 6·23·24 - 114°	8/64"
25	V	69	F	.020	.015	26/64" - 1·7·24 - 19° 12·29·24 - 26°	3/64" - 7·26·23 - 118° 8·23·24 - 115°	12/64"
26	▲	69	B	.020	.015	28/64" - 12·29·24 - 26°	1/64" - 6·23·24 - 114° 8·23·24 - 115°	13/64"
27	V	69	C	.010	.015	10/64" - 12·29·24 - 26°	0 - Read 3 times	4/64"
28		70	B	.015	.010	29/64" - 12·15·23 - 27° 12·29·24 - 26°	0 - 7·13·23 - 94° 10·1·23 - 107°	23/64"
29	V	69	F	.015	.020	12/64" - 10·26·25 - 79°	0 - Read 4 times	4/64"
30	▲	70	D	.015	.015	27/64" - 12·29·24 - 26°	0 - 7·26·23 - 118° 10·1·23 - 107°	9/64"
31	V	69	C	.020	.020	26/64" - 1·7·24 - 19° 12·29·24 - 26°	0 - Read 3 times	12/64"
32	▲	70	F	.015	.015	9/64" - 6·26·23 - 75°	0 - Read 3 times	2/64"
33	V	70	B	.025	.015	31/64" - 12·15·23 - 27° 1·7·24 - 19°	1/64" - 10·1·23 - 107°	18/64"
34		69	G	.020	.015	28/64" - 12·29·24 - 26°	0 - Read 3 times	9/64"
35	V	70	E	.020	.015	33/64" - 8·23·24 - 115° 12·29·24 - 26°	5/64" - 6·23·24 - 114°	22/64"
36	▲	69	E	.015	.015	29/64" - 12·15·23 - 27°	0 - 7·13·23 - 94°	11/64"
37	V	69	F	.010	.020	27/64" - 12·29·24 - 26°	0 - Read 3 times	6/64"
38	▲	69	F	.015	.015	14/64" - 1·7·24 - 19°	0 - 7·15·25 - 100°	5/64"
39	V	69	F	.025	.025	32/64" - 10·26·25 - 79°	2/64" - 7·26·23 - 118° 8·13·23 - 102°	16/64"

Exhibit A—Continued

Number	Kind of Joint	Av. Carbon	Ingot Letter	Batter Measurements Oct. 26 '25		Measurements of Joint Gaps Showing Date & Temperature		
				N. Rail	S. Rail	Maximum	Minimum	Average
40	▲	69	D	.010	.015	14/64"-7.13.23-94°	0-6.23.24-114°	6/64"
41	V	69	F	.015	.015	18/64"-1.7.24-19°	0-7.13.23-94° 10.1.23-107°	8/64"
42	▲	69	G	.020	.025	32/64"-1.7.24-19°	0-Read 3 times	9/64"
43	V	69	D	.020	.025	25/64"-12.29.24-26°	5/64"-6.27.23-94°	11/64"
44	▲	70	G	.025	.015	32/64"-10.26.25-79°	1/64"-8.23.24-115°	13/64"
45	V	69	B	.015	.015	25/64"-1.7.24-19°	1/64"-8.23.24-115°	13/64"
46	▲	69	G	.015	.015	9/64"-7.13.23-94° 1.7.24-19°	0-7.26.23-118° 8.23.24-115°	3/64"
47	V	69	C	.020	.015	24/64"-11.1.23-57°	1/64"-6.23.24-114° 10.26.25-79°	12/64"
48	▲	70	G	.015	.015	21/64"-12.15.23-27° 1.7.24-19°	1/64"-8.23.24-115°	10/64"
49	V	70	D	.015	.025	31/64"-12.29.24-26°	0-Read 3 times	16/64"
50	▲	67	D	.015	.015	29/64"-12.29.24-26°	0-8.23.24-115°	9/64"
51	V	70	B	.015	.015	28/64"-12.29.24-26°	0-7.13.23-94° 7.26.23-118°	7/64"
52	▲	67	E	.010	.015	14/64"-12.29.24-26°	0-6.23.24-114°	8/64"
53	V	67	G	.015	.015	24/64"-10.26.25-79°	3/64"-7.15.25-100°	12/64"
54	▲	70	G	.015	.015	20/64"-1.7.24-19° 10.26.25-79°	0-Read 4 times	6/64"
55	V	70	F	.020	.030	26/64"-10.26.25-79°	0-Read 5 times	5/64"
56	▲	67	G	.015	.020	31/64"-12.29.24-26°	0-Read 3 times	11/64"
57	V	67	F	.015	.015	25/64"-7.13.23-94°	6/64"-8.23.24-115°	17/64"
58	▲	67	D	.015	.015	19/64"-1.7.24-19°	0-Read 3 times	6/64"
59	V	70	B	.015	.015	18/64"-12.15.23-27°	0-7.26.23-118° 10.1.23-107°	9/64"
60		69	C	.010	.015	6/64"-12.29.24-26°	0-Read 5 times	2/64"
61	V	67	D	.015	.015	28/64"-12.29.24-26°	0-6.27.23-94° 8.23.24-115°	11/64"
62	▲	67	G	.025	.020	25/64"-12.29.24-26°	1/64"-10.1.23-107° 8.23.24-115°	10/64"
63	V	67	D	.020	.015	24/64"-1.7.24-19°	0-7.15.25-100°	7/64"
64	▲	67	G	.015	.030	19/64"-1.7.24-19°	0-Read 3 times	5/64"
65	V	67	D	.015	.030	17/64"-12.15.23-27°	1/64"-10.1.23-107°	6/64"
66	▲	67	B	.035	.035	32/64"-12.29.24-26°	0-7.13.23-94° 7.26.23-118°	13/64"
67	V	63	D	.035	.030	33/64"-12.29.24-26°	2/64"-10.1.23-107°	17/64"
68	▲	63	G	.025	.025	32/64"-12.29.24-26°	2/64"-8.23.24-115°	9/64"
69	V	67	G	.020	.025	18/64"-12.29.24-26°	0-6.27.23-94° 8.13.23-102°	5/64"
70	▲	67	F	.025	.025	22/64"-10.26.25-79°	5/64"-6.26.23-75°	12/64"
71	V	67	G	.025	.025	32/64"-12.29.24-26° 10.26.25-79°	4/64"-6.27.23-94°	21/64"
72	▲	67	D	.020	.025	25/64"-1.7.24-19°	2/64" Read 3 times	10/64"
73		67	B	.010	.015	28/64"-7.15.25-100°	3/64"-10.26.25-79°	11/64"
74	V	67	F	.015	.015	28/64"-12.29.24-26°	1/64" Read 3 times	11/64"
75		67	D	.015	.010	5/64"-11.1.23-57°	0-Read 5 times	1/64"
76	▲	67	B	.015	.015	18/64"-12.15.23-27° 1.7.24-19°	1/64"-7.26.23-118° 6.23.24-114°	7/64"
77		67	D	.015	.015	26/64"-1.7.24-19°	0-Read 3 times	6/64"
78		67	C	.015	.020	30/64"-12.29.24-26°	0-Read 3 times	5/64"
79		67	D	.020	.025	31/64"-12.15.23-27°	0-7.26.23-118°	12/64"
80	▲	67	C	.025	.020	30/64"-10.26.25-79°	0-10.1.23-107°	10/64"
81	▲	63	E	.010	.015	25/64"-11.1.23-57°	0-Read 3 times	7/64"
82	▲	67	B	.020	.015	25/64"-1.7.24-19°	0-Read 3 times	8/64"
83	▲	67	D	.015	.015	30/64"-12.15.23-27° 1.7.24-19°	4/64"-6.27.23-94°	12/64"
84	▲	67	C	.015	.015	29/64"-12.29.24-26°	0-7.13.23-94°	9/64"
85	▲	70	E	.020	.015	24/64"-7.15.25-100° 10.26.25-79°	0-Read 3 times	7/64"
86	▲	63	B	.015	.015	31/64"-12.15.23-27°	6/64"-Read 3 times	13/64"
87	▲	70	F	.015	.015	19/64"-12.29.24-26°	0-7.26.23-118°	8/64"
88	▲	67	F	.020	.020	22/64"-12.29.24-26°	5/64" Read 4 times	8/64"

Exhibit A—Continued

Number	Kind of Joint	Av. Carbon	Ingot Letter	Batter Measurements Oct. 26 25		Measurements of Joint Gaps Showing Date & Temperature		
				N. Rail	S. Rail	Maximum	Minimum	Average
89	▲	67	D	.015	.020	28/64"-10·26·25-79°	2/64"-8·23·24-115° 7·15·25-100°	11/64"
90	▲	67	G	.020	.025	29/64"-1·7·24-19°	2/64"-Read 3 times	14/64"
91	▲	67	B	.015	.015	23/64"-8·27·23-76°	1/64"-7·15·25-100° 10·26·25-79°	7/64"
92	▲	67	E	.025	.025	30/64"-10·26·25-79°	1/64"-6·23·24-114°	9/64"
93	▲	70	A	.020	.015	28/64"-12·29·24-26°	0-Read 4 times	6/64"
94	▲	67	A	.025	.020	36/64"-12·29·24-26°	0-8·23·24-115°	13/64"
95	▲	70	A	.015	.015	35/64"-1·7·24-19°	0-8·23·24-115° 7·15·25-100°	13/64"
96	▲	70	A	.010	.015	12/64"-12·29·24-26°	0-Read 3 times	4/64"
97	▲	70	A	.020	.015	19/64"-1·7·24-19°	5/64"-Read 6 times	8/64"
98	▲	70	A	.020	.020	33/64"-1·7·24-19°	1/64"-10·1·23-107°	12/64"
99	▲	70	A	.010	.020	17/64"-7·13·23-94°	0-8·23·24-115° 7·15·25-100°	6/64"
100	▲	70	A	.020	.015	24/64"-1·7·24-19°	0-7·13·23-94° 7·26·23-118°	8/64"
101	▲	67	A	.025	.025	32/64"-1·7·24-19°	2/64"-7·26·23-118°	15/64"
102		68	A	.020	.015	10/64"-6·26·23-75°	1/64"-Read 5 times	3/64"
103	▲	67	A	.015	.020	26/64"-1·7·24-19° 12·29·24-26°	1/64"-6·23·24-114° 8·23·24-115°	10/64"
104		67	A	.015	.065	16/64"-12·15·23-27°	0-Read 7 times	4/64"
105	▲	70	A	.020	.020	28/64"-10·26·25-79°	0-8·13·23-102° 10·1·23-107°	9/64"
106		66	C	.065	.040	30/64"-12·29·24-26°	0-Read 7 times	6/64"
107	▲	67	A	.010	.020	14/64"-12·15·23-27°	0-Read 4 times	4/64"
108		69	G	.025	.015	25/64"-12·29·24-26°	0-Read 4 times	6/64"
109	▲	67	A	.020	.020	23/64"-12·29·24-26°	1/64"-6·23·24-114°	9/64"
110		64	A	.015	.015	15/64"-1·7·24-19°	0-7·26·23-118°	6/64"
111	▲	67	A	.020	.020	29/64"-12·29·24-26°	0-Read 4 times	7/64"
112		64	A	.015	.015	18/64"-12·15·23-27°	0-Read 5 times	5/64"
113	▲	70	A	.020	.025	31/64"-12·15·23-27° 1·7·24-19°	0-7·13·23-94° 7·26·23-118°	17/64"
114	▲	68	A	.010	.025	8/64"-6·26·23-75°	0-Read 6 times	2/64"
115	▲	63	A	.020	.025	36/64"-12·29·24-26°	0-8·13·23-102° 10·1·23-107°	8/64"
116		63	A	.025	.025	31/64"-12·15·23-27° 1·7·24-19°	1/64"-8·23·24-115°	20/64"
117		68	A	.020	.015	34/64"-10·26·25-79°	0-10·1·23-107°	13/64"
118	▲	63	A	.015	.015	14/64"-12·29·24-26°	0-Read 7 times	3/64"
119	▲	67	A	.015	.015	2/64"-Read 3 times	0-Read 7 times	1/64"
120	▲	67	A	.010	.010	10/64"-1·7·24-19°	0-Read 3 times	4/64"
121	▲	70	A	.015	.015	13/64"-7·13·23-94° 1·7·24-19°	3/64"-7·26·23-118° 7·15·25-100°	9/64"
122	▲	67	A	.015	.015	19/64"-1·7·24-19°	1/64"-6·23·24-114°	7/64"
123	▲	63	A	.015	.015	24/64"-1·7·24-19°	0-6·27·23-94°	9/64"
124		67	A	.020	.025	33/64"-12·29·24-30°	0-Read 4 times	10/64"
125	▲	67	A	.015	.015	24/64"-12·15·23-27°	0-Read 7 times	6/64"
126	V	68	A	.015	.020	16/64"-7·13·23-94° 7·26·23-118°	1/64"-Read 3 times	9/64"
127	▲	67	A	.015	.015	30/64"-1·7·24-19°	0-Read 3 times	11/64"
128		68	A	.015	.015	17/64"-1·7·24-19°	1/64"-6·23·24-114° 8·23·24-115°	7/64"
129	▲	68	A	.015	.025	16/64"-1·7·24-19°	0-6·27·23-94°	6/64"
130	▲	68	A	.010	.015	15/64"-1·7·24-19°	0-Read 3 times	4/64"
131		68	A	.020	.015	31/64"-10·1·23-105°	0-6·27·23-94°	10/64"
132	▲	68	A	.015	.020	23/64"-12·15·23-27°	0-Read 4 times	8/64"
133	▲	68	A	.015	.030	6/64"-7·26·23-118°	0-7·13·23-94°	3/64"
134	▲	68	A	.020	.020	21/64"-12·29·24-30°	1/64"-8·23·24-115°	13/64"
135	▲	68	A	.030	.020	28/64"-12·29·24-30°	0-6·27·23-94°	12/64"
136	▲	68	A	.015	.020	16/64"-12·15·23-27° 1·7·24-19°	0-8·27·23-76°	6/64"
137	▲	68	A	.020	.020	28/64"-7·15·25-100°	0-10·1·23-107°	6/64"

Exhibit A—Continued

Number	Kind of Joint	Av. Carbon	Ingot Letter	Batter Measurements Oct. 26'25		Measurements of Joint Gaps Showing Date & Temperature		
				N. Rail	S. Rail	Maximum	Minimum	Average
138	▲	69	E	.015	.015	30/64"-11·1·23-57°	0- 7·26·23-118° 10·1·23-107°	9/64"
139	▲	70	E	.020	.015	25/64"-12·15·23-27°	0-Read 5 times	8/64"
140	▲	69	D	.020	.025	23/64"- 1·7·24-19°	0-8·23·24-115°	21/64"
141	▲	69	E	.015	.020	12/64"-12·29·24-30°	0-Read 4 times	3/64"
142	▲	70	E	.020	.020	30/64"-12·29·24-30°	0-8·13·23-102°	11/64"
143	▲	69	E	.025	.035	36/64"-12·29·24-30°	0-10·1·23-107°	11/64"
144		69	B	.015	.015	11/64"-12·29·24-30°	0-Read 8 times	2/64"
145	▲	69	D	.020	.015	20/64"-12·15·23-27°	1/64"- 7·26·23-118° 8·23·24-115°	9/64"
146	▲	70	C	.015	.015	28/64"-12·29·24-30°	0-Read 5 times	9/64"
147	▲	69	B	.015	.015	20/64"- 1·7·24-19°	0- 8·13·23-102° 7·15·25-100°	5/64"
148	▲	63	D	.015	.020	22/64"- 7·15·25-100°	0- 6·26·23-80° 8·23·24-115°	6/64"
149	▲	69	B	.015	.015	15/64"- 1·7·24-19°	1/64"-6·23·24-114°	8/64"
150	▲	63	E	.020	.020	22/64"- 11·1·23-57°	1/64"- 7·13·23-94° 8·23·24-115°	10/64"
151	▲	69	G	.015	.015	21/64"-12·15·23-27°	0-Read 4 times	8/64"
152				.025	.020	31/64"- 12·29·24-30°	4/64"- 6·23·24-114° 8·23·24-115°	18/64"
153	▲	69	E	.015	.015	19/64"- 12·29·24-30°	1/64"-Read 3 times	5/64"
154	▲	69	G	.015	.020	26/64"- 1·7·24-19°	4/64"-Read 5 times	10/64"
155		69	E	.020	.015	16/64"- 1·7·24-19°	0- 7·15·25-100°	6/64"
156	▲	70	F	.020	.020	20/64"-8·27·23-76°	0-10·1·23-107°	8/64"
157		69	G	.010	.020	20/64"- 11·1·23-57° 1·7·24-19°	0- 6·23·24-114° 7·15·25-100°	8/64"
158	▲	69	D	.020	.025	30/64"- 12·15·23-27°	2/64"- 7·26·23-118° 10·1·23-107°	12/64"
159		69	E	.010	.015	28/64"- 12·15·23-27° 1·7·24-19°	0-10·26·25-79°	9/64"
160	▲	69	E	.015	.020	24/64"- 12·29·24-30°	0- 6·23·24-114° 8·23·24-115°	6/64"
161		70	F	.015	.015	8/64"- 1·7·24-19°	0- Read 7 times	2/64"
162		70	G	.020	.020	21/64" 12·29·24-30°	1/64"- 8·13·23-102° 6·23·24-114°	8/64"
163	▲	67	E	.020	.025	24/64" -12·29·24-30°	0- 8·13·23-102° 10·26·25-79°	6/64"
164	▲	69	G	.025	.025	27/64" -1·7·24-19°	2/64"- 6·23·24-114°	16/64"
165		70	B	.015	.015	23/64"- 11·1·23-57° 12·15·23-27°	0- 10·1·23-107° 7·15·25-100°	9/64"
166		69	F	.025	.025	21/64"- 12·15·23-27° 1·7·24-19°	0- 10·1·23-107°	10/64"
167		70	G	.015	.020	19/64"- 1·7·24-19°	0- Read 4 times	5/64"
168	V	69	E	.025	.025	28/64"- 1·7·24-19°	1/64" - 8·13·23-102°	14/64"
169		65	E	.025	.025	32/64" -12·29·24-30°	0-10·26·25-79°	9/64"
170		69	G	.020	.025	28/64"-12·29·24-30°	0- 7·13·23-94° 10·1·23-107°	11/64"
171	▲	68	B	.015	.020	6/64"- 8·27·23-76° 11·1·23-57°	0- Read 4 times	3/64"
172	V	64	D	.025	.020	28/64" -12·29·24-30°	2/64"-6·23·24-114°	16/64"
173		70	G	.020	.025	26/64" -12·29·24-30°	0- 8·13·23-102° 10·1·23-107°	7/64"
174		68	D	.015	.020	18/64" - 12·29·24-30°	0- 7·13·23-94° 8·13·23-102°	6/64"
175	▲	68	G	.025	.020	24/64"-12·15·23-27°	0- 7·13·23-94°	8/64"
176		69	B	.020	.020	19/64"- 12·29·24-30°	0-8·23·24-115°	11/64"
177		68	G	.025	.025	32/64"- 1·7·24-19°	0-10·1·23-107°	17/64"
178	V	68	B	.020	.015	24/64"-8·27·23-76°	0- 6·23·24-114° 8·23·24-115°	12/64"
179	▲	68	E	.020	.020	28/64" - 1·7·24-19°	0-Read 4 times	7/64"
180	▲	64	F	.015	.025	24/64" - 1·7·24-19°	0-Read 4 times	6/64"
181	▲	68	F	.020	.020	31/64"-12·15·23-27°	0- 8·23·24-115° 10·1·23-107°	12/64"
182		64	G	.025	.025	28/64"-12·29·24-30°	0-Read 6 times	6/64"
183	▲	69	A	.020	.040	24/64"- 12·29·24-30° 7·15·25-100°	1/64"-10·1·23-107°	8/64"
184	▲	64	E	.015	.020	8/64" - 1·7·24-19°	0- 8·23·24-122°	4/64"
185		68	E	.035	.035	24/64"- 12·29·24-30° 7·15·25-100°	0-Read 5 times	7/64"
186	▲	64	D	.025	.020	30/64"-12·29·24-30°	2/64"-6·23·24-114°	12/64"

Exhibit A—Continued

Number	Kind of Joint	Av. Carbon	Ingot Letter	Batter Measurements Oct. 26'25		Measurements of Joint Gaps Showing Date & Temperature		
				N. Rail	S. Rail	Maximum	Minimum	Average
187	V	68	D	.035	.035	28/64"-12·29·24-30°	0-Read 3 times	7/64"
188	▲	69	E	.015	.020	16/64"-1·7·24-32°	0-Read 3 times	4/64"
189	V	68	G	.015	.020	17/64"-12·15·23-37°	0-Read 5 times	2/64"
190		69	E	.020	.020	27/64"-12·29·24-30°	0-Read 3 times	8/64"
191	V	68	G	.015	.020	22/64"-1·7·24-32°	0-Read 4 times	7/64"
192	V	69	G	.020	.020	17/64"-12·29·24-30°	0-Read 4 times	4/64"
193	V	68	B	.015	.020	14/64"-12·29·24-30°	0-Read 5 times	4/64"
194		69	G	.015	.020	26/64"-11·1·23-57°	0-7·13·23-94° 8·13·23-102°	10/64"
195	V	76	D	.020	.020	24/64"-12·29·24-30°	0-Read 5 times	6/64"
196		69	D	.025	.030	22/64"-12·15·23-37° 1·7·24-32°	1/64"-10·1·23-107° 7·15·25-100°	9/64"
197	V	76	E	.015	.010	23/64"-12·29·24-30°	0-Read 3 times	5/64"
198	V	64	F	.025	.030	29/64"-12·29·24-30°	0-7·13·23-94°	12/64"
199	V	68	E	.010	.010	6/64"-12·15·23-37°	0-Read 7 times	1/64"
200	V	69	F	.015	.015	30/64"-12·15·23-37°	0-Read 3 times	5/64"
201	V	68	F	.015	.020	16/64"-11·1·23-57°	0-Read 6 times	2/64"
202	V	69	F	.015	.020	26/64"-8·27·23-76°	1/64"-10·1·23-107° 8·23·24-122°	9/64"
203	V	76	E	.015	.015	6/64"-12·29·24-30°	0-Read 6 times	2/64"
204		63	E	.015	.020	16/64"-12·29·24-30°	0-Read 4 times	6/64"
205	V	76	E	.015	.015	30/64"-12·15·23-37°	0-8·23·24-122°	12/64"
206	V	69	E	.025	.015	19/64"-8·27·23-76°	0-8·23·24-122° 10·26·25-85°	5/64"
207	V	66	E	.015	.015	15/64"-12·29·24-30°	0-Read 6 times	4/64"
208		69	E	.020	.020	24/64"-7·15·25-100°	0-Read 6 times	8/64"
209	V	76	G.	.015	.015	16/64"-10·26·25-85°	0-Read 7 times	2/64"
210		69	D	.030	.030	28/64"-12·29·24-30°	0-8·23·24-122°	13/64"
211	V	76	F	.015	.020	21/64"-12·15·23-37° 1·7·24-32°	0-8·23·24-122°	9/64"
212	▲	69	D	.020	.015	28/64"-12·29·24-30°	0-10·1·23-107°	11/64"
213	V	76	G.	.020	.015	28/64"-12·29·24-30°	0-7·13·23-94° 8·23·24-122°	7/64"
214		69	F	.015	.030	24/64"-1·7·24-32°	0-Read 3 times	9/64"
215	V	76	G	.015	.020	23/64"-1·7·24-32°	0-Read 3 times	7/64"
216	▲	69	B	.015	.015	32/64"-7·13·23-94°	1/64"-8·23·24-122°	15/64"
217	V	76	G	.025	.020	26/64"-12·29·24-30°	0-Read 6 times	7/64"
218		76	G	.020	.020	30/64"-12·29·24-30°	0-10·1·23-107°	8/64"
219	V	68	D	.025	.025	30/64"-12·15·23-37°	0-Read 4 times	10/64"
220	▲	64	C	.015	.020	25/64"-1·7·24-32°	0-7·15·25-100°	10/64"
221	V	76	F	.030	.020	33/64"-12·29·24-30°	0-10·1·23-107°	12/64"
222		69	F	.020	.025	28/64"-12·29·24-30°	0-7·13·23-94°	10/64"
223	V	76	B	.020	.020	32/64"-7·13·23-94°	0-6·27·23-93°	15/64"
224		69	B	.035	.035	31/64"-12·15·23-37°	4/64"-6·26·23-93°	19/64"
225	V	76	E	.025	.020	31/64"-1·7·24-32°	5/64"-6·27·23-93°	15/64"
226	V	76	B	.010	.010	25/64"-1·7·24-32°	0-Read 5 times	7/64"
227		69	G	.020	.035	28/64"-12·29·24-30°	0-7·13·23-94°	13/64"
228	V	70	F	.015	.025	26/64"-8·27·23-76°	0-8·23·24-122° 7·15·25-100°	8/64"
229	▲	69	E	.035	.040	30/64"-7·13·23-94° 1·7·24-32°	2/64"-7·26·23-118°	15/64"
230	▲	70	C	.030	.030	30/64"-12·15·23-37°	3/64"-10·26·25-85°	22/64"
231	▲	69	E	.020	.025	32/64"-11·1·23-57° 12·15·23-37°	2/64"-7·26·23-118°	11/64"
232	▲	70	F	.025	.025	28/64"-7·15·25-100°	0-10·26·25-85°	10/64"
233	V	63	A	.020	.025	32/64"-1·7·24-32°	0-7·13·23-94°	13/64"
234		65	D	.015	.015	19/64"-11·1·23-57° 12·29·24-30°	0-Read 3 times	4/64"
235	▲	70	C	.025	.020	22/64"-8·27·23-76°	0-6·27·23-93° 10·1·23-107°	11/64"

Exhibit A—Continued

Number	Kind of Joint	Av. Carbon	Ingot Letter	Batter Measurements Oct 26 '25		Measurements of Joint Gaps Showing Date & Temperature		
				N. Rail	S. Rail	Maximum	Minimum	Average
236	▲	70	D	.020	.020	27/64"-1·7·24-32°	0-Read 4 times	8/64"
237		70	B	.025	.020	16/64"-12·15·23-37°	0-Read 7 times	4/64"
238	▲	70	B	.020	.015	28/64"-12·29·24-30°	0-Read 6 times	7/64"
239		69	E	.010	.015	24/64"-1·7·24-32°	0-Read 5 times	5/64"
240		70	C	.015	.015	10/64"-12·15·23-37°	0-Read 5 times	3/64"
241	▲	69	G	.015	.015	23/64"-12·29·24-30°	0-8·13·23-94°	9/64"
242		70	D	.020	.020	25/64"-12·29·24-30°	0-8·13·23-94° 8·23·24-122°	7/64"
243		70	G	.015	.020	20/64"-1·7·24-32°	0-Read 3 times	6/64"
244	V	70	G	.015	.030	9/64"-8·27·23-76° 11·1·23-57°	0-Read 4 times	3/64"
245	V	70	B	.020	.020	19/64"-11·1·23-57°	0-8·13·23-94° 8·23·24-122°	7/64"
246		69	G	.020	.020	25/64"-Read 3 times	0-6·23·24-114°	11/64"
247	V	67	G	.025	.025	28/64"-12·29·24-35°	0-Read 3 times	9/64"
248		69	G	.020	.020	24/64"-1·7·24-32°	0-Read 4 times	6/64"
249		67	F	.020	.020	15/64"-11·1·23-57°	0-7·15·25-100° 10·26·25-85°	4/64"
250	▲	69	G	.015	.050	10/64"-12·15·23-37°	0-Read 3 times	3/64"
251	V	67	B	.025	.025	26/64"-1·7·24-32°	0-Read 4 times	8/64"
252		69	C	.050	.040	32/64"-12·29·24-35°	0-8·23·24-122°	18/64"
253	V	67	B	.015	.015	17/64"-8·27·23-76°	1/64"-8·23·24-122°	7/64"
254	▲	69	C	.020	.025	30/64"-1·7·24-32°	0-6·23·24-114°	12/64"
255	V	67	C	.010	.015	20/64"-12·29·24-35°	0-Read 4 times	6/64"
256	▲	69	B	.030	.015	32/64"-1·7·24-32°	4/64"-6·23·24-114°	17/64"
257	V	67	E	.020	.020	16/64"-12·29·24-35°	0-Read 6 times	3/64"
258	V	69	B	.020	.015	25/64"-11·1·23-57°	1/64"-Read 3 times	10/64"
259		69	A	.020	.025	28/64"-12·29·24-35°	0-Read 4 times	10/64"
260		69	C	.015	.020	26/64"-12·29·24-35°	0-Read 4 times	4/64"
261		67	E	.025	.025	24/64"-12·29·24-35°	0-Read 3 times	7/64"
262		69	B	.020	.020	30/64"-11·1·23-57°	0-10·1·23-107° 6·23·24-114°	13/64"
263		67	B	.020	.020	10/64"-6·27·23-95°	0-8·23·24-122° 10·26·25-85°	4/64"
264		69	D	.015	.010	7/64"-Read 3 times	1/64"-10·1·23-107°	4/64"
265		69	B	.030	.025	19/64"-12·15·23-37°	0-Read 4 times	7/64"
266		69	E	.015	.040	10/64"-1·7·24-32°	0-Read 5 times	3/64"
267		69	G	.030	.020	23/64"-12·29·24-35°	0-8·13·23-102° 8·23·24-122°	6/64"
268	▲	69	B	.055	.030	28/64"-12·29·24-35° 7·15·25-100°	0-8·23·24-122°	11/64"
269	▲	69	F	.025	.020	18/64"-12·29·24-35°	0-Read 5 times	5/64"
270		69	E	.025	.015	21/64"-1·7·24-32°	1/64"-8·23·24-122°	9/64"
271	▲	69	D	.015	.020	11/64"-1·7·24-32°	0-Read 6 times	2/64"
272	V	69	F	.015	.020	21/64"-11·1·23-57°	1/64"-Read 3 times	8/64"
273	▲	67	G	.020	.015	25/64"-11·1·23-57°	0-Read 4 times	7/64"
274		69	D	.020	.025	25/64"-12·29·24-35°	-0-Read 5 times	3/64"
275	▲	70	E	.015	.050	22/64"-11·1·23-57° 12·15·23-37°	0-Read 4 times	9/64"
276		69	C	.025	.020	28/64"-12·29·24-35°	0-8·13·23-102° 8·23·24-122°	10/64"
277	▲	67	F	.050	.035	25/64"-12·15·23-37°	0-Read 6 times	9/64"
278		69	B	.015	.025	16/64"-7·15·25-100°	0-8·23·24-122°	6/64"
279	▲	69	G	.025	.020	25/64"-12·29·24-35°	0-8·13·23-102°	6/64"
280		67	G	.030	.025	24/64"-11·1·23-57°	0-7·26·23-118° 8·23·24-122°	7/64"
281	▲	70	F	.010	.010	10/64"-6·27·23-95°	0-Read 13 times	1/64"
282		68	E	.015	.015	15/64"-1·7·24-32°	0-Read 3 times	5/64"
283		70	G	.015	.020	9/64"-6·27·23-95°	0-Read 7 times	2/64"
284	▲	68	D	.015	.020	8/64"-11·1·23-57°	0-Read 4 times	2/64"

Exhibit A—Continued

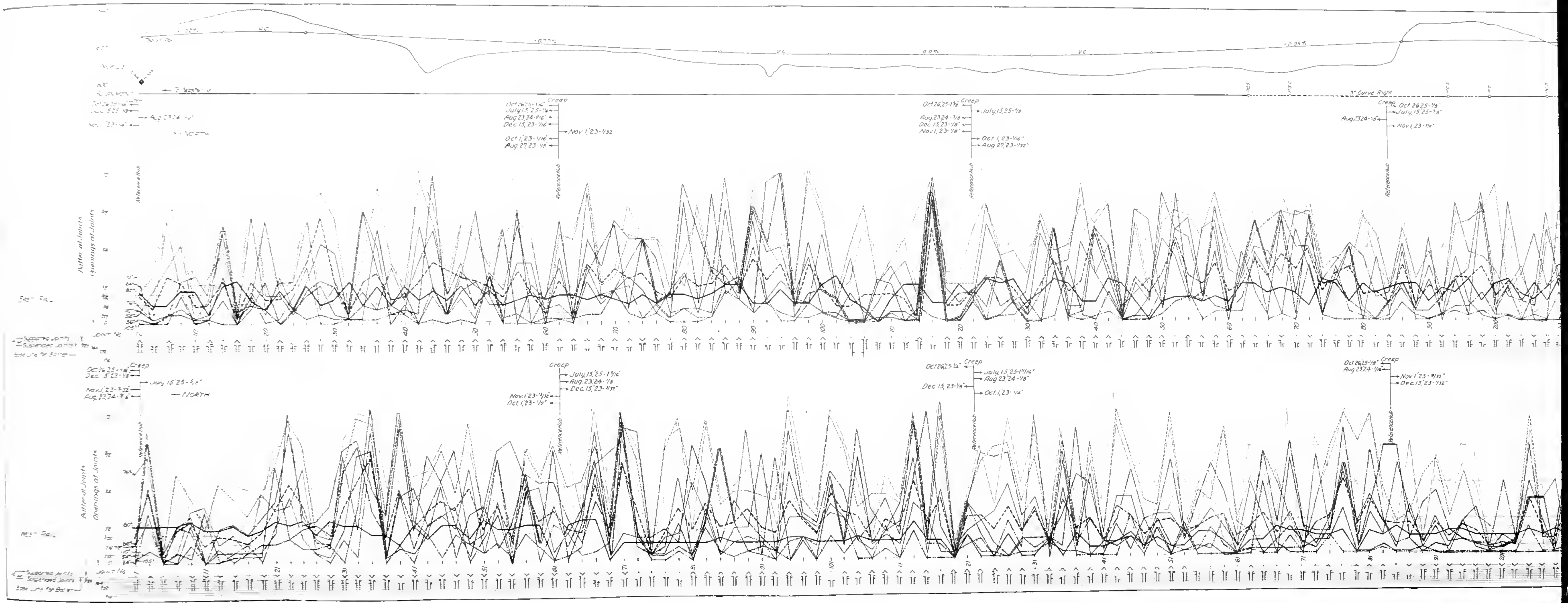
Number	Kind of Joint	Av. Carbon	Ingot Letter	Batter Measurements Oct. 26 '25		Measurements of Joint Gaps Showing Date & Temperature		
				N. Rail	S. Rail	Maximum	Minimum	Average
285	V	70	B	.010	.010	7/64"- 6.27.23-95°	0- 8.23.24-122° 7.15.25-100°	3/64"
286	▲	68	E	.020	.020	20/64"- 7.15.25-100°	0-Read 5 times	4/64"
287		70	B	.010	.015	5/64"- 1.7.24-32°	0-Read 10 times	1/64"
288	V	68	F	.025	.025	23/64"- 1.7.24-32°	0-Read 5 times	8/64"
289		70	E	.015	.015	28/64"- 1.7.24-32°	0-Read 6 times	7/64"
290	V	68	C	.020	.015	27/64"- 12.29.24-35°	0- 10.1.23-107° 8.23.24-122°	10/64"
291		70	B	.010	.010	7/64"-Read 3 times	0-Read 10 times	1/64"
292		63	E	.030	.030	32/64"- 11.1.23-57°	6/64"- 10.1.23-107°	20/64"
293	▲	70	G	.010	.015	16/64"- 12.15.23-37°	0-Read 9 times	3/64"
294		63	D	.030	.025	28/64"- 12.15.23-37°	0- 7.13.23-94°	11/64"
295		70	G	.015	.020	16/64"- 11.1.23-57°	0-Read 8 times	3/64"
296		63	F	.015	.015	26/64"- 12.29.24-35°	0- 7.13.23-94°	6/64"
297	V	70	D	.020	.020	33/64"- 11.1.23-57° 1.7.24-32°	0-Read 3 times	11/64"
298		68	F	.020	.015	23/64"- 1.7.24-32°	1/64"- 8.13.23-102° 8.23.24-122°	9/64"
299		70	E	.015	.025	14/64"- 1.7.24-32°	0-Read 6 times	4/64"
300		68	B	.015	.045	12/64"- 12.15.23-37°	1/64"-Read 4 times	5/64"
301		70	D	.025	.020	18/64"- 8.27.23-76°	0-Read 4 times	7/64"
302		70	B	.045	.040	32/64"-Read 4 times	2/64"- 8.23.24-122°	16/64"
303	V	70	F	.020	.020	31/64"- 12.29.24-35°	0-Read 4 times	7/64"
304		67	A	.025	.020	19/64"- 12.29.24-35°	0-Read 4 times	5/64"
305		68	G	.015	.020	13/64"- 11.1.23-57°	0-Read 7 times	4/64"
306	V	68	E	.020	.020	17/64"- 1.7.24-32° 12.29.24-35°	0- 7.13.23-94°	7/64"
307	▲	68	E	.020	.020	29/64"- 12.15.23-37°	0-Read 6 times	8/64"
308		63	B	.020	.020	28/64"- 1.7.24-32°	1/64"- 10.1.23-107°	10/64"
309	▲	68	B	.020	.020	23/64"- 1.7.24-32°	0-Read 7 times	6/64"
310		70	D	.015	.020	11/64"- 11.1.23-57°	0- 7.15.25-100°	5/64"
311	▲	68	E	.015	.015	11/64"- 8.27.23-76°	0- 8.13.23-102° 8.23.24-122°	3/64"
312	V	63	G	.025	.020	26/64"- 12.29.24-35°	0- 7.13.23-94° 10.1.23-107°	10/64"
313		63	G	.015	.025	23/64"- 1.7.24-32°	0-Read 3 times	7/64"
314	V	63	B	.020	.020	15/64"- 1.7.24-32°	0- 8.23.24-122° 7.15.25-100°	8/64"
315	▲	64	F	.020	.020	25/64"- 12.29.24-35°	0-Read 4 times	9/64"
316		63	D	.020	.020	29/64"- 1.7.24-32°	0- 7.26.23-118°	10/64"
317	▲	64	G	.020	.020	20/64"- 1.7.24-32°	0- 8.23.24-112°	8/64"
318	V	63	D	.020	.020	25/64"- 12.15.23-37°	1/64"-Read 3 times	8/64"
319	▲	63	D	.025	.025	11/64"- 12.29.24-35°	0-Read 5 times	4/64"
320	V	63	E	.020	.020	11/64"- 12.29.24-35	0- 8.23.24-122°	4/64"
321		68	E	.020	.020	23/64"- 11.1.23-57°	0-Read 4 times	9/64"
322	V	63	E	.020	.020	21/64"- 11.1.23-57°	0- 8.23.24-122°	7/64"
323		68	E	.015	.020	10/64"- 8.27.23-76°	0-Read 3 times	4/64"
324		63	B	.020	.020	24/64"- 1.7.24-32°	1/64"- 8.23.24-122° 7.15.25-100°	9/64"
325		67	B	.025	.025	30/64"- 1.7.24-32°	0- 8.23.24-122°	11/64"
326		67	A	.025	.025	28/64"- 12.29.24-35°	0- 7.13.23-94°	9/64"
327	▲	63	G	.015	.010	6/64"- 12.15.23-37°	0-Read 7 times	2/64"
328	▲	63	F	.025	.035	24/64"- 12.15.23-37°	1/64"- 8.23.24-122°	10/64"
329	▲	67	G	.015	.020	23/64"- 1.7.24-32°	0- 10.1.23-107° 8.23.24-122°	7/64"
330		63	E	.030	.020	17/64"- 1.7.24-32° 12.29.24-35°	0-Read 5 times	8/64"
331		68	G	.025	.020	16/64"- 10.26.25-85°	0- 7.15.25-100°	6/64"
332	V	63	F	.020	.020	19/64"- 1.7.24-32°	1/64"- 8.23.24-122° 7.15.25-100°	9/64"
333		68	F	.015	.020	22/64"- 8.27.23-76°	0- 7.15.25-100° 8.23.24-122°	7/64"

Exhibit A—Continued

Number	Kind of Joint	Av. Carbon	Ingot Letter	Batter Measurements Oct. 26 '25		Measurements of Joint Gaps Showing Date & Temperature		
				N. Rail	S. Rail	Maximum	Minimum	Average
334		63	F	.020	.020	16/64"-12·29·24-35°	0-10·1·23-107°	9/64"
335	V	67	D	.030	.020	28/64"-12·15·23-37° 12·29·24-35°	0-8·23·24-122°	11/64"
336		63	C	.025	.020	25/64"-1·7·24-32°	1/64"-Read 3 times	9/64"
337		67	F	.020	.020	20/64"-12·29·24-35°	0-Read 3 times	4/64"
338	▲	67	D	.025	.020	28/64"-12·29·24-35°	0-7·13·23-94°	12/64"
339		68	B	.025	.020	14/64"-12·15·23-37°	1/64"-8·23·24-122° 7·15·25-100°	5/64"
340		68	F	.020	.020	11/64"-1·7·24-32°	0-Read 5 times	4/64"
341		68	B	.020	.050	23/64"-1·7·24-32°	0-Read 4 times	6/64"
342		68	G	.020	.020	14/64"-12·15·23-37°	0-Read 3 times	5/64"
343		64	D	.050	.035	28/64"-1·7·24-32°	1/64"-Read 3 times	9/64"
344	V	68	F	.015	.035	19/64"-12·29·24-35°	0-Read 4 times	3/64"
345		68	E	.010	.015	7/64"-6·28·23-80°	0-7·13·23-94° 10·1·23-107°	2/64"
346	V	67	E	.035	.025	19/64"-12·29·24-35°	0-Read 6 times	4/64"
347	▲	67	D	.020	.025	27/64"-1·7·24-32°	0-7·13·23-94° 8·13·23-102°	8/64"
348	V	69	C	.020	.020	29/64"-12·29·24-35°	0-Read 4 times	6/64"
349		67	E	.020	.025	20/64"-12·29·24-35°	0-Read 5 times	4/64"
350	V	68	D	.020	.020	29/64"-12·29·24-35°	1/64"-7·15·25-100°	10/64"
351	▲	68	G	.025	.025	30/64"-12·29·24-35°	0-Read 5 times	7/64"
352	V	68	B	.020	.015	30/64"-12·29·24-35°	0-Read 3 times	9/64"
353	▲	68	G	.015	.015	21/64"-1·7·24-32°	0-Read 3 times	7/64"
354		68	D	.015	.015	25/64"-12·29·24-35°	0-7·15·25-100°	8/64"
355		68	B	.015	.020	24/64"-1·7·24-32°	0-Read 3 times	8/64"
356	▲	67	B	.010	.020	10/64"-12·29·24-35°	1/64"-7·15·25-100°	7/64"
357	▲	68	G	.025	.020	28/64"-12·29·24-35°	0-Read 4 times	6/64"
358	V	68	F	.025	.025	35/64"-12·29·24-35°	0-7·15·25-100°	14/64"
359	▲	68	G	.015	.015	12/64"-12·15·23-37°	0-7·13·23-94° 10·1·23-107°	3/64"
360	V	67	G	.025	.025	40/64"-12·29·24-35°	0-7·15·25-100°	10/64"
361	▲	68	B	.015	.020	18/64"-12·29·24-35°	0-Read 4 times	4/64"
362	▲	67	A	.025	.020	25/64"-12·15·23-37° 1·7·24-32°	0-Read 3 times	10/64"
363	▲	69	A	.035	.015	18/64"-1·7·24-32°	0-Read 4 times	5/64"
364		70	A	.025	.015	34/64"-12·15·23-37°	0-Read 3 times	14/64"
365	V	70	A	.010	.015	9/64"-6·28·23-70°	0-Read 7 times	2/64"
366	V	63	A	.015	.020	33/64"-1·7·24-32°	5/64"-Read 3 times	14/64"
367	V	76	A	.015	.020	19/64"-1·7·24-32°	0-Read 7 times	4/64"
368	▲	69	C	.020	.020	29/64"-1·7·24-32°	6/64"-7·15·25-100° 10·26·25-85°	19/64"
369	V	70	G	.020	.020	15/64"-8·27·23-77°	0-Read 6 times	5/64"
370	▲	68	G	.020	.025	34/64"-11·1·23-57°	0-7·13·23-94°	19/64"
371	V	67	C	.015	.010	32/64"-7·13·23-94° 12·29·24-35°	0-Read 6 times	7/64"
372	V	70	F	.025	.025	34/64"-Read 3 times	3/64"-7·15·25-100° 10·26·25-85°	26/64"
373	V	68	G	.015	.015	10/64"-12·29·24-35°	0-7·13·23-94° 8·23·24-122°	4/64"
374	V	68	C	.025	.025	34/64"-12·15·23-37°	0-7·15·25-100°	25/64"
375	V	69	C	.015	.015	9/64"-6·28·23-70°	0-Read 3 times	2/64"
376		69	C	.025	.025	34/64"-12·15·23-37°	0-7·15·25-100°	14/64"
377	▲	63	G	.020	.020	15/64"-11·1·23-57°	0-Read 5 times	5/64"
378		67	F	.020	.020	26/64"-1·7·24-32°	0-Read 3 times	8/64"
379		69	C	.020	.040	17/64"-12·29·24-35°	0-Read 4 times	4/64"
380	▲	68	E	.035	.035	30/64"-1·7·24-32°	2/64"-7·13·23-94° 7·26·23-118°	12/64"
381	V	67	B	.045	.025	25/64"-Read 3 times	0-Read 6 times	9/64"
382		70	B	.020	.020	19/64"-8·27·23-77°	0-8·23·24-122° 7·15·25-100°	8/64"

Exhibit A—Continued

Number	Kind of Joint	Av. Carbon	Ingot Letter	Batter Measurements Oct. 26 '25		Measurements of Joint Gaps Showing Date & Temperature		
				N. Rail	S. Rail	Maximum	Minimum	Average
383	▲	70	F	.015	.020	12/64"-1·7·24-32°	0-Read 6 times	3/64"
384	▲	68	B	.020	.030	28/64"-1·7·24-32°	0-10·1·23-107° 7·15·25-100°	11/64"
385	▲	63	G	.015	.015	7/64"-6·28·23-95°	0-Read 5 times	3/64"
386	▲	68	F	.030	.025	28/64"-Read 4 times	0-Read 3 times	17/64"
387	▲	68	C	.020	.020	16/64"-12·29·24-35°	0-Read 4 times	6/64"
388	▲	68	B	.020	.020	30/64"-12·29·24-35°	0-7·13·23-94° 7·15·25-100°	13/64"
389	▲	68	E	.015	.025	20/64"-8·27·23-77°	0-8·13·23-102° 10·1·23-107°	6/64"
390	▲	68	C	.015	.025	22/64"-12·15·23-37° 1·7·24-32°	0-Read 3 times	7/64"
391	▲	70	D	.015	.015	30/64"-12·29·24-35°	0-8·13·23-102°	9/64"
392				.015	.015	19/64"-1·7·24-32°	0-Read 3 times	6/64"
393		66	C	.010	.010	7/64"-12·29·24-35°	0-Read 8 times	2/64"


V.C.
-0.77%
0.0%
V.C.
+0.35%
3° Curve Right
P.C.S.
P.S.C.
P.C.S.
P.T.
Creep
Oct 26,'25-1/16"
July 15,'25-1/16"
Aug. 23,'24-1/16"
Dec 15,'23-1/16"
Nov 1,'23-1/32
Oct 1,'23-1/16"
Aug. 27,'23-1/8"
Oct. 26,'25-1 3/8
July 15,'25-1/8
Aug. 23,'24-3/8
Dec. 15,'23-1/8"
Nov 1,'23-1/8"
Oct. 1,'23-1/16"
Aug 27,'23-1/32"
Oct 26,'25-1/8"
July 15,'25-3/8"
Aug. 23,'24-1/8"
Nov 1,'23-1/8"
NORTH
Reference Hub
Pattern at Joints
Openings at Joints
East Rail
Joint No.
Supported Joints
Suspended Joints
Base Line for Batter
July 15,'25-5/8"
July 15,'25-1 3/16
Aug. 23,'24-1/8
Dec. 15,'23-3/32"
Nov. 1,'23-13/32
Oct. 1,'23-1/2"
Oct. 26,'25-1/4"
July 15,'25-1 11/16"
Aug. 23,'24-1/8"
Dec 15,'23-1/8"
Oct. 1,'23-1/4"
Oct 26,'25-1/8"
Aug 23,'24-1/16"
Nov 1,'23-9/32"
Dec. 15,'23-1/32"
West Rail
10
20
30
40
50
60
70
80
90
100
200

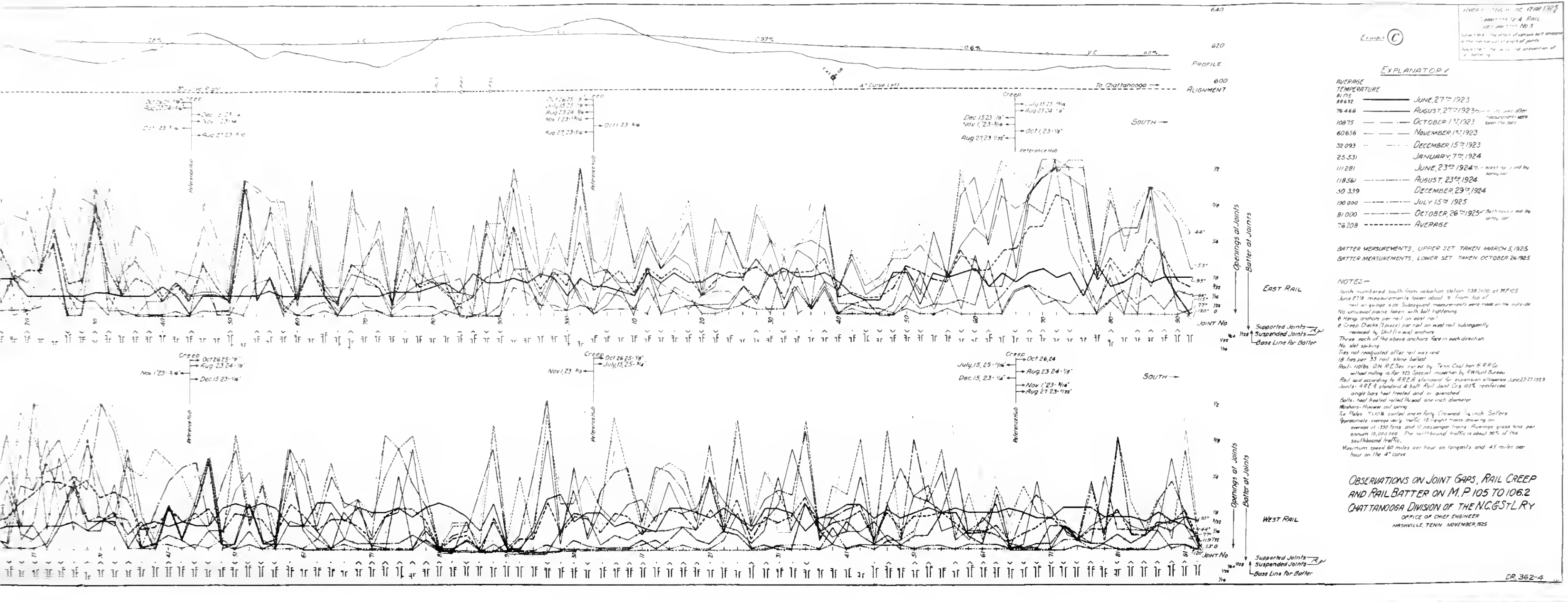


Exhibit (C)

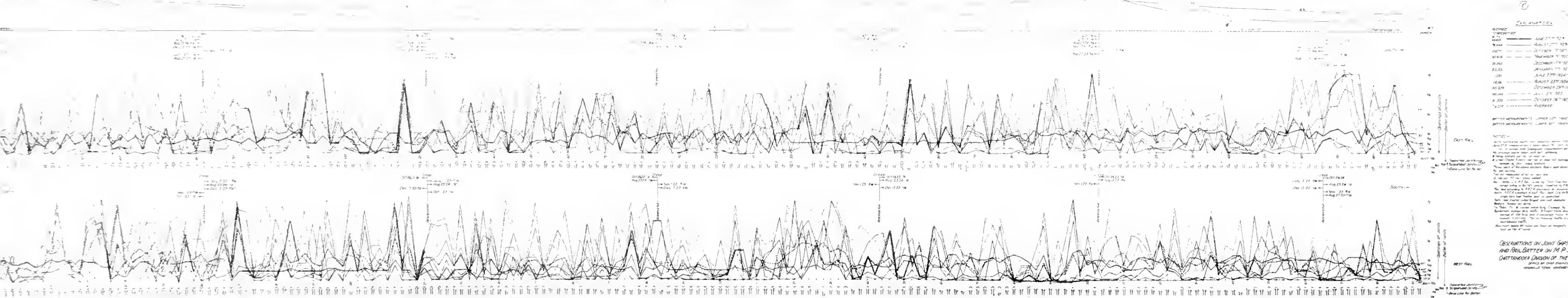
BATTER MEASUREMENTS, UPPER SET TAKEN MARCH 5, 1925
BATTER MEASUREMENTS, LOWER SET TAKEN OCTOBER 26 1925

NOTES—
Joints numbered south from valuation station 5583+00 at M.P.105
June 27th measurements taken about ½ from top of rail on gauge side. Subsequent measurements were made on the outside
No unusual gains taken with bolt tightening
6 Heng anchors per rail on east rail
6 Creep Checks (2 piece) per rail on west rail subsequently replaced by Unit (1 piece) anchors
Three each of the above anchors face in each direction
No slot spiking
Ties not readjusted after rail was laid
18 ties per 33 rail stone ballast
Rail - 110 lbs. O.H. R.E. Sec. rolled by Tenn. Coal Iron & R.R. Co. without milling in Apr. 1923 Special inspection by R.W. Hunt Bureau
Rail laid according to A.R.E.A. standard for expansion allowance June 23-27 1923
Joints - A.R.E.A. standard 4 bolt Rail Joint Co's 100% reinforced angle bars heat treated and oil quenched
Bolts - heat treated rolled thread one inch diameter
Washers - Hipower coil spring
Tie Plates 7×10½ canted one in forty Crowned ⅛ inch Sellers
Approximate average daily traffic 18 freight trains drawing an average of 1350 tons and 12 passenger trains. Average gross tons per annum 12,000,000. The northbound traffic is about 90% of the southbound traffic.
Maximum speed 60 miles per hour on tangents and 45 miles per hour on the 4° curve

OBSERVATIONS ON JOINT GAPS, RAIL CREEP AND RAIL BATTER ON M.P 105 TO 106.2 CHATTANOOGA DIVISION OF THE N.C.&St.L.Ry

OFFICE OF CHIEF ENGINEER
NASHVILLE, TENN. NOVEMBER, 1925

DR. 362-4



OBSERVATIONS ON JOINT GAPS
AND RAIL BATTER ON M P
CHATTANOOGA DIVISION OF THE
OFFICE OF CHIEF ENGINEER
NASHVILLE TENN.

Exhibit B

NOTES ON BATTER, END OVERFLOW, CHIPPING, GAP READINGS, MOVEMENT, ETC., AT JOINTS, SUPPLEMENTING OBSERVATIONS ON 110-LB. RAILS AND JOINTS M.P. 105-106.2, CHATTANOOGA DIVISION OF THE NASHVILLE, CHATTANOOGA AND ST. LOUIS RAILWAY. 1923-1925.

(The absence of notes indicates that the information shown in Log on preceding pages and on chart, Plate C, is complete. These notes are as of October 26th, 1925, unless other dates are shown. N.R. indicates North Rail, S.R. South Rail. Bolt tensions and stresses in splices were taken by observers under Prof. A. N. Talbot, Chairman of the Special Committee on Stresses in Railroad Track. Bolts are numbered from north end.)

Joint

3 Both ends badly battered. S.R. badly chipped on top. N.R. damaged on top at outside edge by fin on S.R. N.R. frozen. S.R. moving.

4 Gap Readings. 0″. 7-26-23, 118°. 10-1-23, 107°. 7-25-25, 100°. 10-26-25, 79°. End overflow on top of S.R. damaging N.R.

5 Gap Readings. 0″. 7-13-23, 94°. 7-26-23, 118°. 8-13-23, 102°. 8-27-23, 76°. 10-1-23, 107°. 7-15-25, 100°. 10-26-25, 79°. Slight end overflow on gage corner of each rail. Nov. 7-12, 1925, Bolt Tensions: Bolt 1 = 15,000, 2 = 16,000, 3 = 10,500, 4 = 29,000. Stresses in splices also taken.

6 3-6-25, Small end overflow on gage corner of N.R. sawed off. 10-26-25, gage corner of S.R. shows damage by end overflow breaking off. N.R. chipped on top near gage side.

7 Gap Readings. 0″. 8-13-23, 102°. 10-1-23, 107°. 8-23-24, 115°. 10-26-25, N.R. frozen. S.R. moving.

8 N.R. chipped on gage corner. Slight end overflow on gage corner of S.R. N.R. frozen. S.R. moving.

9 Slight end overflow on gage corner of N.R. and top of S.R.

10 Gap Readings. 0″. 8-13-23, 102°. 8-27-23, 78°. 10-1-23, 107°. Slight end overflow on gage corner of S.R.

11 Gap Readings. 0″. 7-13-23, 94°. 7-26-23, 118°. 8-13-23, 102°. 10-1-23, 107°. 11-1-23, 56°. 8-23-24, 115°. 10-26-25, 79°. N.R. slightly chipped on gage corner.

12 Slight end overflow on gage corner and top of S.R.

13 Gap Readings. 0″. 7-26-23, 118°. 10-1-23, 107°. 7-15-25, 100°. 7-26-25, S.R. chipped on top and end overflow on gage corner. N.R. slight end overflow on top.

14 N.R. slightly chipped on top near gage side. S.R. slight end overflow on top near gage side. S.R. frozen. N.R. moving. Nov. 7-12, 1925. Bolt Tensions, Bolt 1 = 6,000, 2 = 5,000, 3 = 16,400, 4 = 12,000.

15 N.R. slight end overflow on gage corner.

16 Gap Readings. 0″. 7-13-23, 94°. 9-13-23, 102°. 8-2-23, 76°. 10-1-23, 107°. 11-1-23, 57°. 8-23-24, 115°.

17 S.R. slightly chipped. N.R. slight end overflow at gage side.

Joint

18 S.R. end overflow at gage corner.

19 N.R. slight end overflow at gage corner.

20 Gap Readings. 0″. 7-13-23, 94°. 7-26-23, 118°. 10-1-23, 107°. 6-23-24, 114°. S.R. slight end overflow on gage side. S.R. frozen. N.R. moving.

21 7-22-24, Open 7/64″ 110°. Closed at top when bolts were slacked. 7-25-25, Gap 21/64″ 100°. Closed tight when bolts were loosened. 10-26-25, S.R. slight end overflow on top.

22 S.R. slightly chipped on top and slight end overflow on top near gage side.

23 N.R. slightly chipped on gage side. 12-1-24, Slight end overflow on each rail principally on gage corners. One bolt loose. 3-26-25, Small fin on gage corner S.R. sawed off. 10-26-25, No overflow.

24 Slight end overflow on top of N.R. and on gage corner of S.R.

25 S.R. slight end overflow on top.

26 Slight end overflow on top of S.R. and on top of N.R. at gage side.

27 Gap Readings. 0″. 7-13-23, 94°. 7-26-23, 118°. 8-13-23, 102°. N.R. frozen. S.R. moving.

28 Slight end overflow on top of N.R.

29 Gap Readings. 0″. 7-13-23, 94°. 7-26-23, 118°. 8-13-23, 102°. 10-1-23, 107°.

30 Slight end overflow on top of S.R. near gage side.

31 Gap Readings. 0″. 7-13-23, 94°. 8-13-23, 101°. 8-23-24, 115°. 12-1-24, ⅜″ Two loose bolts. 7-15-25, Open 20/64″ 100°. Closed tight when bolts were loosened.

32 Gap Readings. 0″. 7-13-23, 94°. 8-13-23, 101°. 7-15-25, 100°. Slight end overflow on gage corner of S.R.

33 7-22-24, 115°. Open $\frac{7}{16}$″. Bolts loosened. Closed at top 110°, but open $\frac{1}{16}$″ below. N.R. slightly overflowed on gage corner. 10-26-25, S.R. frozen. N.R. moving. Nov. 7-12, 1925, Bolt Tensions Bolt 1.......Extremely hard to loosen Reading unreliable. 2 = 24,000. 3 = 8,000. 4 = 43,000.

34 Gap Readings. 0″. 7-13-23, 94°. 7-26-23, 118°. 8-13-23, 102°.

35 7-22-24, Open $\frac{5}{16}$″ 115°. Bolts slacked. Closed after one train passed. 10-26-25, Slight end overflow on each rail at gage corners. S.R. frozen. N.R. moving.

36 S.R. slight end overflow on gage corner.

37 Gap Readings. 0″. 7-13-23, 94°. 8-13-23, 102°. 10-1-23, 107°. N.R. frozen. S.R. moving.

38 S.R. end overflow on gage corner.

39 7-22-24, Open $\frac{5}{16}$″ 118°. After bolts loosened $\frac{3}{32}$″. After six trains passed 0″ at top. 3-6-25, $\frac{7}{16}$″ open and frozen. After bolts loosened $\frac{7}{32}$″. 7-15-25, 0″ 100°. 10-26-25, Slight end overflow on top of each rail.

40 End overflow on top of N.R. at gage side. Top of S.R. at gage side damaged by overflow from N.R.

41 3-6-25, End overflow sawed off. 10-26-25, No end overflow. Slight chip on top of N.R.

42 Gap Readings. 0″. 10-1-23, 107°. 8-23-24, 115°. 7-15-25, 100°. S.R. chipped on top and at gage corner. N. R. end overflow on top and gage corner.

Joint

43 7-15-25, 100° Open 24/64". Closed to 5/64" when bolts were loosened. 10-26-25 End overflow at top on each rail.

44 12-29-24, 100° ½" open. One loose bolt. Slight end overflow on N.R. near outer edge. S.R. dented by overflow on N.R. 10-26-25, N.R. frozen. S.R. moving.

45 Slight end overflow on top of each rail.

46 12-29-24, Two loose bolts. Slight end overflow on gage corner of S.R.

47 3-6-25, End overflow sawed off. Chip on top of S.R. near gage side. 10-26-25, No end overflow.

48 S.R. chipped on top near outside. Slight end overflow on top of each rail.

49 Gap Readings. 0". 7-13-23, 94°. 7-26-23, 118°. 10-1-23, 107°. 7-22-24 ¼" 120°. Bolts loosened. 0" after one train passed. 12-29-24, ½" open. 26°. Two loose bolts. 10-26-25, Slight end overflow on top of each rail.

50 Small chip on top of S.R. near gage side.

51 N.R. end overflow on top at gage damaging S.R.

52 Slight end overflow on top of each rail.

53 S.R. frozen. N.R. moving.

54 Gap Readings. 0" 7-13-23, 94°. 10-1-23, 107°. 6-23-24, 114°. 7-15-25, 100°. Bolt Tensions. Nov. 7-12, 1925, Bolt 1 = 31,500, 2 = 11,000, 3 = 18,500, 4 = 10,000.

55 Gap Readings. 0". 7-13-23, 94°. 7-26-23, 118°. 8-13-23, 102°. 8-27-23, 76°. 10-1-23, 107°. S.R. frozen. N.R. moving. Bolt Tensions. Nov. 7-12, 1925, Bolt 1 = 14,500, 2 = 19,500, 3 = 11,000, 4 = 32,000. Stresses in splices also taken.

56 Gap Readings. 0". 7-26-23, 118°. 10-1-23, 107°. 10-26-25, 79°. N.R. badly chipped. End overflow on gage corner of S.R. Nov. 7-12, 1925. Bolt Tensions. Bolt 1 = 1,500 found loose, 2 = 7,500, 3 = 12,000, 4 = 11,000. Stresses in splices also taken.

57 End overflow at top on each rail. Nov. 7-12, 1925, Bolt Tensions. Bolt 1 = 17,000, 2 = 27,200, 3 = 6,500, 4 = 28,500. Stresses in splices also taken.

58 Gap Readings. 0". 10-1-23, 107°. 8-23-24, 115°. 7-15-25, 100°. 12-29-24, 26° One loose bolt.

59 7-22-24, Open 7/64" 120°. After bolts loosened 0". 10-26-25, Small chip on top of S.R. at gage side. Slight end overflow on top of N.R.

60 Gap Readings. 0". 7-13-23, 94°. 7-26-23, 118°. 9-13-23, 102°. 8-27-23, 76°. 10-1-23, 107°.

61 3-5-25, S.R. chipped ⅜" x 1¼" x ⅛" near gage side. 7-15-25, 100° Open 25/64" Closed to 10/64" when bolts were loosened. 10-26-25 S.R. chipped on top at gage side, N.R. on top at center.

62 N.R. chipped on top. End overflow on top of S.R.

63 S.R. badly chipped on top. N.R. badly chipped on gage corner.

64 Gap Readings. 0". 8-13-23, 102°. 8-27-23, 76°. 10-1-23, 107°. 10-26-25, Top of N.R. slightly chipped. Slight end overflow on top of each rail.

65 N.R. chipped on top at gage side.

66 Gap Readings. 12-29-24, 26°. 15/32". 3-6-25, ½" and frozen. 10-26-25, 79° 18/64". 12-29-24, Both rails badly battered. N.R. dented by end overflow from S.R. Joint swinging ½". 3-6-25, Top of S.R. chip-

Joint

ping out to ½″ back from end. Overflow on top of S.R. sawed off. Joint closed tight when bolts were loosened. Improved Hi-Power washers applied. When splices were removed inside showed oil on top and bottom. Outside showed no oil. Splices oiled top and bottom and replaced. 7-15-25 Washers O.K. 10-26-25, Both ends very badly battered. N.R. slightly chipped and slight end overflow on top at gage corner. Much recent overflow on top of S.R. N.R. frozen. S.R. moving. 11-10-25, Bolt Tensions. Bolt 1 = 20,500. 2 = 11,000. 3 = 11,000. 4 = 4,000. Splice stresses also taken. Joint built up by welding. This joint included in study of twelve worst battered joints. Plate I-b. 12-1-25, 50° Welds holding up. No end overflow. No crushing down. Apparently frozen. Joint gap ¼″. Batter N.R. end .020; batter S.R. end .010.

67 7-22-24, Open ¼″ 125° Bolts loosened, 3/64″ after one train passed. 3-6-25, Open $\frac{7}{16}$″ and frozen. Closed tight when bolts were loosened. 3-6-25, S.R. slightly chipped at gage corner. Slight end overflow on gage corner of N.R. sawed off. When splices were removed inside splice showed oil on top and bottom, outside splice none. Splices were oiled on tops and bottoms and replaced. Improved Hi-Power washers put on. 7-15-25 Washers in perfect condition. Joint closed at 100°. 10-26-25, Apparently frozen. End overflow on top of each rail. 11-10-25 Splices removed and gre dag applied to contact surfaces which were fairly bright. Excess squeezed out as bolts were tightened. Washers O.K. Nov. 9-13, 1925, Welded up account excessive batter. Included in special study. See Plate I-b. Lubricated with gre dag. Fishing surfaces found bright. 40″ wrench used to tighten bolts. Washers in excellent condition. 12-1-25, 50° Welds holding up. No end overflow. Slight crushing in evidence. S.R. frozen. N.R. moving. Joint gap ½″. Batter N.R. .024; S.R. .022.

68 12-29-24, 26° ½″ open. 3-6-25, ½″ open. Closed to ⅜″ when bolts were loosened. Slight end overflow on each rail. Improved Hi-Power washers put on. 7-15-25, Washers O.K. 10-26-25, Slight end overflow on top of S.R. Bolt Tensions. Nov. 7-12, 1925, Bolt 1 = 20,000. 2 = 13,000. 3 = 16,000. 4 = 9,500. Stresses in splices also taken.

69 12-29-24, Very slight end overflow on S.R. All four bolts loose. Open ¼″ 26° Bolts tightened.

70 10-26-25, End overflow on top of each rail.

71 7-15-25, 100° 28/64″ open. Closed to 7/64″ when bolts were loosened. 10-26-25, Slight end overflow on both rails. N.R. frozen. S.R. moving.

72 Gap Readings. 2/64″. 7-13-23, 94°. 7-26-23, 118°. 8-23-24, 115°.

73 12-29-24, Slight end overflow on S.R. Two bolts have spring washers loose. One bolt tight without spring washer. 10-26-25, Slight end overflow on top of N.R.

74 Gap Readings. $\frac{1}{64}$″. 7-26-23, 118°. 10-1-23, 107°. 8-23-24, 115°. 10-26-25, Small chip on top of N.R. near outside.

75 Gap Readings. 0″. 7-13-23, 94°. 7-26-23, 118°. 8-13-23, 102°. 10-1-23, 107°. 7-15-25, 100°.

76 Slight overflow on top of N.R.

77 Gap Readings. 0″. 7-13-23, 94°. 7-26-23, 118°. 10-1-23, 107°. 10-26-25, Small chip on top of N.R.

78 Gap Readings. 0″. 7-13-23, 94°. 7-26-23, 118°. 10-1-23, 107°.

79 12-29-24, S.R. chipped at gage corner. Three loose bolts. S.R. moving. 10-26-25, Bad chip on gage side of S.R.

Joint

80 N.R. frozen. S.R. moving. Nov. 7-12, 1925, Bolt Tensions. Bolt 1 = 15,000, 2 = 17,500, 3 = 5,000, 4 = 10,000. Stresses in splices also taken.

82 Gap Readings. 0″. 7-13-23, 94°. 8-13-23, 102°. 10-1-23, 107°.

83 N.R. slightly damaged on top by end overflow from S.R. End overflow on top of each rail.

84 Small chip on top of N.R. Slight end overflow on each rail.

85 Gap Readings. 0″. 7-13-23, 94°. 7-26-23, 118°. 8-13-23, 102°. 7-15-25, 0″ 100°. 10-26-25, S.R. chipped on top at gage side. S.R. frozen. N.R. moving.

86 Slight end overflow on top of both rails.

87 12-29-24, 26° $\frac{3}{8}$″ open. Four bolts loose.

88 Gap Readings. 5/64″ 8-13-23, 102°. 8-27-23, 76°. 6-23-24, 114°. 8-23-24, 115°. 10-26-25, Overflow on top of both rails.

89 7-22-24, 13/64″ open, 125°. After bolts loosened and one train passed 0″. 12-29-24, $\frac{5}{16}$″ open, 26°. All bolts loose. Tightened. Slight end overflow on gage corner of N.R. Nov. 7-12, 1925, Bolt Tensions. Bolt 1 = 5,000, 2 = 14,000, 3 = 12,500, 4 = 16,500. Stresses in splices also taken.

90 Gap Readings. 2/64″ 6-23-24, 114°. 8-23-24, 115°. 10-26-25, 79°. S.R. badly chipped on top at outside. Extreme end overflow on top of each rail and at gage corners.

91 S.R. badly and N.R. slightly chipped at gage side.

92 End overflow on top of S.R. at gage side. S.R. frozen. N.R. moving.

93 Gap Readings. 0″. 7-13-23, 94°. 8-13-23, 102°. 10-1-23, 107°. 7-15-25, 100°. 10-26-25, 79°. Small chip on top of N.R. near outside.

94 12-29-24, S.R. chipped slightly. Three bolts loose. $\frac{5}{8}$″ open. 26°. Joint swinging. 10-26-25, S.R. chipped on top in two places. Nov. 7-12, 1925, Bolt Tensions. Bolt 1 = 18,500, 2 = 14,000, 3 = 20,000, 4 = 9,500. Stresses in splices also taken.

95 Tops of each rail slightly chipped and ends overflowed.

96 Gap Readings. 0″. 7-13-23, 94°. 6-23-24, 114°. 8-23-24, 115°.

97 Gap Readings. 5/64″. 6-27-23, 94°. 6-23-24, 114°. 8-23-24, 115°. 7-15-25, 100°. 10-26-25, 79°. S.R. slightly chipped at gage side. Slight end overflow on top of each rail.

98 12-29-24, $\frac{1}{2}$″ open. Three bolts loose. Slight end overflow on each rail. 10-26-25, Slight overflow on both rails. S.R. frozen. N.R. moving.

99 Both rails slightly chipped. No overflow.

100 End overflow on each rail.

101 N.R. chipped on top at gage side. 10-26-25, End overflow on each rail. S.R. damaged on top at gage side by end overflow from N.R.

102 Gap Readings. $\frac{1}{64}$″. 7-26-25, 118°. 8-13-23, 102° 8-27-23, 76°. 10-1-23, 107°. 6-23-24, 114°. Slight end overflow on each rail.

104 Gap Readings. 0″. 7-13-23, 94°. 7-26-23, 118°. 10-1-23, 107°. 8-23-24, 115°. 12-29-24, 26°. 7-15-25, 100°. 10-26-25, 79°. Slight end overflow on each rail at gage corner.

105 12-29-24, $\frac{1}{2}$″ open. 26°. 7-15-25, 100°. 22/64″ open. Closed tight when bolts were loosened. 10-26-25, Slight end overflow on top of S.R. Nov. 7-12, 1925, Bolt Tensions. Bolt 1 = 13,200. 2 = 19,000. 3 = 12,500. 4 = 9,500. Stresses in splices also taken.

Joint

106 Gap Readings. 0″. 7-13-23, 94°. 8-13-23, 102°. 10-1-23, 107°. 11-1-23, 57°. 6-23-24, 114°. 8-23-24, 115°. 10-26-25, 79°. 12-29-24, ¼″ open. 26°. Badly battered. S.R. chipped out. End overflow on N.R. One loose bolt. Joint coincides with south edge of north tie. 10-26-25, Both ends extremely battered. S.R. badly chipped. Heavy end overflow on top of N.R. Both ends extremely battered. S.R. badly chipped. 11-1-25, This joint welded up and chip taken to be photographed. Nov. 7-12, 1925, Bolt Tensions. Bolt 1 = 15,000. 2 = 5,500. 3 = 15,000. 4 = 6,000. Stresses in splices also taken. Nov. 9-13, 1925. Special study made. See Plate I-b. 12-1-25, 50° Welds holding up. Slight end overflow on each rail. Slight crushing in evidence on each rail but the N.R. is a little worse than the S.R. Both rails moving. Gap ½″. Batter N.R. .026; S.R. .024.

107 Gap Readings. 0″. 8-13-23, 102°. 10-1-23, 107°. 6-23-24, 114°. 8-23-24, 115°.

108 Gap Readings. 0″. 6-26-23, 75°. 8-13-23, 102°. 8-27-23, 76°. 10-1-23, 107°. 12-29-24, N.R. slightly chipped. ½″ open. Two loose bolts. 10-26-25, N.R. chipped in three small places.

109 S.R. chipped at gage corner. Slight overflow on both rails.

110 S.R. overflowed at gage corner.

111 Gap Readings. 0″. 7-26-23, 118°. 10-1-23, 107°. 6-23-24, 114°. 8-23-24, 115°. 10-26-25, N.R. chipped at gage corner. S.R. end overflow at gage corner.

112 Gap Readings. 0″. 7-26-23, 118°. 8-13-23, 102°. 10-1-23, 107°. 8-23-24, 115°. 7-15-25, 100°.

113 7-22-24, Open 7/64″, 125° Closed to 1/16″ and tight at top when bolts were slacked. 7-15-25, 100° Open 26/64″. Closed when bolts were loosened. 10-26-25, Slight end overflow on top of S.R.

114 Gap Readings. 0″. 7-13-23, 94°. 8-13-23, 102°. 8-27-23, 76°. 10-1-23, 107°. 8-23-24, 115°. 7-15-25, 100°. 10-26-25, Both rails slightly chipped. Slight end overflow on each rail.

115 12-29-24, Slight end overflow on each rail. 7-15-25, 100° 28/64″ open. Closed tight when bolts were loosened. 10-26-25, Both rails chipped at gage corner and N.R. slightly chipped on top.

116 S.R. chipped on top near outside. End overflow on top of S.R.

118 Gap Readings. 0″. 7-13-23, 94°. 8-13-23, 102°. 8-27-23, 76°. 10-1-23, 107°. 6-23-24, 114°. 8-23-24, 115°. 7-15-25, 100°. 3-5-25, S.R. chipped ¼″ x ¾″ x ⅛″ near gage side.

119 Gap Readings. 0″. 6-27-23, 94°. 7-13-23, 94°. 7-26-23, 118°. 8-13-23, 102°. 8-27-23, 76°. 10-1-23, 107°. 11-1-23, 57°. 10-26-25, End overflow on N.R. at gage corner, damaging S.R.

120 Gap Readings. 0″. 8-13-23,. 102°. 8-27-23, 76°. 10-1-23, 107°.

121 Slight end overflow on each rail.

123 Both rails slightly chipped.

124 Gap Readings. 0″. 7-13-23, 94°. 10-1-23, 107°. 8-23-24, 115°. 7-15-25, 100°. 3.-5-25, Both rails chipped. 10-26-25, N.R. chipped at center. S.R. chipped at gage side. End overflow on N.R. at gage side.

125 Gap Readings. 0″. 6-27-23, 94°. 7-13-23, 94°. 7-26-23, 118°. 10-1-23, 107°. 6-23-24, 114°. 8-23-24, 115°. 7-15-25, 100°. 10-26-25, N.R. chipped at gage corner.

126 Gap Readings. 1/64″. 6-23-24, 114°. 8-23-24, 115°. 7-15-25, 100°. 10-26-25, N.R. chipped at center. Slight end overflow on S.R. Nov. 7-12, 1925, Bolt Tensions. Bolt 1 = 25,500, 2 = 11,500, 3 = 14,000, 4 = 10,000. Stresses in splices also taken.

Joint

127 Gap Readings. 0″. 8-23-24, 115°. 7-15-25, 100°. 10-26-25, 79°. Slight end overflow on each rail.

128 S.R. slightly chipped.

129 12-29-24, One loose bolt.

130 Gap Readings. 0″. 7-26-23, 118°. 10-1-23, 107°. 7-15-25, 100°. Both rails slightly chipped in center and slight end overflow on top at gage side.

131 End overflow on each rail.

132 Gap Readings. 0″. 7-13-23, 94°. 10-1-23, 57°. 8-23-24, 115°. 7-15-25, 100°. 10-26-25, End overflow at gage corner on S.R. damaging N.R.

135 12-29-24, One loose bolt. 10-26-25, Slight end overflow on N.R.

136 Both rails slightly chipped. No end overflow.

137 Slight end overflow on gage corner of S.R.

139 Gap Readings. 0″. 7-13-23, 94°. 7-26-23, 118°. 8-23-24, 115°. 7-15-25, 100°. 11-10-25, End of both rails show no saw marks and appear to have been milled.

141 Gap Readings. 0″. 8-13-23, 102°. 10-1-23, 107°. 6-23-24, 114°. 8-23-24, 115°. 12-29-24, Opening $\frac{9}{16}$″. 26°. Works badly under passing trains. $\frac{3}{8}$″ above tie plate. 10-26-25, Slight end overflow on each rail. Nov. 7-12, 1925, Bolt Tensions. Bolt 1 = 11,500, 2 = 19,500, 3 = 11,000, 4 = 20,000. Stresses in splices also taken.

142 Slight end overflow on each rail. 11-10-25, End of both rails show no saw marks and appear to have been milled.

143 12-29-24, S.R. chipped out. Two loose bolts and one Hi-Power washer gone. 3-5-25, S.R. chipped across head. 10-26-25, S.R. badly chipped. End overflow on N.R.

144 Gap Readings. 0″. 7-13-23, 94°. 8-13-23, 102°. 8-27-23, 76°. 10-1-23, 107°. 11-1-23, 57°. 12-15-23, 27°. 6-23-24, 114°. 7-15-25, 100°. S.R. chipped at center.

145 Slight end overflow on each rail.

146 Gap Readings. 0″. 7-26-23, 118°. 8-13-23, 102°. 10-1-23, 107°. 6-23-24, 114°. 8-23-24, 115°. 10-26-25, Small chip on N.R. 11-10-25, End of both rails show no saw marks and appear to have been milled.

148 Small chip on N.R. Slight end overflow on S.R. 11-10-25, End of both rails show no saw marks and appear to have been milled.

149 Slight end overflow on N.R.

150 N.R. badly chipped.

151 Gap Readings. 0″. 6-23-24, 114°. 8-23-24, 115°. 7-15-25, 100°. 10-26-25, 79°. 12-29-24, Slight end overflow on N.R. damaging S.R. Two loose bolts. 10-26-25, No end overflow.

152 3-5-25, New rail in place of old one. Heat No. 54787 D 9-1924. 2-26-25, Heat No. 61813-G, Original removed account moonshaped break in base over a tie. 10-26-25, Slight end overflow at gage corner of each rail. 11-10-25, End of N.R. shows no saw marks and appears to have been milled.

153 Gap Readings. $\frac{1}{64}$″. 10-1-23, 107°. 6-23-24, 114°. 8-23-24, 115°. 10-26-25, Slight end overflow on S.R.

154 Gap Readings. 4/64″. 7-13-23, 94°. 7-26-23, 118°. 8-27-23, 76°. 6-23-24, 114°. 10-26-25, 79°. 10-26-25, S.R. chipped on top at outside and on gage corner. End overflow on S.R.

156 N.R. slightly chipped.

Joint

158 Nov. 7-12, 1925, Bolt Tensions. Bolt 1 = 4,500. 2 = 3,100. 3 = 12,500. 4 = 21,000. Stresses in splices also taken.

160 12-29-24, One loose bolt.

161 Gap Readings. 0". 6-27-23, 94°. 7-13-23, 94°. 8-13-23, 102°. 10-1-23, 107°. 8-23-24, 115°. 7-15-25, 100°. 10-26-25, 79°.

164 N.R. chipped at gage side. End overflow on S.R.

167 Gap Readings. 0". 7-13-23, 94°. 8-13-23, 102°. 8-27-23, 70°. 10-1-23, 107°. 10-26-25, N.R. slightly chipped.

168 7-22-24, Wire spacer installed. 7-15-25, Wire spacer still in place. 10-26-25, Slight end overflow on each rail.

170 End overflow at gage corner of N.R.

171 Gap Readings. 0". 7-13-23, 94°. 10-1-23, 107°. 1-7-24, 19°. 10-26-25, 79°.

172 7-22-24, Wire spacer installed. 7-15-25, Wire spacer now missing. 10-26-25, End overflow on each rail.

174 End overflow on S.R.

175 12-29-24, 26° About ½" open. One loose bolt. 10-26-25, Slight end overflow on each rail.

176 End overflow on S.R.

177 7-22-24, Open 11/64" 125° 0" after bolts loosened. 7-15-25, 20/64" open, 100°. 0" when bolts were loosened.

178 Small chip on gage side N.R. Slight end overflow on gage side S.R. N.R. frozen. S.R. moving.

179 Gap Readings. 0". 6-27-23, 94°. 7-13-23, 94°. 10-1-23, 107°. 8-23-24, 114°. 12-29-24, 26° Open $\frac{5}{16}$" One loose bolt.

180 Gap Readings. 0". 7-26-23, 118°. 8-13-23, 102°. 8-27-23, 76°. 8-23-24, 115°.

182 Gap Readings. 0". 7-13-23, 94°. 8-13-23, 102°. 10-1-23, 107°. 8-23-24, 115°. 7-15-25, 100°. 10-26-25, 79°. S.R. chipped on top. End overflow on S.R. damaging N.R.

183 3-5-25, Chipped ⅜" x 2½" x ⅛" across S.R. 7-15-25, 100°. Open 24/64". Closed tight when bolts were loosened. 10-26-25 Slight end overflow on N.R.

184 Slight end overflow on N.R.

185 Gap Readings. 0". 7-13-23, 94°. 7-26-23, 118°. 8-13-23, 102°. 10-1-23, 107°. 8-23-24, 122°. 10-26-25, Both ends very badly battered. N.R. badly chipped out. Slight end overflow on S.R. Nov. 9-13, 1925. Welded up account excessive batter. Special study made. See Plate I-b. 12-1-25, 50° Welds holding up. No end overflow. Slight crushing on each rail on gage side. Both rails moving. Gap ½". Batter N.R. .037; S.R. .024.

186 End overflow at gage side of N.R. damaging S.R.

187 Gap Readings. 0". 8-13-23, 102° . 10-1-23, 107°. 8-23-24, 122°. 12-29-24, S.R. chipped on top. End overflow on N.R. 10-26-25 Both ends badly battered. Heavy end overflow on N.R. damaging S.R. Nov. 9-13, 1925. Welded up account excessive batter. Special study made. See Plate I-b. 12-1-25, 50° Welds holding up. No end overflow. S.R. frozen. Gap ⅜". Batter N.R. .027; S.R. .030.

189 Gap Readings. 0". 7-13-23, 94°. 7-26-23, 118°. 8-13-23, 102°. 10-1-23, 107°. 7-15-25, 100°.

190 Gap Readings. 0". 8-13-23, 102°. 10-1-23, 107°. 8-23-24, 122°.

Joint

191 Gap Readings. 0". 7-26-23, 118°. 8-13-23, 102°. 10-1-23, 107°. 8-23-24, 122°. S.R. chipped.

192 Gap Readings. 0". 7-13-23, 94°. 7-26-23, 118°. 8-13-23, 102°. 10-26-25, 85°. Slight end overflow on S.R.

193 Gap Readings. 0". 7-26-23, 118°. 8-13-23, 102°. 8-27-23, 76°. 10-1-23, 107°. 8-23-24, 122°. 3-5-25, Chipped ⅜" x 1" x ⅛" across head.

194 End overflow at gage corner of each rail.

195 Gap Readings. 0". 7-13-23, 94°. 7-26-23, 118°. 8-13-23, 102°. 10-1-23, 107°. 8-23-24, 122°. 12-29-24, S.R. badly chipped on top. N.R. slight end overflow. 10-26-25, S.R. badly chipped on top.

197 Gap Readings. 0". 8-13-23, 102°. 10-1-23, 107°. 8-23-24, 122°. N.R. chipped near outside.

198 End overflow on each rail.

199 Gap Readings. 0". 7-13-23, 94°. 7-26-23, 118°. 8-13-23, 102° 8-27-23, 76°. 10-1-23, 107°. 8-23-24, 122°. 7-15-25, 100°.

200 Gap Readings. 0". 7-26-23, 118°. 8-27-23, 76°. 10-1-23, 107°. 12-29-24, S.R. chipped at gage corner. Very slight end overflow on N.R. 3-5-25, S.R. chipped at gage corner.

201 Gap Readings. 0". 7-13-23, 94°. 7-26-23, 118°. 8-13-23, 102°. 10-1-23, 107°. 6-23-24, 114°. 8-23-24, 122°.

202 12-29-24, Chipped at gage corner. Slight end overflow on N.R. 10-26-25, Same.

203 Gap Readings. 0". 7-13-23, 94°. 8-13-23, 102°. 10-1-23, 107°. 6-23-24, 114°. 8-23-24, 122°. 7-15-25, 100°. 11-10-25, Lubricated with gre dag. Fishing surfaces found bright. 40" wrench used to tighten bolts. Hi-Power washers flattened. Not replaced.

204 Gap Readings. 0". 10-1-23, 107°. 1-7-24, 32°. 8-23-24, 122°. 7-15-25, 100°.

205 Both rails chipped.

207 Gap Readings. 0". 7-13-23, 94°. 7-26-23, 118°. 8-13-23, 102°. 10-1-23, 107°. 1-7-24, 32°. 8-23-24, 122°.

208 Gap Readings. 0". 7-13-23, 94°. 7-26-23, 118°. 8-13-23, 102°. 10-1-23, 107°. 8-23-24, 122°. 10-26-25, 85°.

209 Gap Readings. 0". 7-13-23, 94°. 7-26-23, 118°. 8-13-23, 102°. 8-27-23, 76°. 10-1-23, 107°. 8-23-24, 122°. 7-15-25, 100°. Nov. 7-12, 1925, Bolt Tensions. Bolt 1 = 27,500, 2 = 11,500, 3 = 8,500, 4 = 15,000. Stresses in splices also taken.

210 Slight end overflow on S.R.

212 End overflow on N.R.

214 Gap Readings. 0". 6-26-23, 93°. 7-13-23, 94°. 8-13-23, 102°. 10-26-25, Slight end overflow on each rail.

215 Gap Readings. 0". 7-13-23, 94°. 10-1-23, 107°. 8-23-24, 122°. 10-26-25, N.R. chipped. End overflow on S.R.

216 S.R. chipped and end overflowed.

217 Gap Readings. 0". 7-13-23, 94°. 7-26-23, 118°. 8-13-23, 102°. 10-1-23, 107°. 11-1-23, 57°. 1-7-24, 32°. 7-15-25, Open 24/64", 100°. Closed to 10/64" when bolts were loosened. 10-26-25 Slight overflow on S.R. damaging N.R.

218 N.R. chipped.

219 Gap Readings. 0". 7-13-23, 94°. 7-26-23, 118°. 8-13-23, 102°. 10-1-23, 107°. S.R. chipped at gage corner.

Joint

220 Slight end overflow on each rail.

221 3-6-25, S.R. chipped near outside. End overflow on top of S.R. near gage side and on top of N.R. near outside sawed off. 100°. ½″ open. Closed to 15/64″ when bolts were loosened. 10-26-25, No recent overflow.

222 3-6-25, Fin on gage corner on S.R. sawed off. 10-26-25, Slight overflow on N.R.

223 7-22-24, Open 7/64″ 125°. After bolts loosened 0″. 7-15-25, Open 20/64″ 100° After bolts loosened 0″, but opened to 20/64″ after Joint 225 closed.

224 3-6-25, Fin on gage corner N.R. sawed off. 10-26-25, Slight end overflow on N.R.

225 7-22-24, Open $\frac{3}{16}$″ 125° Closed to $\frac{1}{16}$″ after bolts loosened. 7-15-25, Open 22/64″ 100°. 0″ after bolts loosened.

226 Gap Readings. 0°. 7-13-23, 94°. 8-13-23, 102°. 8-27-23, 76°. 10-1-23, 107°. 8-23-24, 122°.

227 3-5-25, Chipped ¼″ x 1¼″ x ⅛″ across center of S.R. 7-22-24, 125° Open ⅛″ 125° 0″ after bolts loosened. 11-10-25, Lubricated with gre dag. Fishing surfaces found bright. 40″ wrench used to tighten bolts. Hi-Power washers flattened. Not replaced.

228 N.R. chipped at gage side. Slight end overflow on S.R.

229 12-29-24, Both rails chipped at top. Joint $\frac{1}{16}$″ open. Three bolts loose. Two washers broken and gone. Replaced by Improved Hi-Power washers. 3-6-25, 0″ 100° Splices taken off. The two Improved Hi-Power washers previously applied removed in perfect condition. The two Hi-Power washers were flattened. No oil on tops and bottoms of splices. Oil applied and splices replaced with Verona spring washers on inside. 7-15-25, Washers O.K. 10-26-25, S.R. frozen N.R. moving. End overflow on N.R. Nov. 7-12, 1925, Bolt Tension. Bolt 1 = 4,000, 2 = 11,500, 3 = 14,000, 4 = 19,000. Nov. 9-13, 1925. Welded up account excessive batter. Special study made. See Plate I-b. 12-1-25, 50° Welds holding up. Slight end overflow. Slight crushing on each rail. Joint frozen. Gap ⅜″. Batter N.R. .033; S.R. .037.

230 3-6-25, End overflow on top of both rails sawed off. Open 30/64″ 100° Closed to ⅛″ after bolts loosened. Verona washers put on inside. 7-15-25, 16/64″ open. Washers O.K. and both rails moving freely. 10-26-25, Frozen. 11-10-25 Lubricated with gre dag. Fishing surfaces found bright. 40″ wrench used to tighten bolts.

233 End overflow on S.R.

234 Gap Readings. 0″. 7-13-23, 94°. 8-13-23, 102°. 10-1-23, 107°. End overflow on N.R.

235 Slight end overflow on each rail.

236 Gap Readings. 0″. 8-13-23, 102°. 10-1-23, 107°. 8-23-24, 122°. 7-15-25, 100°. 10-26-25, S.R. chipped. Slight end overflow on N.R.

237 Gap Readings. 0″. 7-13-23, 94°. 7-26-23, 118°. 8-13-23, 102°. 10-1-23, 107°. 11-1-23, 57°. 8-23-24, 122°. 10-26-25, 85°.

238 Gap Readings. 0″. 7-13-23, 94°. 7-26-23, 118°. 8-13-23, 102°. 8-27-23, 76°. 10-1-23, 107°. 8-23-24, 122°. 3-6-25 N.R. chipped at gage side. End overflow on top of S.R. at gage side sawed off. 10-26-25, No overflow.

239 Gap Readings. 0″. 7-13-23, 94°. 7-26-23, 118°. 8-13-23, 102°. 7-15-25, 100°. 10-26-25, 85°. N.R. chipped. Slight end overflow on S.R.

Joint

240 Gap Readings. 0°. 7-13-23, 94°. 8-13-23, 102°. 8-27-23, 76°. 10-1-23, 107°. 8-23-24, 122°. Both rails chipped. No end overflow.

241 Slight end overflow on N.R.

242 Slight end overflow on N.R.

243 Gap Readings. 0″. 7-13-23, 94°. 8-13-23, 102°. 10-1-23, 107°.

244 Gap Readings. 0″. 6-26-23, 93°. 8-13-23, 102°. 10-1-23, 107°. 8-23-24, 122°. Slight end overflow on S.R., damaging N.R.

246 Maximum Gap Readings 25/64″. 12-15-23, 37°. 1-7-24, 32°. 12-2-24, 35°. End overflowed on each rail.

247 Gap Readings. 0″. 7-13-23, 94°. 8-13-23, 102°. 10-1-23, 107°. S.R. frozen N.R. moving.

248 Gap Readings. 0″. 7-13-23, 94°. 7-26-23, 118°. 8-13-23, 102°. 10-1-23, 107°. 3-6-25, Small fin on both rails at gage side sawed off. 10-26-25, Slight end overflow on N.R.

250 Gap Readings. 0″. 7-13-23, 94°. 8-13-23, 102°. 10-1-23, 107°. 10-26-25, Slight end overflow on each rail.

251 Gap Readings. 0″. 7-26-23, 118°. 8-13-23, 102°. 8-23-24, 122°. End overflow on S.R. damaging N.R. S.R. frozen. N.R. moving.

252 3-6-25, Both rails chipped out on top ⅛″ wide. Fin on gage corner of N.R. sawed off. ½″ open and frozen. Closed to ⅛″ when bolts were loosened. Verona washers put on inside. 7-15-25, Washers in good condition. S.R. only moving. 10-26-25, Recent end overflow on N.R. Both rails badly chipped and battered. N.R. frozen. S.R. moving. Nov. 9-13, 1925. Welded up account excessive batter. Special study made. See Plate I-b. 11-10-25, Lubricated with gre dag. Fishing surfaces found bright. 40″ wrench used to tighten bolts. 12-1-25, 50°, Welds holding up. Considerable end overflow on gage side of each rail with major overflow on N.R. S.R. moving. N.R. frozen. Gap ⅜″. Batter N.R. .027; S.R. .017.

253 N.R. frozen. S.R. moving.

254 3-6-25, Fins on both rails at gage corner sawed off.

255 Gap Readings. 0″. 7-26-23, 118°. 8-13-23, 102°. 10-1-23, 107°. 8-23-24, 122°. N.R. chipped near outside.

256 3-6-25, Overflow at gage side on N.R. sawed off. 10-26-25, Slight end overflow on each rail.

257 Gap Readings. 0″. 7-13-23, 94°. 7-26-23, 118°. 8-13-23, 102°. 8-27-23, 76°. 10-1-23, 107°. 11-1-23, 57°.

258 Gap Readings 1/64″ 10-1-23, 107° 7-15-25, 100°. 10-26-25, 85°. N.R. chipped at gage corner and end overflow.

259 Gap Readings. 0″. 7-13-23, 94°. 7-26-23, 118°. 8-13-23, 102°. 10-1-23, 107°. 3-5-25, Chip ¼″ wide across head. 10-26-25, N.R. frozen. S.R. moving.

260 Gap Readings. 0″. 7-13-23, 94°. 8-13-23, 102°. 10-1-23, 107°. 8-23-24, 122°. Slight end overflow on S.R.

261 Gap Readings. 0″. 8-13-23, 102°. 10-1-23, 107°. 8-23-24, 122°. 7-8-24, Joint chipped out. Bolts loose. Tightened. 12-29-24, One bolt loose. 3-6-25, N.R. chipped on top. End overflow on S.R. sawed off. 7-15-25, Metal overflowed on both rails but rails not touching. No sign of movement. 10-26-25, N.R. badly chipped. S.R. frozen. N.R. moving.

262 3-6-25, Fin on S.R. at gage corner filed off. 25/64″ open and frozen. Closed tight when bolts were loosened. Verona washers installed on inside. 7-15-25 Open 10/64″ 100°. 10-26-25, Slight end

Joint

overflow on each rail. 11-10-25, Lubricated with gre dag. Fishing surfaces found bright. 40″ wrench used to tighten bolts.

263 3-6-25, End overflow on S.R. sawed off. 10-26-25, S.R. slight end overflow and chipped near outside.

264 Maximum Gap Readings. 7/64″. 1-7-24, 32°. 7-15-25, 100°. 10-26-25, 85°. 3-6-25, End overflow on each rail at gage corner sawed off. 10-26-25, Slight end overflow on each rail.

265 Gap Readings. 0″. 10-1-23, 107°. 8-23-24, 122°. 7-15-25, 100°. 10-26-25, 85°. 7-8-24, Bolts loose. Tightened.

266 Gap Readings. 0″. 6-26-23, 93°. 7-13-23, 94°. 8-13-23, 102°. 10-1-23, 107°. 8-23-24, 122°. Both ends chipped at gage corner.

267 3-6-25, Slight end overflow on each rail at top sawed and filed off. 10-26-25, Slight end overflow on each rail.

268 7-15-25, Both rails badly battered. N.R. chipped. 10-26-25, N.R. badly chipped. Heavy end overflow on S.R. S.R. frozen. N.R. moving. Nov. 9-13, 1925, Welded up account excessive batter. Special study made. See Plate I-b. 12-1-25, 50°. Welds holding up. Slight end overflow on each rail. N.R. moving. S.R. frozen. Gap ¾″. Batter N.R. .023; S.R. .022.

269 Gap Readings. 0″. 7-13-23, 94°. 7-26-23, 118°. 8-13-23, 102°. 10-1-23, 107°. 8-23-24, 122°. 10-26-25, End overflow on each rail.

270 3-6-25, End overflow on gage corner S.R. sawed off. 10-26-25, S.R. end overflow at gage corner, damaging N.R. slightly.

271 Gap Readings. 0″. 7-13-23, 94°. 7-26-23, 118°. 8-13-23, 102°. 8-27-23, 76°. 10-1-23, 107°. 8-23-24, 122°.

272 Gap Readings. $\frac{1}{64}$″. 8-13-23, 102°. 10-1-23, 107°. 8-23-24, 122°. 10-26-25, S.R. end overflow at gage corner, damaging N.R.

273 Gap Readings. 0″. 8-13-23, 102°. 10-1-23, 107°. 8-23-24, 122°. 10-26-25, 85°. 7-8-24, Bolt loose. Tightened.

274 Gap Readings. 0″. 7-13-23, 94°. 8-13-23, 102°. 10-1-23, 107°. 8-23-24, 122°. 10-26-25, 85°. S.R. chipped at center. N.R. end overflow at gage corner, damaging S.R.

275 Gap Readings. 0″. 7-26-23, 118°. 8-13-23, 102°. 10-1-23, 107°. 8-23-24, 122°. 10-26-25, N. R. frozen. S.R. moving.

276 3-5-25, Both rails chipped. 10-26-25, N.R. badly chipped at gage side. S.R. at center. End overflow on S.R.

277 Gap Readings. 0″. 7-13-23, 94°. 7-26-23, 118°. 8-13-23, 102°. 10-1-23, 107°. 8-23-24, 122°. 10-26-25, 85°. 7-8-24, S.R. chipped but chip not out. Bolts slightly loose and were tightened up. End overflow on N.R. 3-5-25, Both rails chipped. S. R. chipped across head. 7-15-25, Opening only 3/64″. Both rails badly chipped. No sign of movement. Metal in N.R. overflowed over S.R. 10-26-25, both ends very badly battered. Heavy end overflow on N.R. damaging S.R. Both rails badly chipped near outside. Nov. 9-13, 1925. Welded up account excessive batter. Special study made. See Plate I-b. 12-1-25, 50° Welds holding up. Overflow on S.R. Slight crushing on N.R. Both rails moving. Gap $\frac{5}{16}$″. Batter N.R. .012; S.R. .033.

278 N.R. slight overflow at gage corner, damaging S.R. S.R. frozen. N.R. moving.

279 3-6-25, End overflow on gage corner N.R. sawed off. 10-26-25, Slight end overflow on each rail.

Joint

280 3-6-25, Fin on top of S.R. sawed off. 10-26-25, End overflow on N.R. S.R. badly chipped.

281 All Gap Readings 0″ since 7-13-23. 7-8-24, No batter. 3-6-25, Joint lipped $\frac{1}{16}$″ on inside and ⅛″ on outside. Difference in width of heads probably due to crushing of south head (an F rail). Splices when removed showed inside splice well lubricated on top and bottom while outside splice was dry. Rail under outside splice badly corroded caused by brine. Splices oiled on top and bottom and replaced using Verona spring washers on inside. 7-15-25, Washers in good condition. 10-26-25, No end overflow. Nov. 7-12, 1925, Bolt Tensions. Bolt 1 = 34,500, 2 = 10,000, 3 = 4,500, 4 = 11,500.

282 Gap Readings. 0″. 7-13-23, 94°. 8-13-23, 102°. 10-1-23, 107°. 10-26-25, N.R. end overflow at gage corner. N.R. frozen. S.R. moving.

283 Gap Readings. 0″. 7-26-23, 118°. 8-13-23, 102°. 8-27-23, 76°. 10-1-23, 107°. 8-23-24, 122°. 7-15-25, 100°. 10-26-25, 85°. Small chip at center of N.R.

284 Gap Readings. 0″. 7-13-23, 94°. 8-23-24, 122°. 7-15-25, 100°. 10-26-25, 85°.

286 Gap Readings. 0″. 8-13-23, 102°. 10-1-23, 107°. 11-1-23, 57°. 8-23-24, 122°. 10-26-25, 85°. Slight end overflow on N.R.

287 Gap Readings. 0″. 7-13-23, 94°. 7-26-23, 118°. 8-13-23, 102°. 8-27-23, 76°. 10-1-23, 107°. 11-1-23, 57°. 8-23-24, 122°. 12-29-24, 35°. 7-15-25, 100°. 10-26-25, 85°. Slight end overflow on S.R. damaging N.R.

288 Gap Readings. 0″. 7-13-23, 94°. 8-13-23, 102°. 10-1-23, 107°. 8-23-24, 122°. 7-15-25, 100°. 3-5-25 Chipped ¼″ x 1¾″ x ⅛″ at gage S.R. 10-26-25, N. R. badly chipped and both rails badly battered (E and F rails). No recent end overflow. Nov. 9-13, 1925, Welded up account excessive chipping. Special study made. See Plate I-b. 12-1-25, 50°, Welds holding. Slight overflow on each rail. Joint frozen. Gap $\frac{1}{32}$″. Batter N.R. .004; S.R. .003. Probably left a little high at time of welding.

289 Gap Readings. 0″. 7-13-23, 94°. 7-26-23, 118°. 8-13-23, 102°. 10-1-23, 107°. 8-23-24, 122°. 7-15-25, 100°. 10-26-25, S. R. slightly chipped.

291 Gap Readings. 0″. 6-27-23, 95°. 7-13-23, 94°. 7-26-23, 118°. 8-13-23, 102°. 10-1-23, 107°. 11-1-23, 57°. 6-23-24, 114°. 8-23-24, 122°. 12-29-24, 35°. 10-26-25, 85°. Slight end overflow on each rail.

293 Gap Readings. 0″. 6-27-23, 95°. 7-13-23, 94°. 7-26-23, 118°. 8-13-23, 102°. 8-27-23, 76°. 10-1-23, 107°. 8-23-24, 122°. 7-15-25, 100°. 10-26-25, 85°.

294 Both ends chipped and overflowed.

295 Gap Readings. 0″. 7-26-23, 118°. 8-13-23, 102°. 10-1-23, 107°. 6-23-24, 114°. 8-23-24, 122°. 12-29-24, 35°. 7-15-25, 100°. 10-26-25, 85°.

296 3-6-25, End overflow on top of S.R. sawed off. 10-26-25, Slight end overflow on N.R.

297 Slight end overflow on S.R. damaging N.R.

298 Slight end overflow on each rail.

299 Gap Readings. 0″. 7-26-23, 118°. 8-13-23, 102°. 10-1-23, 107°. 6-23-24, 114°. 8-23-24, 122°. 7-15-25, 100°.

Joint

300 Gap Readings. $\frac{1}{64}$″. 8-13-23, 94°. 10-1-23, 107°. 6-23-24, 114°. 8-23-24, 122°. 10-26-25, Slight end overflow on each rail.

301 Gap Readings. 0″. 8-13-23, 102°. 10-1-23, 107°. 6-23-24, 114°. 8-23-24, 122° N.R., chipped at gage corner. End overflow on each rail. N.R. frozen. S.R. moving.

302 7-8-24, No gap and very little batter. 3-5-25, Both rails badly chipped. 10-26-25, Both ends very badly battered and chipped. End overflow on N.R.

303 Gap Readings. 0″. 7-26-23, 118°. 8-13-23, 102°. 10-1-23, 107°. 8-23-24, 122°. 3-6-25, Small fin on gage corner N.R. 10-26-25, Both ends battered. End overflow on N.R. damaging S.R.

304 Gap Readings. 0″. 7-26-23, 118°. 10-1-23, 107°. 7-15-25, 100°. 10-26-25, 85°.

305 Gap Readings. 0″. 7-13-23, 94°. 7-26-23, 118°. 8-13-23, 102°. 10-1-23, 107°. 6-23-24, 114°. 8-23-24, 122°. 7-15-25, 100°.

306 N.R. badly chipped at gage corner. End overflow on N.R.

307 Gap Readings. 0″. 7-13-23, 94°. 7-26-23, 118°. 8-13-23, 102°. 10-1-23, 107°. 8-23-24, 122°. 7-15-25, 100°. 3-6-25, Slight chip on N.R. Fin on gage corner S.R. sawed off. 10-26-25, S.R. chipped on gage corner and slight end overflow damaging N.R.

308 Slight end overflow on both rails.

309 Gap Readings. 0″. 7-13-23, 94°. 7-26-23, 118°. 8-13-23, 102°. 10-1-23, 107°. 6-23-24, 114°. 8-23-24, 122°. 7-15-25, 100°. Both ends battered. S.R. chipped. Slight end overflow on N.R.

310 Slight end overflow on both rails.

311 End overflow on N.R. at gage corner, damaging S.R.

312 12-29-24, ½″ open. Chipping at gage corner. 3-5-25, S.R. mashing ⅜″ too wide across head. 10-26-25, Slight end overflow on both rails.

313 Gap Readings. 0″. 8-13-23, 102°. 8-23-24, 122°. 7-15-25, 100°. 7-8-24, S.R. slightly chipped. 10-26-25, End overflow on N.R. at gage corner, damaging and chipping S.R.

314 12-29-24, No opening. N.R. chipped out ½″ across top except at gage corner. 10-26-25, N.R. badly chipped. End overflow on S.R.

315 Gap Readings. 0″. 7-26-23, 118°. 8-13-23, 102°. 10-1-23, 107°. 8-23-24, 122°. 10-26-25, Slight end overflow on each rail.

316 Slight end overflow on each rail.

317 3-6-25, Fin on gage corner S.R. sawed off and end overflow on gage corner N.R. sawed off. 10-26-25, Slight end overflow on S.R. damaging N.R.

318 Gap Readings. $\frac{1}{64}$″. 7-26-23, 118°. 8-13-23, 102°. 10-1-23, 107°.

319 Gap Readings. 0″. 7-13-23, 94°. 7-26-23, 118°. 8-13-23, 102°. 10-1-23, 107°. 8-23-24, 122°. 3-6-25, Top of N.R. slightly chipped. Fin on top of S.R. sawed off. 10-26-25, End overflow on S.R. damaging N.R.

320 End overflow on each rail.

321 Gap Readings. 0″. 7-13-23, 94°. 10-1-23, 107°. 6-23-24, 114°. 8-23-24, 122°. 3-6-25, Both ends chipped on top. Joint $\frac{13}{32}$″ open and frozen. Closed to 7/64″ when bolts were loosened. End dressed off with file. Improved Hi-Power washers installed.

Joint

Splices oiled along top edges and inside at ends with oil can. 7-15-25, Washers in good condition. No sign of movement. 10-26-25, N.R. frozen. S.R. moving. 11-10-25, Lubricated with gre dag. Fishing surfaces found bright. 40″ wrench used to tighten bolts. Two men did this work in 9′ 12″.

322 S.R. chipped at gage corner. End overflow on each rail.

323 Gap Readings. 0″. 7-26-23, 118°. 8-13-23, 102°. 8-23-24, 122°. 3-6-25, S.R. slightly chipped. Fin on gage corner N.R. sawed off. 10-26-25, No end overflow.

324 3-6-25, Fins on top of S.R. sawed off. 10-26-25, Recent end overflow on N.R. Both rails badly chipped. N.R. frozen. S.R. moving.

325 3-6-25, Fin on top of N.R. at gage side filed off. 25/64″ open and frozen. Closed tight when bolts were loosened. Improved Hi-Power washers installed. Splices oiled along top edges and inside at edges with oil can. 7-15-25, Washers in good condition. Joint frozen. 10-26-25, Slight end overflow on each rail. 11-10-25, Lubricated with gre dag. Fishing surfaces found bright. 40″ wrench used to tighten bolts.

326 End overflow on each rail.

327 Gap Readings. 0″. 7-26-23, 118°. 8-13-23, 102°. 10-1-23, 107°. 6-23-24, 114°. 8-23-24, 122°. 12-29-24, 35°. 7-15-25, 100°. 12-19-24, S.R. overflow on N.R. at gage corner. 10-26-25, Slight end overflow on each rail. S.R. chipped on top.

328 3-6-25, S.R. chipped on top. Fin on top of N.R. sawed off. 21/64″ open and frozen. Joint closed tight when bolts were loosened. Splices oiled along top edges and inside at ends with oil can. Hi-Power washers installed. 7-15-25, Washers in good condition. Joint frozen. 10-26-25, Still frozen. No end overflow. 11-10-25, Lubricated with gre dag. Fishing surfaces found bright. 40″ wrench used to tighten bolts.

329 Slight end overflow on both rails.

330 Gap Readings. 0″. 7-13-23, 94°. 7-26-23, 118°. 8-13-23, 102°. 10-1-23, 107°. 12-19-24, S.R. chipped. N.R. dented on top at gage side. N.R. frozen. S.R. moving. 10-26-25, Both rails damaged by end overflow.

331 End overflow on both rails at gage corners. N.R. frozen. S.R. moving.

332 3-6-25, Fin on top of N.R. sawed off. 10-26-25, Slight end overflow on each rail.

333 12-29-24, S.R. dented on top. End overflow on gage corner on N.R. 3-6-25, S.R. chipped on gage corner. Small fin on gage corner N.R. sawed off. 10-26-25, Slight end overflow on each rail.

334 3-6-25, N.R. chipped. Fin on top of S.R. sawed off.

335 3-6-25, Small fin on gage corner N.R. sawed off. Open 25/64″ and apparently frozen. Closed tight when bolts were loosened. Both ends dressed with file. Improved Hi-Power washers installed. 7-15-25, Fin on S.R. lapping over N.R. Washers in good condition. Open 10/64″ 100°. 10-26-25, End overflow on S.R. damaging N.R. Both rails chipping at gage corner. 11-10-25, Lubricated with gre dag. Fishing surfaces found bright. 40″ wrench used to tighten bolts. Two men did this work in 8′ 32″.

Joint

336 Gap Readings. 1/64″. 8-23-24, 122°. 7-15-25, 100°. 10-26-25, 85°. 12-29-24, S.R. overflowed on top of N.R. 3-6-25, N.R. chipped on top. Small fin on top of S.R. sawed off. 10-26-25, S.R. overflowed damaging N.R.

337 Gap Readings. 0″. 8-13-23, 102°. 10-1-23, 107°. 8-23-24, 122°. 12-19-24, Improved Hi-Power washers applied this date. 3-6-25, Small fin on gage corner S.R. sawed off. Splices oiled along top edges and inside at edges at end with oil can. 7-15-25, Washers in good condition. 10-26-25, S.R. overflowed damaging N.R. 11-10-25, Lubricate with gre dag. Fishing surfaces found bright. 40″ wrench used to tighten bolts. Two men did this work in 8′ 26″.

338 7-8-24, Slight overflow. 3-6-25, Both rails overflowed slightly at ends. 7-15-25, Top of both rails overflowed together. Opening 6/64″ at ½″ below top of rail. 10-26-25, Both ends overflowed. 11-10-25, Lubricated with gre dag. Fishing surfaces found bright. 40″ wrench used to tighten bolts.

339 Both ends chipped and overflowed. N.R. frozen. S.R. moving.

340 Gap Readings. 0″. 7-26-23, 118°. 8-13-23, 102°. 10-1-23, 107°. 7-15-25, 100°. 10-26-25, 85°. End overflow on both rails.

341 Gap Readings. 0″. 7-13-23, 94°. 10-1-23, 107°. 6-23-24, 114°. 8-23-24, 122°. 3-6-25, Small fin on S.R. sawed off. 10-26-25, S.R. slightly overflowed at gage corner damaging N.R.

342 Gap Readings. 0″. 7-13-23, 94°. 7-26-23, 118°. 7-15-25, 100°. 3-6-25, The heads of the rails at this joint appear to not be of the same section. 10-26-25, Both rails slightly chipped at gage side. S.R. slightly overflowed.

343 Gap Readings. 1/64″. 10-1-23, 107°. 6-23-24, 114°. 8-23-24, 122°. 12-19-24, Both rails chipped out. 10-26-25, Both ends very badly chipped across the heads. No recent overflow. N.R. frozen. S.R. moving. Nov. 9-13, 1925, Welded up account excessive batter. Special study made. See Plate I-b. 12-1-25, 50°. Welds holding. Slight overflow on gage side of each rail. Joint frozen. Gap ⅜″. Batter N.R. .025; S.R. .024.

344 Gap Readings. 0″. 7-13-23, 94°. 8-13-23, 102°. 10-1-23, 107°. 7-15-25, 100°. Slight overflow on N.R. damaging S.R.

345 N.R. slightly overflowed at gage corner, damaging S.R.

346 Gap Readings. 0″. 7-13-23, 94°. 7-26-23, 118°. 8-13-23, 102°. 10-1-23, 107°. 7-15-25, 100°. 10-26-25, 85°. 3-5-25, Chipped ¼″ x 1¼″ x ½″ across center. 10-26-25, No chipping. Overflow damaging both ends.

347 S.R. overflowed at gage corner damaging N.R.

348 Gap Readings. 0″. 8-13-23, 102°. 8-23-24, 122°. 7-15-25, 100°. 10-26-25, 85°. Slight end overflow on each rail.

349 Gap Readings. 0″. 7-13-23, 94°. 7-26-23, 118°. 8-13-23, 102°. 10-1-23, 107°. 6-23-24, 114°. 3-6-25, Slight fin on gage corner of N.R. sawed off. 10-26-25, N.R. overflowed at gage corner damaging S.R. N.R. frozen. S.R. moving.

350 12-29-24, N.R. overflowed with thin film. Open 28/64″ bottom, 5/16″ top. 3-6-25, N.R. chipped on top. Fin on S.R. sawed off. Redressed with file. 10-26-25, Both ends overflowed damaging both rails. No chipping.

Joint

351 Gap Readings. 0″. 7-26-23, 118°. 8-13-23, 102°. 10-1-23, 107°. 6-23-24, 114°. 8-23-24, 122°. 7-8-24, S.R. chipped out. 3-6-25, Small fins on N.R. sawed and filed off. $\frac{5}{32}$″ open and frozen. Joint closed tight when bolts were loosened. Improved Hi-Power washers installed. Old style Hi-Power washers taken off were badly flattened. 7-15-25, Hi-Power washers installed on 3-6-25 in good condition. 10-26-25, N.R. slightly overflowed. N.R. frozen. S.R. moving. 11-10-25, Lubricated with gre dag. Fishing surfaces found bright. 40″ wrench used to tighten bolts.

352 Gap Readings. 0″. 7-13-23, 94°. 7-26-23, 118°. 7-15-25, 100°. 10-26-25, S.R. partly chipped. Slight end overflow on each rail.

353 Gap Readings. 0″. 7-13-23, 94°. 8-13-23, 102°. 10-1-23, 107°. 10-26-25, N.R. overflowed at gage corner damaging S.R.

354 Both rails slightly chipped and slight end overflow on each.

355 Gap Readings. 0″. 7-26-23, 118°. 8-13-23, 102°. 10-1-23, 107°. Slight end overflow on each rail.

356 Slight end overflow on each rail.

357 Gap Readings. 0″. 7-13-23, 94°. 8-13-23, 102°. 10-1-23, 107°. 8-23-24, 122°. End overflow on each rail. N.R. damaged by overflow.

358 12-29-24, Almost no overflow. Open 34/64″ at bottom. 30/64″ at top. Joint apparently not moving. 3-6-25, Slight fin on gage corner N.R. Ends in good condition. Verona washers installed on inside. 7-15-25, Washers in good condition. 10-26-25, Slight end overflow on both rails. 11-10-25, Lubricated with gre dag. Fishing surfaces found bright. 40″ wrench used to tighten bolts. Work done by two men in 8′ 50″.

359 11-10-25, Hi-Power washers removed and nuts replaced without disturbing splices.

360 7-8-24, Battered 5/64″. 11/64″ open. Bolts slightly loose. 12-29-24, End overflow on both rails. 38/64″ open. Open at top $\frac{7}{16}$″ S.R. moving. 3-6-25, Fin on S.R. filed off. $\frac{3}{16}$″ open. Closed tight as first bolt was loosened. Verona washers installed on inside. Top and bottom of inside splices oiled before being replaced. 7-15-25, Washers in good condition. 10-26-25, End overflow on each rail. 11-10-25, Lubricated with gre dag. Fishing surfaces found bright. 40″ wrench used to tighten bolts. No track oil on inside of splices.

361 Gap Readings. 0″. 7-13-23, 94°. 7-26-23, 118°. 8-13-23, 102°. 10-1-23, 107°. Slight end overflow on each rail.

362 Gap Readings. 0″. 7-13-23, 94°. 7-26-23, 118°. 7-15-25, 100°. N.R. chipped on gage side and end overflow on S.R.

363 Gap Readings. 0″. 7-13-23, 94°. 7-26-23, 118°. 8-13-23, 102°. 10-1-23, 107°. 3-6-25, Fin on S.R. sawed off and both rails filed. 10-26-25, S.R. overflowed damaging N.R.

364 Gap Readings. 0″. 7-13-23, 94°. 7-15-25, 100°. 10-26-25, 85°. 3-6-25, This joint lipped $\frac{1}{8}$″ since rail was laid. Men state that the lip could not be pulled out by tightening. Splices removed and found out that trouble was not a lip but crushed rail end. Verona washers installed on inside. Old style Hi-Power washers mashed flat. 7-15-25, Washers in good condition and joint frozen. 10-26-25, Both ends chipped. No end overflow. 11-10-25. Lubricated with gre dag. Fishing surfaces found bright. 40″ wrench used to tighten bolts.

Joint

365 Gap Readings. 0″. 7-13-23, 94°. 8-13-23, 102°. 8-27-23, 76°. 10-1-23, 107°. 11-1-23, 57°. 6-23-24, 114°. 8-23-24, 122°. S.R. slightly chipped. Slight end overflow on each rail.

366 Gap Readings. 5/64″. 7-13-23, 94°. 7-15-25, 100°. 10-26-25, 85°. 7-8-24, Nail in creep hub missing. Indications are there has been no creep. Nail restored. 10-26-25, End overflow on S.R.

367 Gap Readings. 0″. 7-13-23, 94°. 7-26-23, 118°. 8-13-23, 102°. 10-1-23, 107°. 8-23-24, 122°. 7-15-25, 100°. 10-26-25, 85°. Both ends chipped. No end overflow.

368 Slight end overflow on each rail.

369 Gap Readings. 0″. 7-13-23, 94°. 7-26-23, 118°. 8-13-23, 102°. 10-1-23, 107°. 8-23-24, 122°. 10-26-25, 85°. 3-6-25, S.R. chipped. Fin on N.R. sawed off. Chipped while fin was being removed. 10-26-25, No end overflow.

370 Slight end overflow on each rail.

371 Gap Readings. 0″. 7-26-23, 118°. 8-13-23, 102°. 8-27-23, 76°. 10-1-23, 107°. 6-23-24, 114°. 8-23-24, 122°.

372 12-29-24, Gap Readings 32/64″ 26° Both rails overhanging. 3-6-25, Both rails overhanging. Cut through and opened with saw. 10-26-25, S.R. overflowed damaging N.R.

373 12-29-24, Both chipped out slightly. 10-26-25, Same. Slight end overflow on each rail.

374 N.R. overflowed damaging S.R.

375 Gap Readings. 0″. 7-13-23, 94°. 7-26-23, 118°. 8-13-23, 102°. 3-6-25, N.R. slightly chipped. Slight end overflow on S.R. removed with saw. Improved Hi-Power washers installed. 7-15-25, Washers in good condition. No sign of movement. 10-26-25, N.R. slightly chipped. No overflow. 11-10-25, Lubricated with gre dag. Fishing surfaces found bright. 40″ wrench used to tighten bolts.

376 3-6-25, Verona washers installed on inside. 7-15-25, Verona washers in good condition. Joint tight. No sign of movement. 10-26-25, Both ends frozen. 11-10-25, Lubricated with gre dag. Fishing surfaces found bright. 40″ wrench used to tighten bolts. Done by two men in 7′ 8″.

377 Gap Readings. 0″. 7-13-23, 94°. 7-26-23, 118°. 8-13-23, 102°. 10-1-23, 107°. 8-23-24, 122°. 3-6-25, Both ends slightly chipped. Small fins on both rails trimmed off with saw. 10-26-25, Slight end overflow on S.R. N.R. chipped.

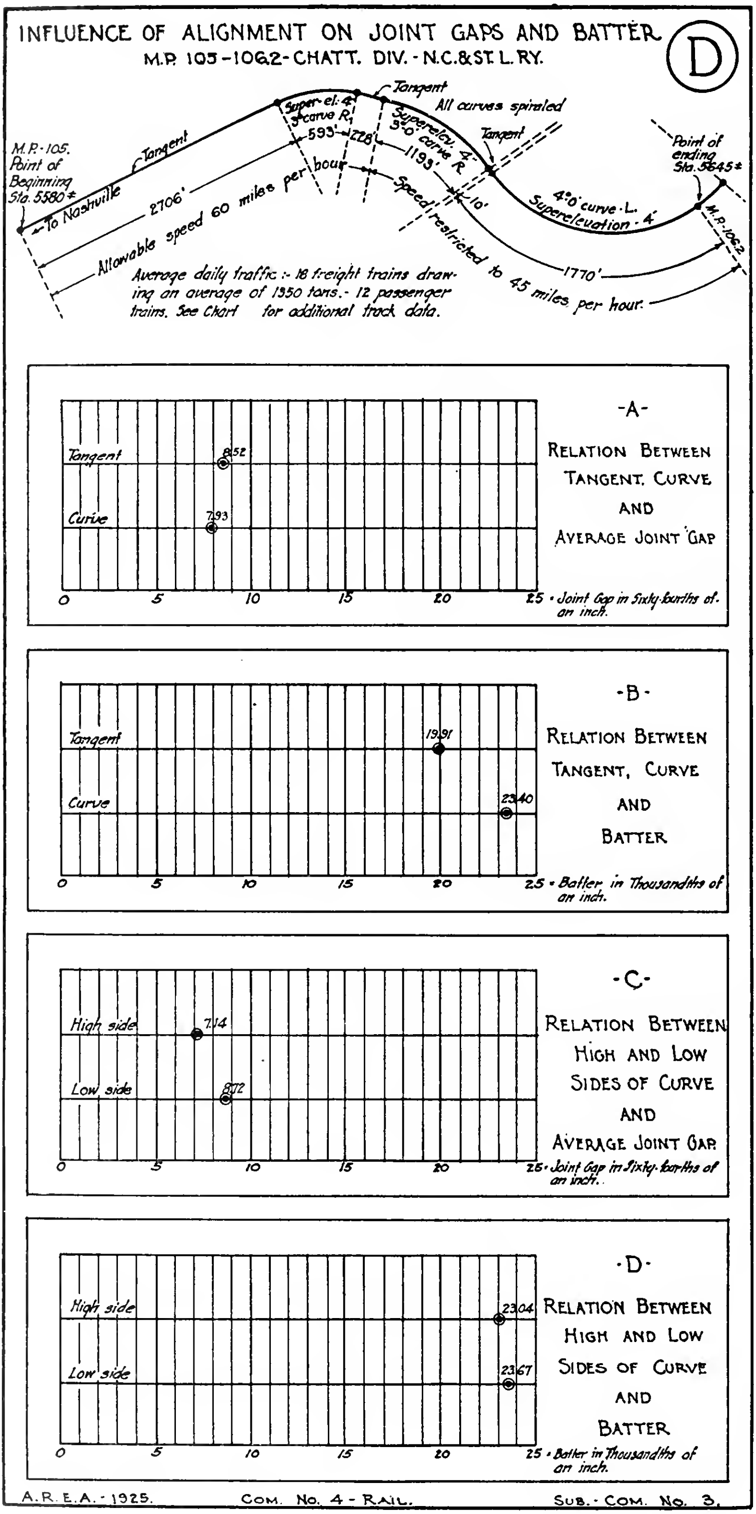
378 Gap Readings. 0″. 10-1-23, 107°. 7-15-25, 100°. 10-26-25, 85°. Both ends overflowed and damaged. S.R. frozen. N.R. moving.

379 Gap Readings. 0″. 7-13-23, 94°. 7-26-23, 118°. 8-13-23, 102°. 10-1-23, 107°. 3-6-25, Both ends slightly chipped. Fins on both rails removed with saw. 10-26-25, No recent overflow. Chipping not increased. S.R. frozen. N.R. moving.

380 7-8-24, Both rails slightly chipped out. 3-6-25, Both rail ends slightly crushed down and chipped. N.R. trimmed with saw. 10-26-25, Slight overflow on N.R. Both ends chipped.

381 Gap Readings. 0″. 7-13-23, 94°. 7-26-23, 118°. 8-13-23, 102°. 10-1-23, 107°. 6-23-24, 114°. 8-23-24, 122°. 7-8-24, S.R. chipped out. 10-26-25, Both ends badly battered. S.R. badly chipped. Nov. 9-13, 1925, Welded up account excessive batter. Special study made. See Plate 1-b. 12-1-25, 50°, Welds holding up.

Joint	
	Slight end overflow on gage side of each rail. Joint frozen. Joint gap 1/16″. Batter N.R. .006; S.R. .005. Probably left a little high at time of welding.
382	3-6-25, Slight fins on rail ends removed with saw. 10-26-25 N.R. slightly chipped. No overflow.
383	Gap Readings. 0″. 7-13-23, 94°. 7-26-23, 118°. 8-13-23, 102°. 10-1-23, 107°. 6-23-24, 114°. 8-23-24, 122°. Both ends battered. S.R. chipped. N.R. slightly overflowed damaging S.R.
384	3-6-25, Slight fins on rail ends removed with saw.
385	Gap Readings. 0″. 7-13-23, 94°. 7-26-23, 118°. 8-13-23, 102°. 10-1-23, 107°. 8-23-24, 122°. 12-29-24, S.R. flaked out slightly. Tight at top. 10-26-25, Both ends slightly overflowed.
386	Gap Readings. 0″. 7-13-23, 94°. 7-26-23, 118°. 7-15-25, 100°. 7-8-24, Open 3/64″ after slacking and hammering. 12-29-24, Both rails chipped out and battered. Open 26/64″. 26°. Verona spring washers applied on inside this date. 3-6-25, Both rail ends badly chipped. Fins on both rail ends cut off with saw. Bolts are tight. 7-15-25, Washers in good condition. No sign of movement. 11-10-25, Lubricated with gre dag. Fishing surfaces found bright. 40″ wrench used to tighten bolts.
387	Gap Readings. 0″. 7-26-23, 118°. 8-13-23, 102°. 6-23-24, 114°. 8-23-24, 122°. 3-6-25, Slight fins on both rails removed by file. 10-26-25, Slight overflow on N.R. at gage corner. S.R. chipped out on gage corner.
388	7-8-24, Slacked bolts, 3-6-25, Slight fins on both rail ends removed with saw.
389	S.R. slightly overflowed damaging N.R.
390	Gap Readings. 0″. 7-13-23, 94°. 7-26-23, 118°. 7-15-25, 100°. Both ends slightly overflowed damaging both rails.
391	3-6-25, S.R. chipped 1/4″ wide across head. Fins on both rail ends trimmed with saw and dressed with file. Splices removed. Found oil on tops and bottoms of splices. Improved Hi-Power washers put on. New oil applied to tops and bottoms of splices before replacing. 7-15-25, These washers in good condition. 10-26-25, N.R. frozen. S.R. moving. S.R. chipped out. 11-10-25, Lubricated with gre dag. Fishing surfaces found bright. 40″ wrench used to tighten bolts.
392	Gap Readings. 0″. 7-13-23, 94°. 10-1-23, 107°. 8-23-24, 122°. Both ends slightly overflowed.
393	Gap Readings. 0″. 7-13-23, 94°. 7-26-23, 118°. 8-13-23, 102°. 8-27-23, 76°. 10-1-23, 107°. 11-1-23, 57°. 12-15-23, 37°. 8-23-24, 122°. N.R. slightly overflowed. S.R. slightly chipped.

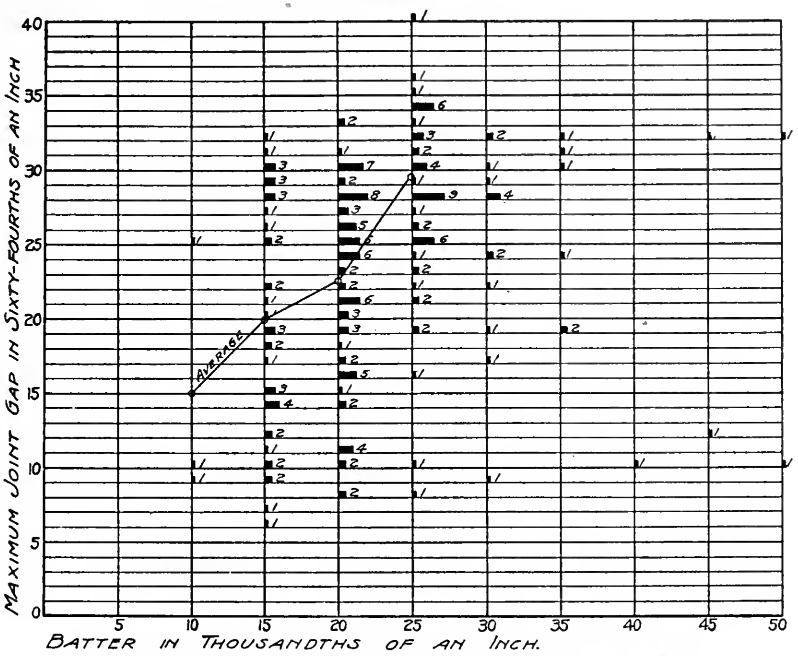

INFLUENCE OF ALIGNMENT ON JOINT GAPS AND BATTER
M.P. 105-106.2-CHATT. DIV.-N.C.&ST. L. RY.
D
M.P.-105. Point of Beginning Sta. 5580±
To Nashville
Tangent
2706'
Allowable speed 60 miles per hour
Super-el.: 4" 3° curve R.
593'
228'
Tangent
All curves spiraled
Superelev. 4" 3°-0' curve R
1193'
Tangent
10'
Speed restricted to 45 miles per hour.
4°-0' curve L. Superelevation - 4"
1770'
Point of ending Sta. 5645±
M.P. 106.2
Average daily traffic :- 18 freight trains drawing an average of 1350 tons.- 12 passenger trains. See Chart for additional track data.
-A-
RELATION BETWEEN TANGENT, CURVE AND AVERAGE JOINT GAP
Tangent
8.52
Curve
7.93
0
5
10
15
20
25
Joint Gap in Sixty-fourths of an inch.
-B-
RELATION BETWEEN TANGENT, CURVE AND BATTER
Tangent
19.91
Curve
23.40
0
5
10
15
20
25
Batter in Thousandths of an inch.
-C-
RELATION BETWEEN HIGH AND LOW SIDES OF CURVE AND AVERAGE JOINT GAP
High side
7.14
Low side
8.72
0
5
10
15
20
25
Joint Gap in Sixty-fourths of an inch.
-D-
RELATION BETWEEN HIGH AND LOW SIDES OF CURVE AND BATTER
High side
23.04
Low side
23.67
0
5
10
15
20
25
Batter in Thousandths of an inch.
A.R.E.A.-1925.
COM. NO. 4 - RAIL.
SUB.-COM. NO. 3.

A.R.E.A.-1925
COM. No. 4-RAIL
SUB-COM. No. 3

Ⓔ

RELATION BETWEEN JOINT GAP AND BATTER
EAST RAIL

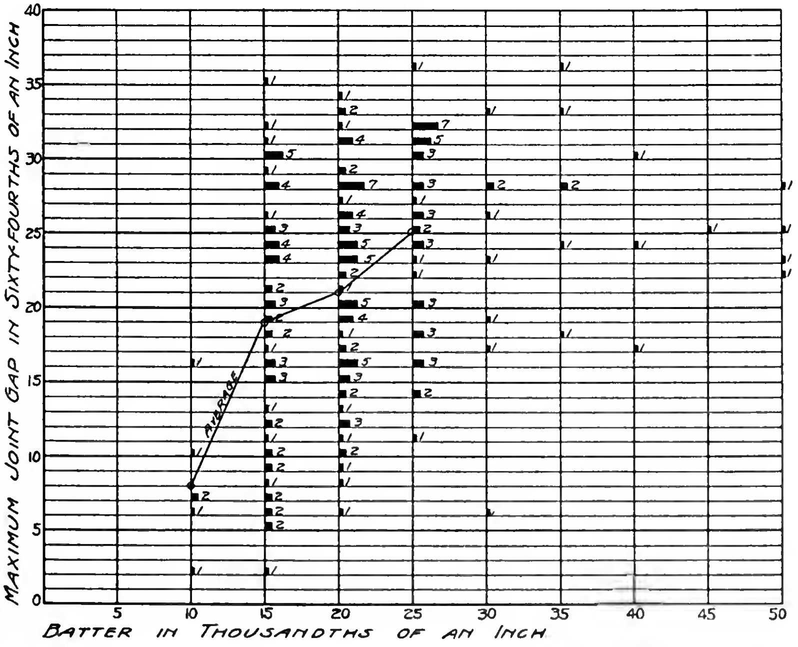
M.P. 105-106.2

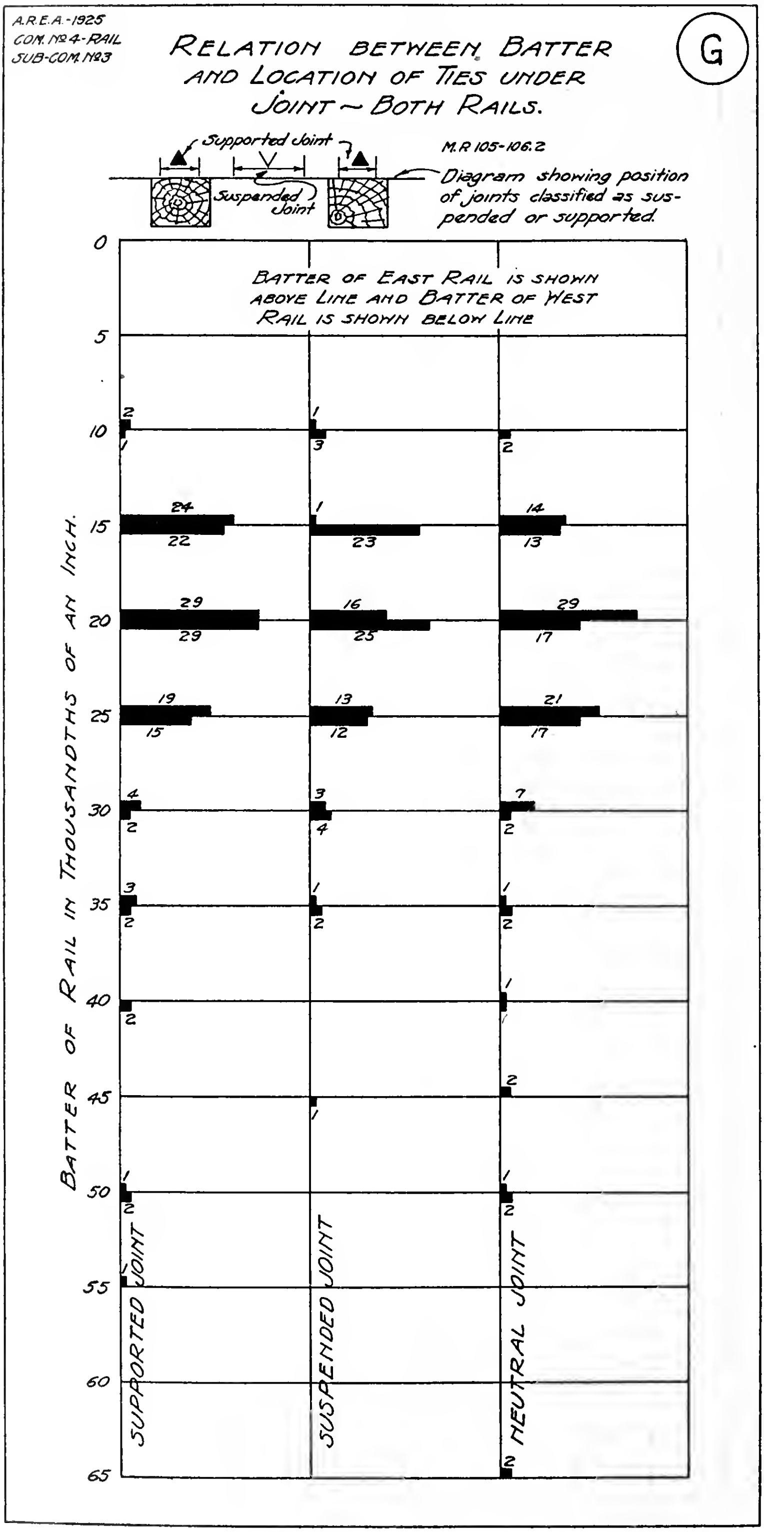


NOTE: Three joints, one with batter of .055" and two with batter of .065" were found, but are not shown on above diagram.

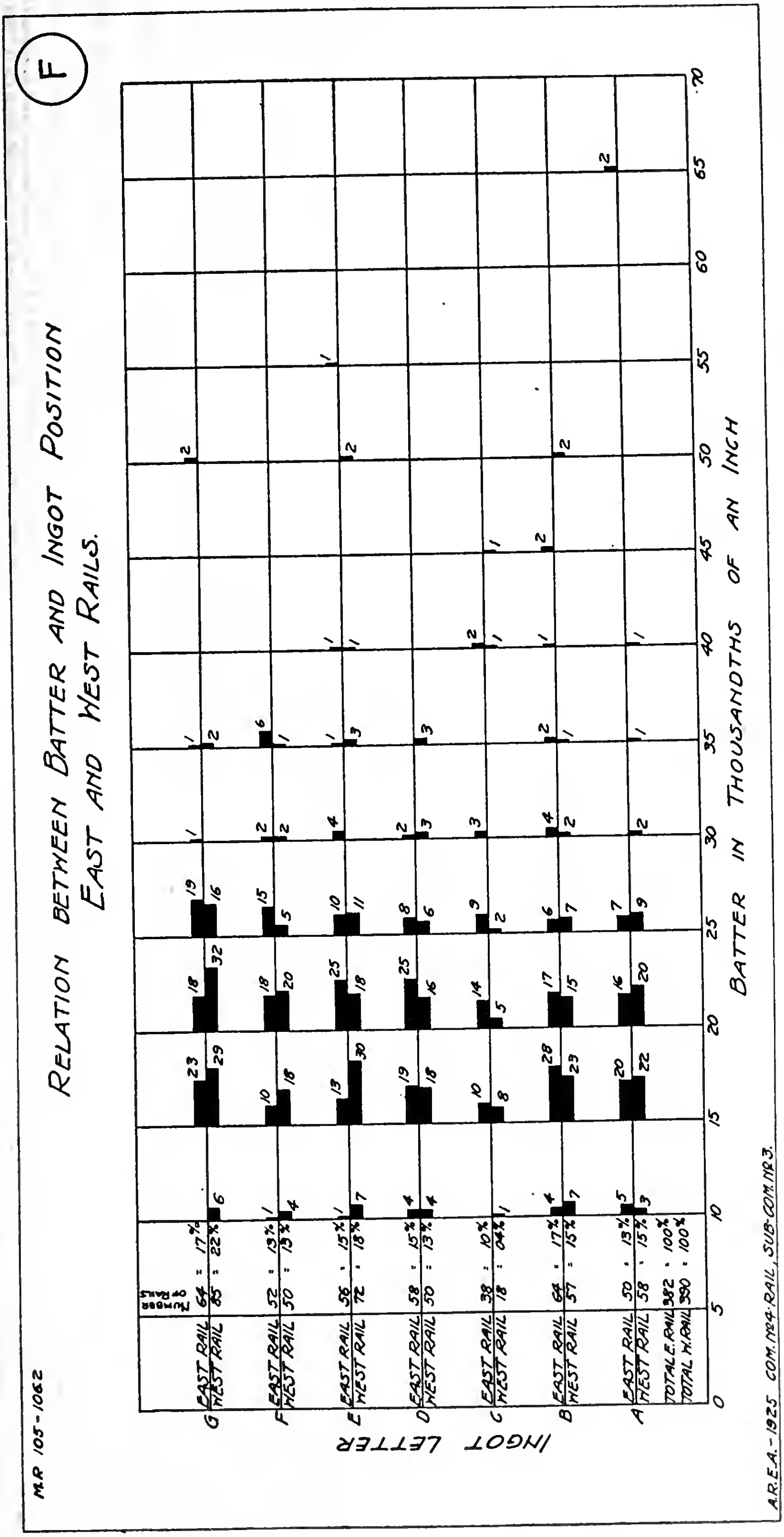
RELATION BETWEEN JOINT GAP AND BATTER
WEST RAIL

M.P. 105-106.2





RELATION BETWEEN BATTER AND LOCATION OF TIES UNDER JOINT ~ BOTH RAILS.



RELATION BETWEEN BATTER AND INGOT POSITION
EAST AND WEST RAILS.

Ingot		Number of Rails	
G	EAST RAIL	64	17%
	WEST RAIL	85	22%
F	EAST RAIL	52	13%
	WEST RAIL	50	13%
E	EAST RAIL	56	15%
	WEST RAIL	72	18%
D	EAST RAIL	58	15%
	WEST RAIL	50	13%
C	EAST RAIL	38	10%
	WEST RAIL	18	04%
B	EAST RAIL	64	17%
	WEST RAIL	57	15%
A	EAST RAIL	50	13%
	WEST RAIL	58	15%
	TOTAL E. RAIL	382	100%
	TOTAL W. RAIL	390	100%

M.R 105-1062

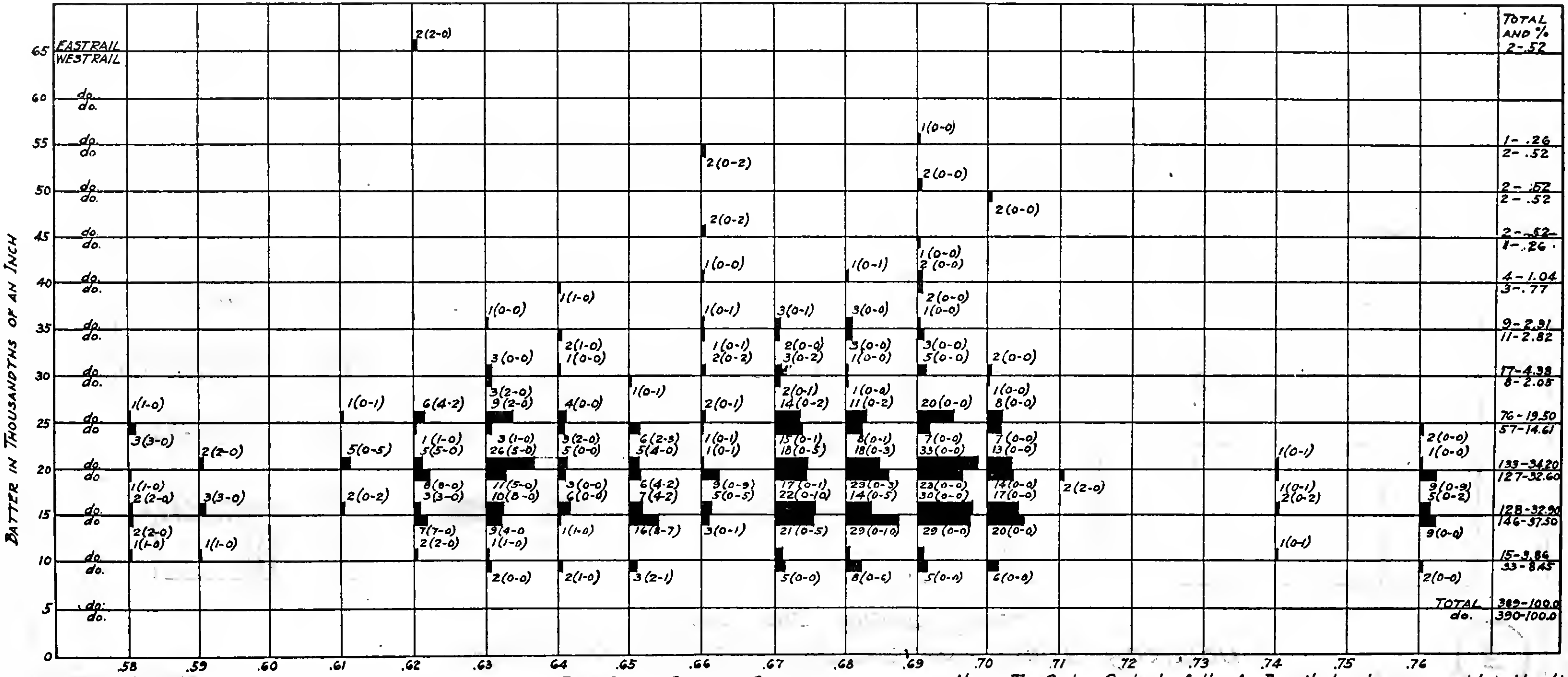
A.R.E.A.-1925 COM. NR4-RAIL, SUB-COM. NR3.

M.P. 105-106.2

A.R.E.A. 1925
Com. No 4 - Rail
Sub-Com. No 3

(H)

Relation between Batter and Carbon Content
East and West Rails



Note—Figures in parenthesis denote number of A & B rails.
For example 21(3-5) indicates a total of 21 rails, of which 3 are A rails and 5 are B rails.

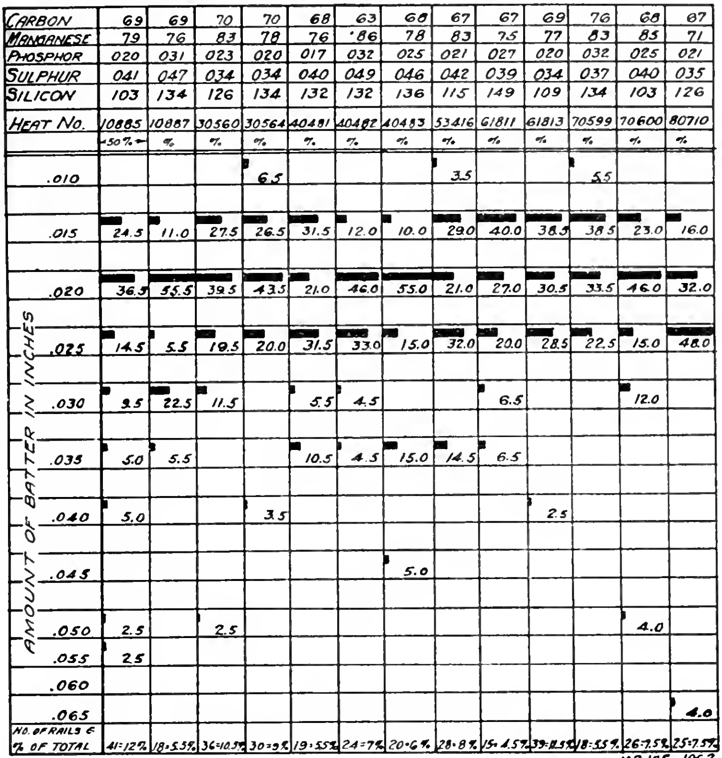
Note: The Carbon Content of the A & B rails has been revised by subtracting .05 from the Average Carbon of the heat for A Rails and .02 for B Rails. This allows for the lower carbon in the heads of A & B rails, due to greater segregation

A.R.E.A.-1925
COM-4-RAIL
SUB COM -3

I-a

RELATION OF HEATS TO BATTER

(PERCENTAGE OF RAILS OF EACH BATTER IN EACH HEAT)



CARBON	69	69	70	70	68	63	68	67	67	69	76	68	67
MANGANESE	79	76	83	78	76	'86	78	83	75	77	83	85	71
PHOSPHOR	020	031	023	020	017	032	025	021	027	020	032	025	021
SULPHUR	041	047	034	034	040	049	046	042	039	034	037	040	035
SILICON	103	134	126	134	132	132	136	115	149	109	134	103	126
HEAT NO.	10885	10887	30560	30564	40481	40482	40483	53416	61811	61813	70599	70600	80710
	←50%→	%	%	%	%	%	%	%	%	%	%	%	%
.010				6.5				3.5			5.5		
.015	24.5	11.0	27.5	26.5	31.5	12.0	10.0	29.0	40.0	38.5	38.5	23.0	16.0
.020	36.5	55.5	39.5	43.5	21.0	46.0	55.0	21.0	27.0	30.5	33.5	46.0	32.0
.025	14.5	5.5	19.5	20.0	31.5	33.0	15.0	32.0	20.0	28.5	22.5	15.0	48.0
.030	9.5	22.5	11.5		5.5	4.5			6.5			12.0	
.035	5.0	5.5			10.5	4.5	15.0	14.5	6.5				
.040	5.0			3.5						2.5			
.045							5.0						
.050	2.5		2.5									4.0	
.055	2.5												
.060													
.065													4.0
NO. OF RAILS & % OF TOTAL	41=12%	18=5.5%	36=10.5%	30=9%	19=5.5%	24=7%	20=6%	28=8%	15=4.5%	39=11.5%	18=5.5%	26=7.5%	25=7.5%

TOTAL JOINTS = 339

M.P 105 - 106.2

TWELVE HEATS OMITTED ON ACCOUNT OF HAVING LESS THAN TEN RAILS.

I-b

DATA ON 12 JOINTS WHERE RAIL ENDS ARE IN VERY BAD CONDITION

M.P. 105-106.2 CHATTANOOGA DIV., N.C.&ST.L.RY

Joint Number	Average Joint Gaps For 14 Readings in 64ths Inch	Depth of Batter on 10-26-1925 in Inches		Frozen or Moving 10-26-25		Heat Number		Carbon Content		Manganese Content		Ingot Letter	
		N. Rail	S. Rail	N. End	S. End	N. Rail	S. Rail	N. Rail	S. Rail	N. Rail	S. Rail	N. Rail	S. Rail
66	13.1	0.030	0.035	F	M	53416	53416	.67	.66	.83	.83	G	B
67	16.9	0.030	0.035	F	F	53416	30558	.67	.63	.83	.80	D	D
106	5.9	0.065	0.065	F	F	80710	10889	.67	.66	.71	.78	A	C
185	6.5	0.040	0.035	F	F	61813	40483*	.69	.68*	.77	.79*	A	E*
187	6.9	0.035	0.035	F	F	40483*	40483	.68*	.68	.79*	.79	E*	D
229	15.1	0.035	0.035	S	F	10885	10885	.69	.69	.79	.79	G	E
252	16.4	0.050	0.050	F	M	10885	10885	.69	.69	.79	.79	G	C
268	11.4	0.040	0.055	M	F	10885	10885	.69	.69	.79	.79	E	B
277	8.2	0.050	0.050	F	F	30560	61811	.70	.67	.83	.75	E	F
288	8.3	0.020	0.025	F	F	70600	70600	.68	.68	.85	.85	E	F
343	8.5	0.050	0.050	F	M	70600	30562	.68	.64	.85	.71	B	D
381	8.6	0.040	0.045	F	F	70601	80710	.69	.67	.90	.71	C	B
Ave.	10.5	0.040	0.043					.675	.670	.811	.782		

* Denotes same rail.
Total rails of each letter involved and percent of each;
A·2 rails, 9%; B·4·17%; C·3·13%, D·4·17%; E·5·22%; F·2·9%; G·3·13%
21% Rail Ends Moving
79% Rail Ends Frozen
21% Rail Ends Chipped

These joints were built-up by welding
Nov. 9 to 13, 1925

A.R.E.A-1925
COM. No.4-RAIL
SUB-COM. No.3

DATA ON 34 RAILS
SHOWING MINIMUM END BATTER (0.010 & 0.0125 AVERAGE)

J

M.P. 105-106.2 CHATTANOOGA DIV.

RAIL NUMBER	AVERAGE JOINT GAPS IN 64THS. OF AN INCH		CHEMICAL CONTENT		INGOT LETTER						
	N. END	S. END	CAR.	MANG.	A	B	C	D	E	F	G
3	15	1	67	83					1		
7	7	9	70	84						1	
9	9	4	70	84		1					
11	4	6	63	80						1	
14	9	1	69	77					1		
15	5	4	69	79							1
16	1	9	69	77		1					
25	12	4	69	77						1	
28	23	9	70	83		1					
35	22	6	70	89					1		
38	5	6	69	77						1	
50	9	8	67	75				1			
58	6	2	67	75				1			
75	1	6	67	83				1			
97	8	6	70	78	1						
112	5	2	64	71	1						
118	3	4	63	86	1						
120	4	7	67	71	1						
128	7	4	68	85	1						
155	6	8	69	77					1		
* 197	5	1	76	83					1		
199	1	2	68	78					1		
226	7	8	76	83		1					
253	7	6	67	83		1					
264	4	3	69	79		1					
281	1	2	70	78						1	
285	3	1	70	78		1					
289	7	1	70	78					1		
291	1	3	70	78		1					
327	2	7	63	86							1
354	8	7	68	76				1			
363	5	2	69	92	1						
371	7	4	67	83			1				
391	9	2	70	78				1			
AVERAGES	6.71†	4.56†	68.6‡	79.9	6=17%	8=23%	1=3%	5=15%	7=21%	5=15%	2=6%

* Indicates average end batter of 0.010"; all others had average of 0.0125

‡ Of 34 rails, the carbon content in 3=63; 1=64; 7=67; 3=68; 8=69; 10=70; 2=76

† Averages for 393 Joints; Joint Gap=8.19, Batter=0.020"; Carbon Content=68.2

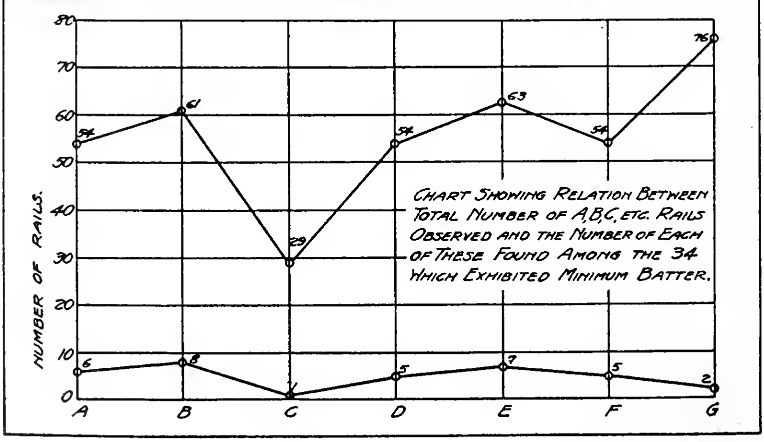


CHART SHOWING RELATION BETWEEN TOTAL NUMBER OF A,B,C, ETC. RAILS OBSERVED AND THE NUMBER OF EACH OF THESE FOUND AMONG THE 34 WHICH EXHIBITED MINIMUM BATTER.

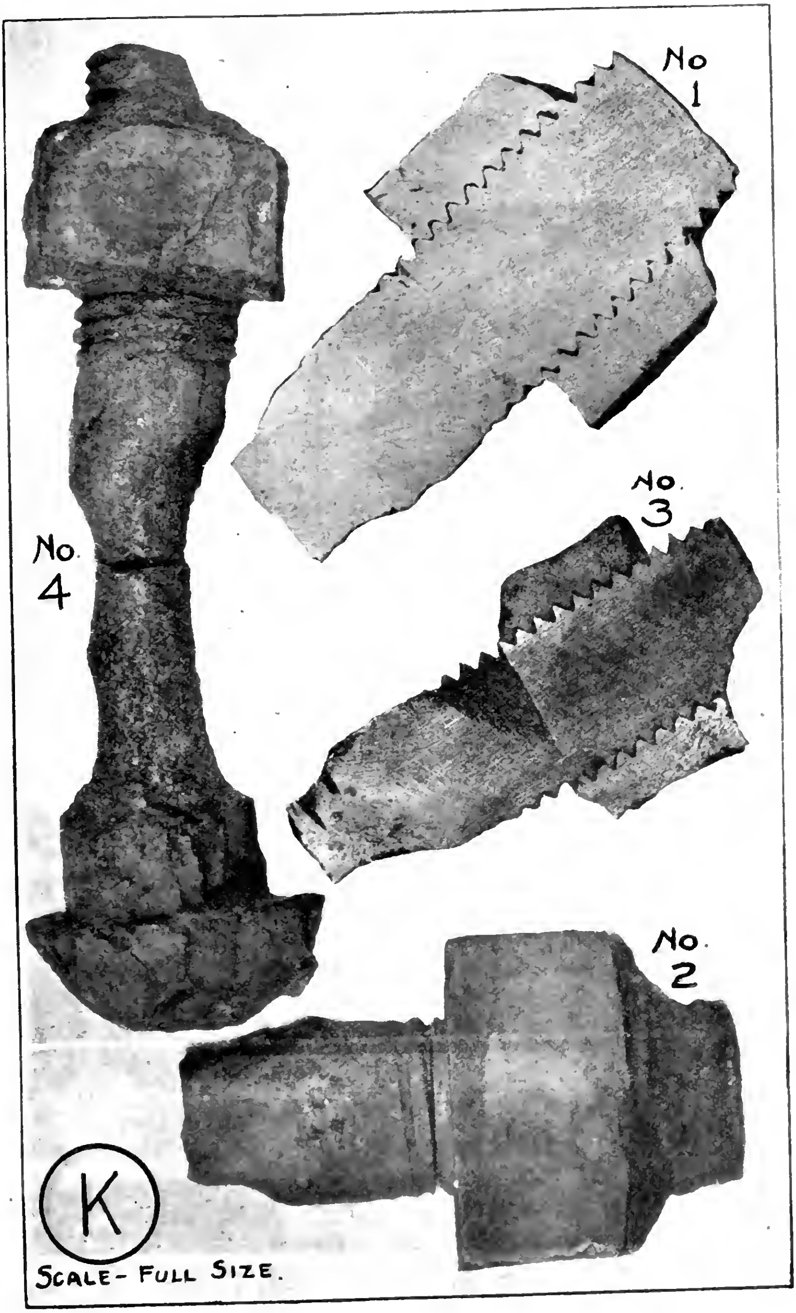

No 1
No 3
No 4
No 2
K
Scale- Full Size.

EXHIBIT - L

Figures 1, 2, 3, and 4 are photographic views of the chip taken from Rail 108 of Joint 106.

1\. The dark area at the top is the effect of the end overflow from the North rail pushing under the overflow from the south rail, producing the chip, by lifting. The final fracture occured along the bottom edge when chip was removed by the welders.

2\. End view of No. 1. looking North. The dark area below is the surface of the fracture resulting from removal.

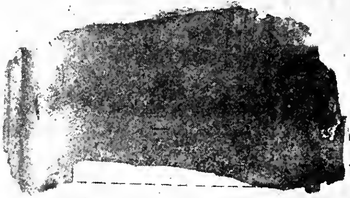
#1.

BOTTOM VIEW

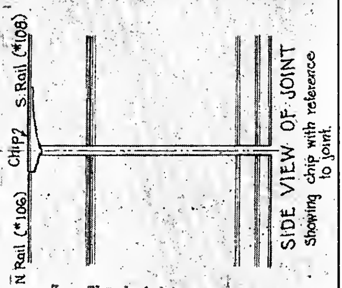
#2.

END VIEW

#3



TOP VIEW



3\. The bright area at the bottom of the cut is due to the supporting effect resulting from the upward pressure of the end overflow from the north rail. The darker area above the joint gap is due to the separated condition of the metal underneath. The final fracture appears at the top. The dotted line at the bottom indicates the probable extent of chip before this small portion was broken off under traffic.

#4

END VIEW

4\. The darker area at the top shows the area of separation of the piece of end overflow referred to under 3.

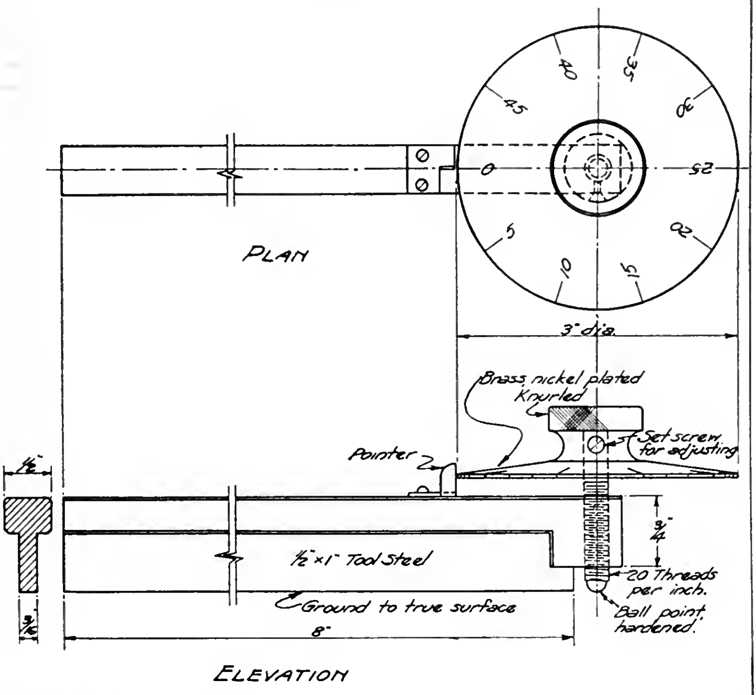
No. 5. View of 110 lb. rail laid near Normandy in June, 1923, and maintained under same conditions as the rail on M. P. 105-106.2. It shows the softness of the rail and the manner in which end overflow operates alternately against each rail to chip and expedite batter.

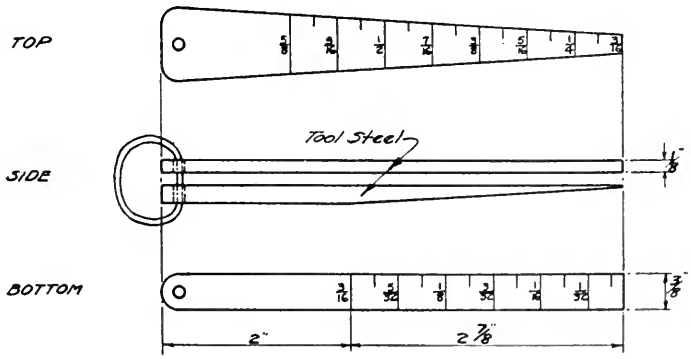
No. 6. is the same joint illustrating the depth and extent of batter. Joint Gap; 6-29-25, 88°, =1/64"; 2-9-25, 69°-4/64". Photos taken 11-18-25.

A.R.E.A. Com. No. 4 – Sub-Com. No. 3 1925

M

DEVICE FOR MEASURING RAIL BATTER.
TO NEAREST 0.005 INCH
SCALE: FULL SIZE





TAPER GAUGES FOR MEASURING JOINT GAPS AND TESTING BATTER FOR WELDING UP.
SCALE: FULL SIZE

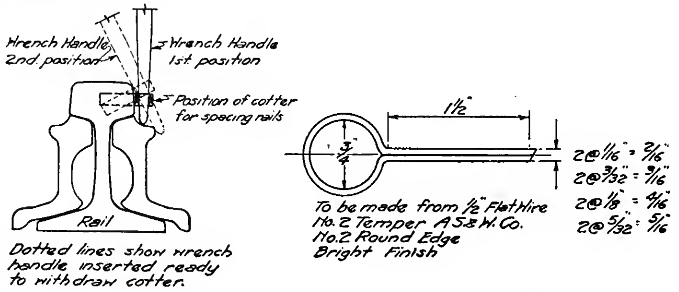
INSTRUMENTS DEVELOPED
FOR TAKING MEASUREMENTS OF JOINT GAP AND BATTER
N.C. & ST.L. RY – OFFICE OF CHIEF ENGINEER – NOV. 1925.

A.R.E.A. COM. No. 4-RAIL SUB-COM. No. 3 1925

N

SUGGESTED EXPANSION ALLOWANCE FOR LAYING 31, 33 AND 39 FT. RAILS.

TEMPERATURE IN DEG. F.	PRESENT ALLOWANCE 33 FT. RAILS	PROPOSED ALLOWANCE		
		33 FT. RAILS	39 FT. RAILS	31 FT. RAILS
0	4/16" Cotter	5/16" Cotter	6/16" Cotter	4/16" Cotter
10	4/16" "	4/16" "	5/16" "	4/16" "
20	4/16" "	4/16" "	5/16" "	4/16" "
25	3/16" "	3/16" "	4/16" "	3/16" "
30	3/16" "	3/16" "	4/16" "	3/16" "
40	3/16" "	3/16" "	3/16" "	3/16" "
50	2/16" "	2/16" "	3/16" "	2/16" "
60	2/16" "	2/16" "	2/16" "	2/16" "
70	2/16" "	2/16" "	2/16" "	2/16" every 2nd Jt.
75	1/16" "	2/16" every 2nd Jt.	2/16" every 2nd Jt.	2/16" " " "
80	1/16" "	2/16" " " "	2/16" " " "	2/16" " " "
85	1/16" "	2/16" every 3rd Jt.	2/16" " " "	2/16" every 3rd Jt.
90	1/16" "	2/16" every 4th Jt.	2/16" every 4th Jt.	2/16" every 4th Jt.
95	1/16" "	2/16" every 8th Jt.	2/16" every 6th Jt.	2/16" every 9th Jt.
100	1/16" "	Lay tight	Lay tight	Lay tight
Over 100	Lay tight			



COTTER EXPANSION SHIM
SHAPED TO FACILITATE EASY REMOVAL.

Appendix D

(8) METALLURGICAL REPORT ON THE EFFECT OF WELDING IN CHANGING STRUCTURE OF RAIL

E. E. Adams, Chairman, Sub-Committee; W. J. Backes, C. F. W. Felt, L. C. Fritch, E. A. Hadley, Hunter McDonald, R. Montfort, W. H. Penfield, Earl Stimson, L. Yager, J. B. Emerson.

STRUCTURAL CHANGES IN RAIL STEEL BY THE WELDING OF TRACTION AND SIGNAL BONDS

This report contains the findings on six 36-inch lengths of section 11025 rails from heat No. 34282, to which have been welded three specific sizes of traction and signal bonds by each of the following companies: The Ohio Brass Company, Mansfield, Ohio, and the American Steel & Wire Company, of Worcester, Mass.

Tabulation of Samples Received

Rail Sample	*No. Applied*	*Location*	*Spaced*	*Type*	*Name*
Bonds applied by the Ohio Brass Company:					
1	5	Outside of head	8″ centers	OB-13997	Stub end Signal
2	5	Outside of head	8″ centers	OB-ST-2	Gas weld rail bond
3	6	Outside of head	11″ centers	OB-ST-5	Heavy propulsion 500,000 c.m. cap

Bonds applied by the American Steel & Wire Company:

Rail Sample	*No. Applied*	*Location*	*Spaced*	*Name*
4	4	2 on outer side head	2″ from ends	Signal bond
		1 on web	15″ from end	
		1 on flange	21″ from end	
5	4	Same as No. 4	Same as No. 4	4/0 Propulsion
6	4	Same as No. 4	Same as No. 4	Heavy propulsion 500,000 c.m. cap

Chemical Analysis

	C	*Mn*	*P*	*S*	*Si*
Ladle of heat No. 34282	.80	.74	.034	.033	.19

Photographs of typical welds from each of the above enumerated rails will immediately follow.

Macro-etchings of transverse and longitudinal sections through these welds are then set forth.

Typical micrographs depicting the structural modifications of the two classes of welds then follow.

Summary of Findings

Fig. 1 to 9, inclusive, illustrate the various types of signal and propulsion bonds which have been applied by two methods to short lengths of 11025 section rails from heat No. 34282 and are reproduced, as near as possible, to natural size.

Fig. 10 to 17 have aimed to show areas affected in the rails by the welding operation as revealed by the macro-etchings. In the area nearest the weld there is slight skin decarburization which is almost negligible—then the harder, somewhat refined grain is evident; adjoining this at increasing depths are found nearly sorbitized rail steel and then the fine grain merges to the original structure. The Brinell hardness varying between 364 in region immediately adjacent to weld; dropping down to 302 in gradation zone; and giving 286 of the rail as rolled. Physically, this variation could be expressed somewhat as follows for a piece of the unaffected head when sorbitized gave:

100,275 lb. per sq. in.—Yield point
154,565 lb. per sq. in.—Ultimate tensile
14.00%—Elongation
35.41%—Reduction of area

while the rail as rolled gave:

79,420 lb. per sq. in.—Yield point
138,150 lb. per sq. in.—Ultimate tensile
9.00%—Elongation
13.08%—Reduction of area

The micrographs, Fig. 18 to 24, show the typical grain alteration induced by the welding, showing the modification of the rolled structure in its various phases from the rolled structure to the sorbitization.

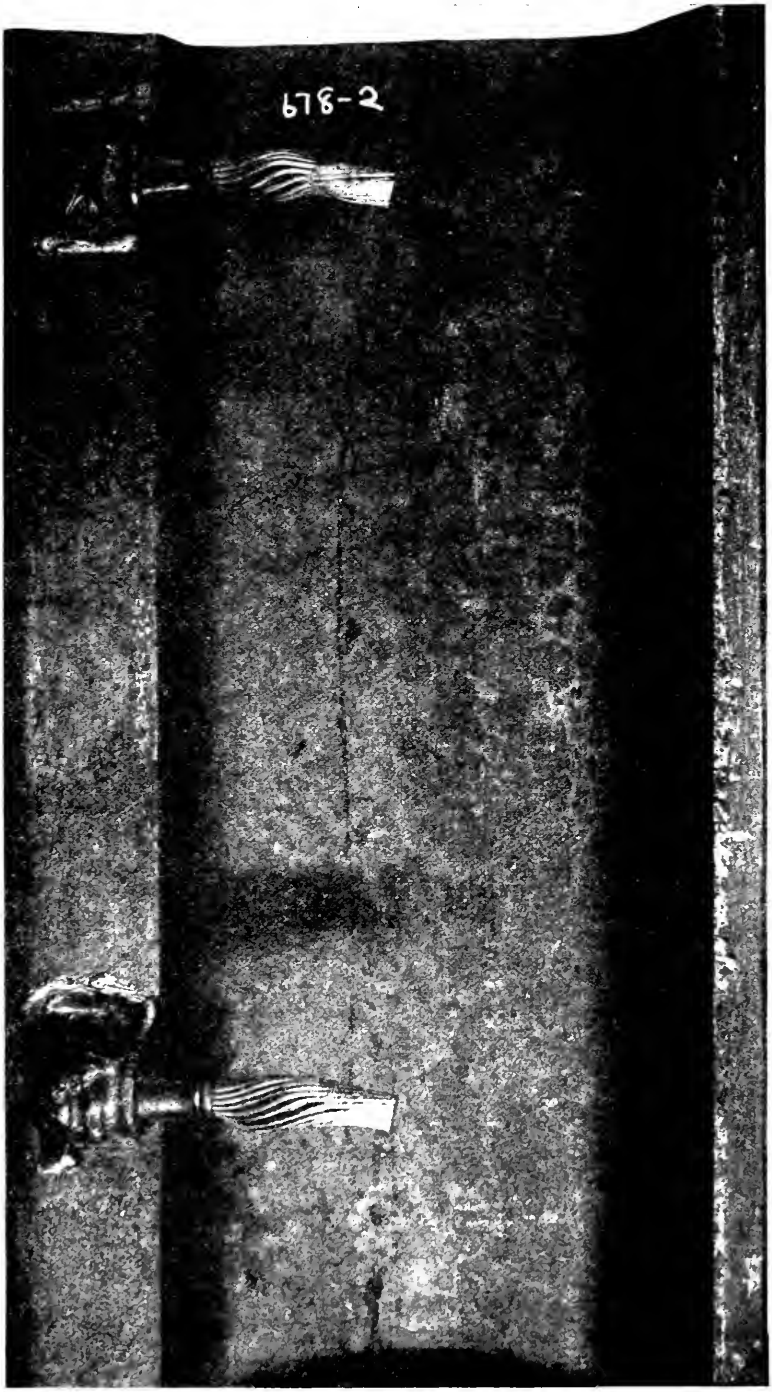


Fig. 1

Photograph at about ¾ natural size of stub end signal bond OB-13997. Welds are applied about 8 inches from center to center and all are attached to outside edge of rail head. The average weld measures about 1¼ inches along edge of rail and tapers to ¾ inch at cable ferrule at right angles to head.

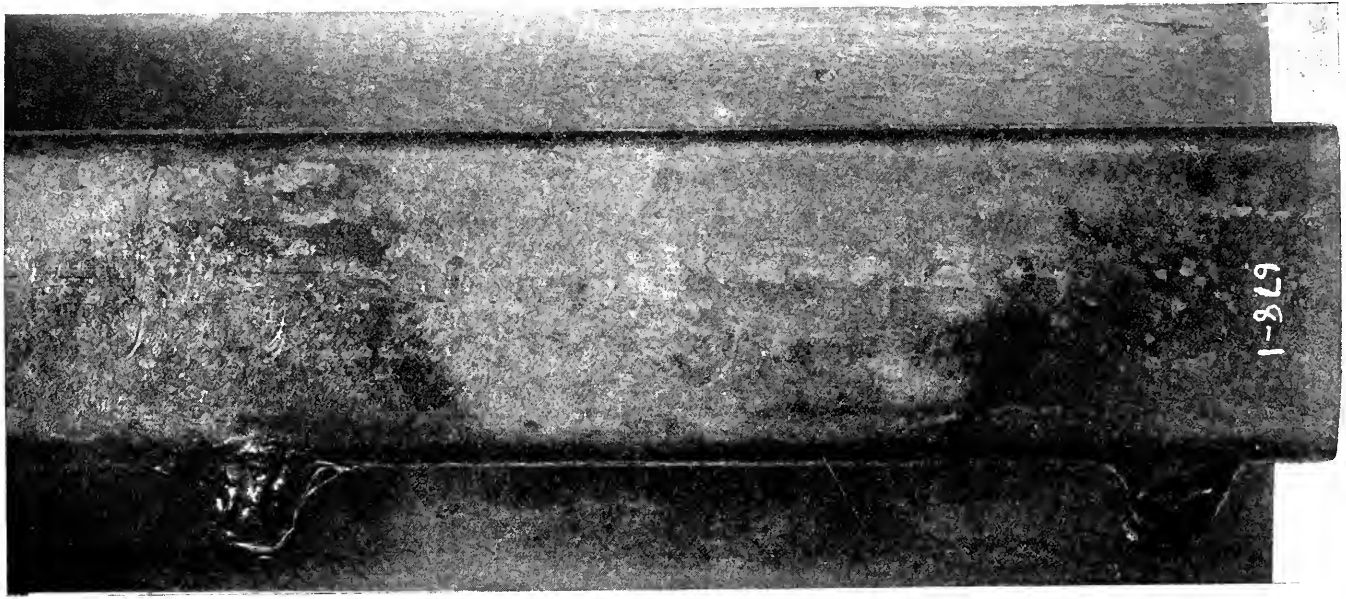


Fig. 2

Reproduction of top projection at ¾ natural size shows that type OB-13997 signal bonds average about ⅞ inch overall width as applied to side of rail.

Fig. 3

Reproduction at ¾ natural size of Ohio Brass type OB-ST-2 gas welded rail bond shows copper joined to edge of head for an average of 1½ inches, and double cable connector ferrules at right angle to the head.

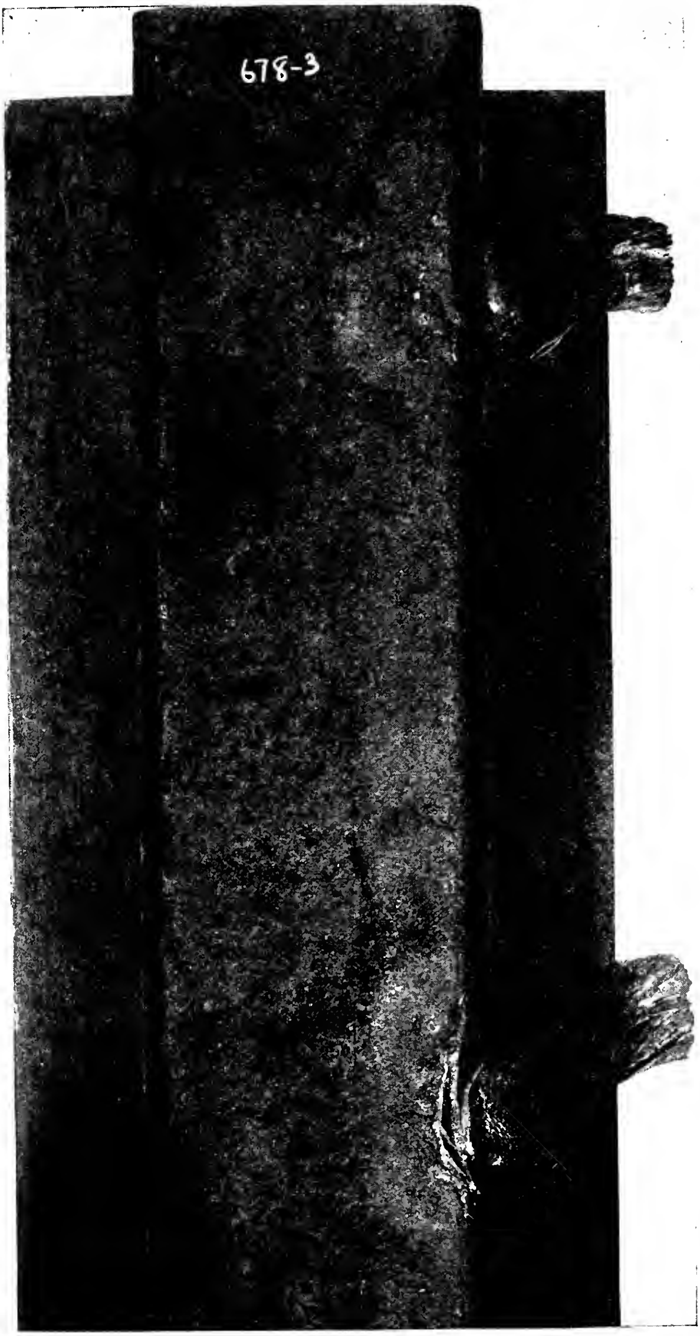


Fig. 4

Top projection of same welded rail bond as shown by Fig. 3 at ¾ natural size. The type OB-ST-2 gives average width from head of ⅞ inch.

Fig. 5

Photograph at ¾ natural size shows Ohio Brass heavy propulsion bond of 500,000 c.m. capacity double bonded arrangement and angular conductor head off.

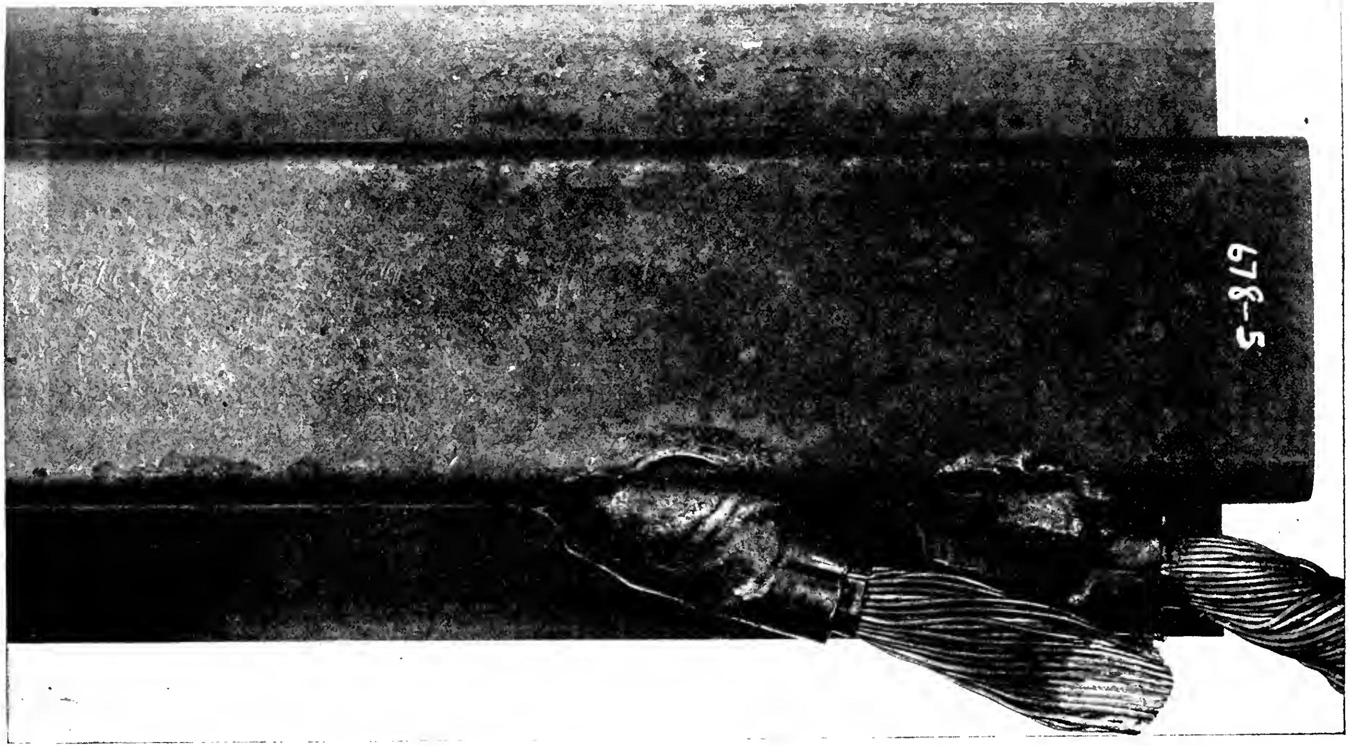


Fig. 6

Top projection of head at ¾ natural size of Ohio Brass heavy propulsion bond showing grouping of two 250,000 c.c. capacity bonds, each of which has affected 2 inches along rail edge and projects outward 1⅛ inches from edge.

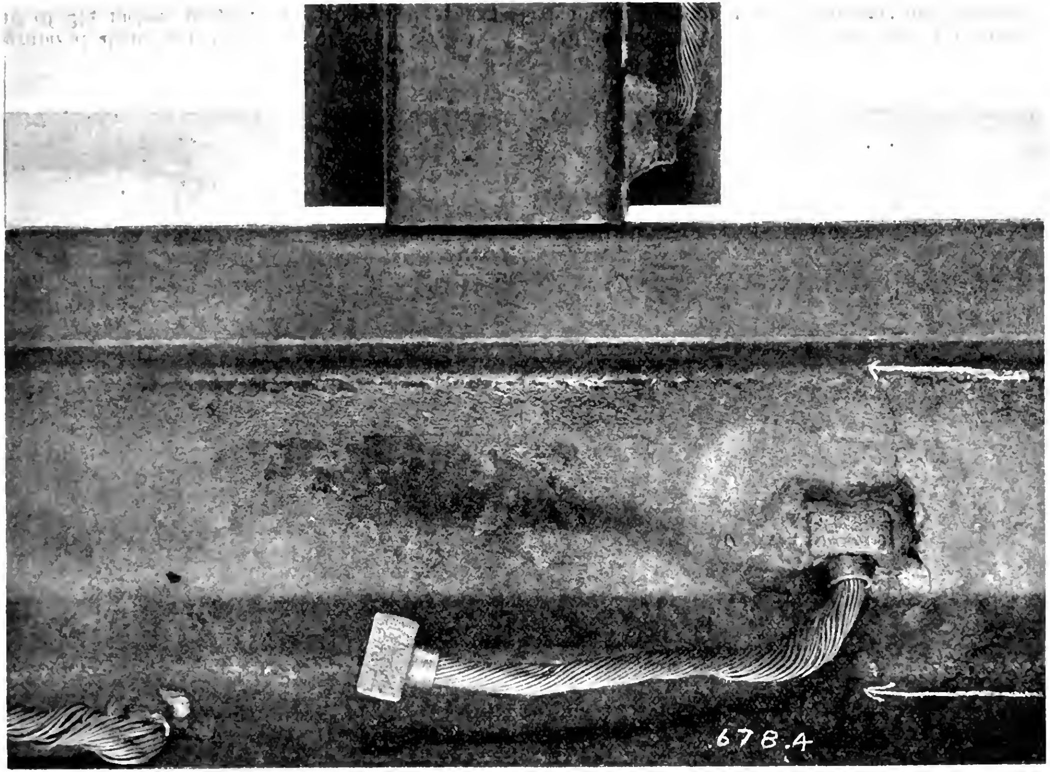


Fig. 7

Photograph at ¾ natural size of American Steel & Wire Company signal bonds. The rail web has been cracked between the white arrows by the application of the bond to the web of rail. This bond is joined to 1¾ inches of the rail by copper and tapers out to a patented flat ferrule of the conductor.

Fig. 8

Photograph at about ⅞ natural size shows A. S. & W. Co. 4/0 propulsion bond. This weld affects a length along rail of 2¼ inches, projects out from head ¾ inch, and outwardly joins patented ferrule and conductor.

Fig. 9

Photograph at about ¾ natural size shows three views of heavy propulsion bond of 500,000 c.m. capacity which affects 3-inch lengths along rail, projects out 1⅛ inches, and joins 2¼ inches ferrule and conductor.

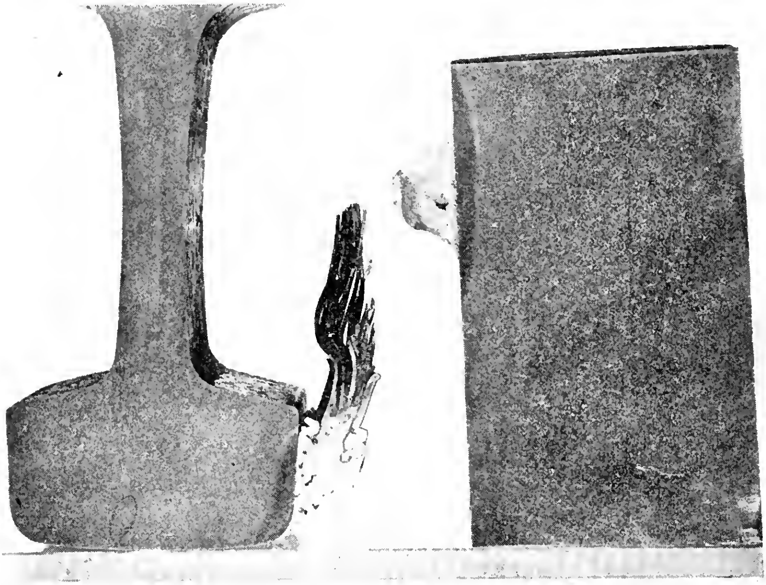


FIG. 10

Transverse and longitudinal section at ⅞ natural size, as etched by the use of 15 per cent ammonium persulphate, shows that the Ohio Brass Company stub end signal bond—OB-13997, has refined and slightly hardened the rail as indicated by dark area adjacent to the bond, which gives Brinell hardness of 364; the sharp lighter gradation band adjacent to this darker area is somewhat softer, giving 302 Brinell, whereas the rail as rolled gives 293 Brinell. Measurements show the longitudinal area adjacent to weld is $\frac{3}{16}$ inch in width, 2¼ inches in length; on the transverse section the maximum width is ¼ inch. No evidence of thermal cracks was found.

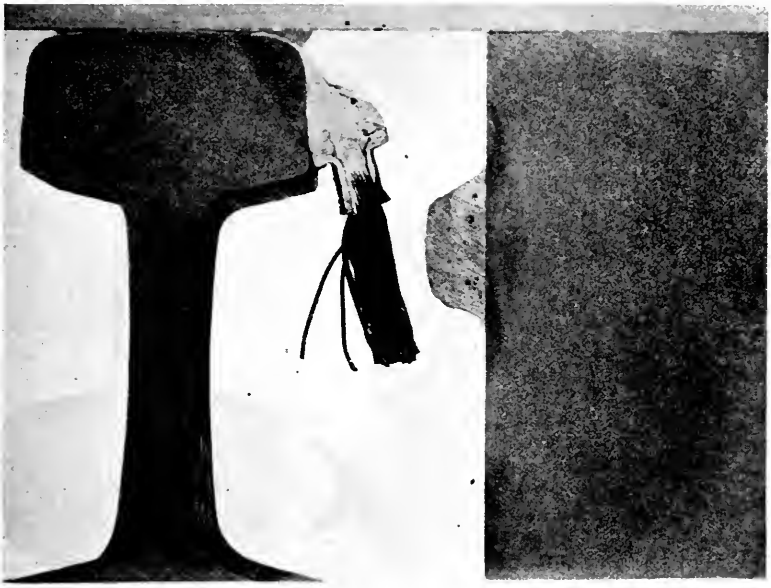


FIG. 11

Reproduction at ⅞ natural size of gas welded rail bond OB-ST-2 etched by the use of ammonium persulphate shows refined, slightly harder area induced by welding the bond, affects 2⅝ inches along length of rail and a depth inwardly on transverse section of $\frac{7}{16}$ inch.. The dark area adjacent to weld has a Brinell of 340. The lighter banding in gradation zone, 293, and the rail as rolled, 269. No evidence of thermal cracking was found.

A

Fig. 12

Transverse and longitudinal section at ⅞ natural size of 250,000 c.m. capacity OB propulsion bond type ST-5. The signal bond affects a length of 4½ inches along rail when coupled together in pairs to get 500,000 c.m. capacity. The transverse projection showing more area of head affected, in fact, the whole side of the head to an average depth of $\frac{7}{16}$ inch. No evidence, of thermal cracks was found. Hardness in dark area, 364, in gradation area, 293, and on rail as rolled, 277.

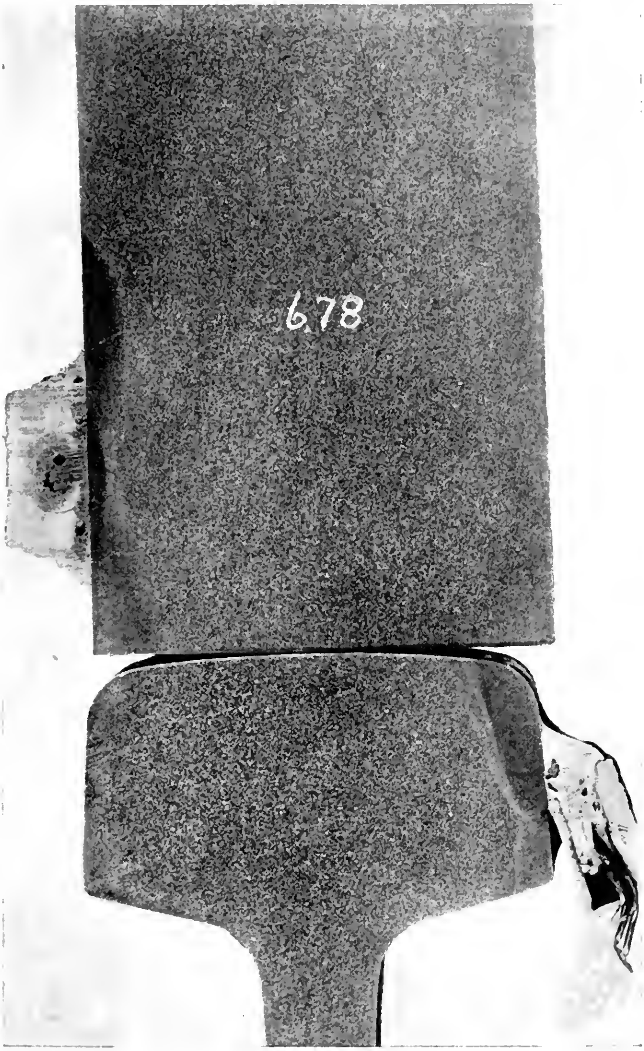


Fig. 13

Photograph of persulphate etching at natural size on American Steel & Wire Company welded signal bond shows transverse and longitudinal section which display slightly hardened and refined areas adjacent to weld affecting depth of ⅜ inch and length of 2½ inches. No evidence of thermal cracking was found in the head section in the vicinity of this weld. Hardness varied from 340 in dark area close to edge, 302 in lighter gradation area, and 277 Brinell in area of natural rail.

FIG. 14

Ammonium persulphate etching at natural size of transverse and longitudinal sections of 4/0 propulsion bond which show slightly hardened and refined areas adjacent to weld which are affected to a depth $\frac{9}{16}$ inch and a length along rail of 2⅞ inches. No evidence of thermal cracks was found. The hardness varied from 340 in dark area, 262 in lighter gradation area, and 277 in rail as rolled.

Fig. 15

Longitudinal and transverse cuts as etched by ammonium persulphate reagent shows that American Steel & Wire Co. 500,000 c.m. capacity heavy propulsion bond affects a length of 4 inches along rail and a depth of ⅝ inch. No evidence of thermal cracking was found. The hardness varied from 321 in dark area adjacent to weld, to 255 in gradation zone, and 277 on rail as rolled.

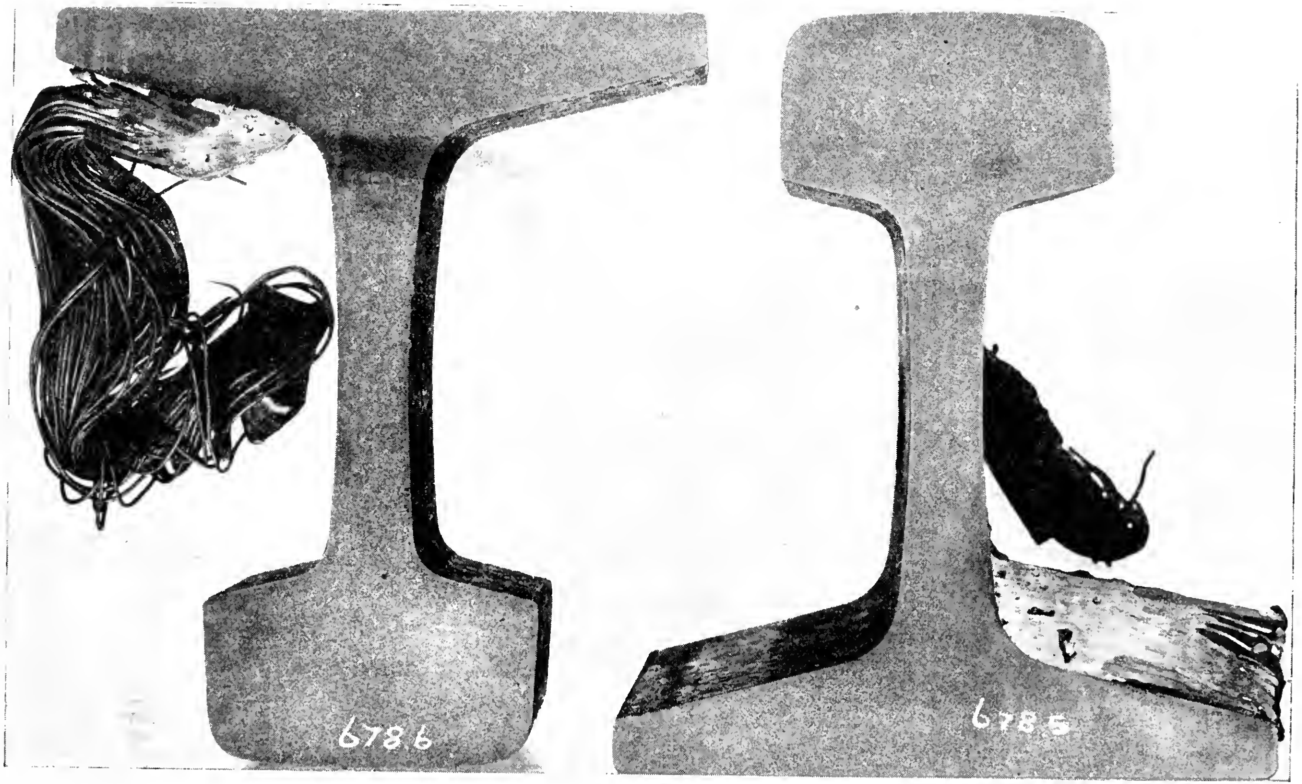


Fig. 16

Photograph at 4/5 natural size of A. S. & W. Co.'s 4/0 propulsion on right and 500,000 c.m. capacity heavy propulsion bond on left, which have been welded to flange of rail outside of joint area as etched by ammonium persulphate reagent. The print shows area affected by the welds in the crescent-like area of slightly refined and hardened metal. The Brinell hardness next to weld is 340 and in lighter banded area is 262; the rail as rolled shows Brinell of 269.

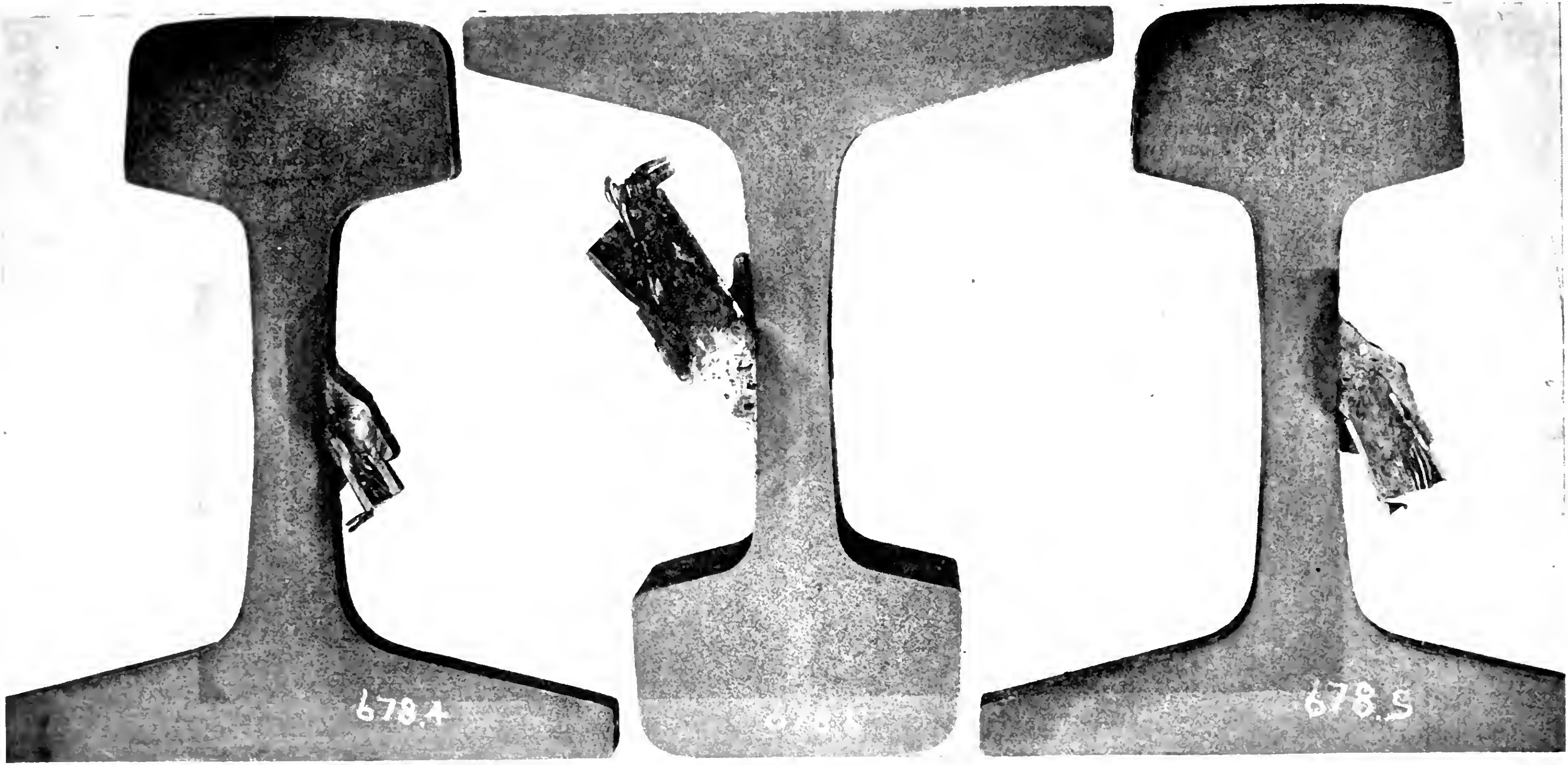
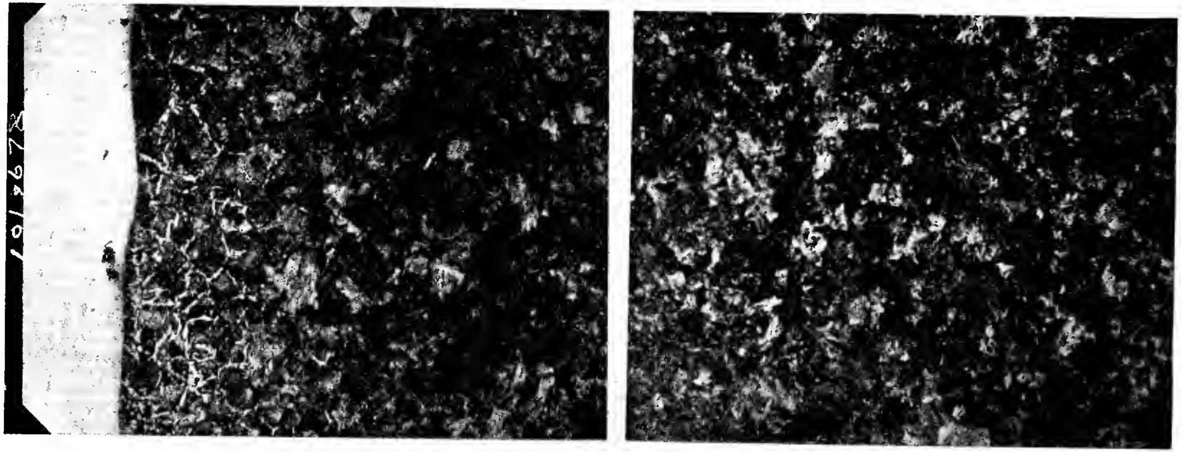


FIG. 17

Prints at 3/5 natural size show A. S. & W. Co.'s welded specimen which have been joined to the web. From left to right signal bond, with the thermal crack in the head induced by weld to web; next, 500,000 c.m. propulsion bond; and on extreme right the 4/0 propulsion bond. The maximum depth affected is ½ inch as shown by center specimen. Hardnesses are comparable as set forth previously.



A

B

FIG. 18.—Micros. x150

Along edge of light area is copper weld—merges into decarburized rail edge and then to thermally refined grain.

Typical Micrographs of Grain Structural. Fine grain from A continues into B; shows more sorbitic nature, then gradates to structure shown in C.

C

Changes from Edge to Depth of ⅜ inch; as welded by Ohio Brass Company. At $\frac{3}{32}$ inch depth from the edge of the structure merges from fine to the typical rolled structure.

D

Structure typical of rail as rolled at depth ⅜ inch from edge shows average grain structure for steel of eutectoid composition.

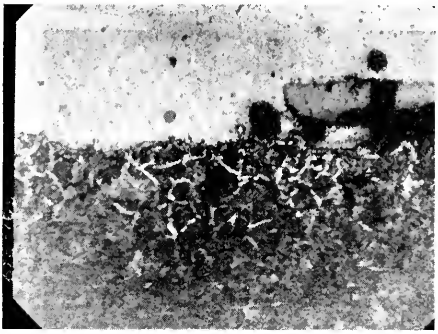


FIG. 19

Nitric Acid Etching. A. S. & W. Co. x150. Typical weld at junction of copper with rail's decarburized edge, oxides external to weld are occasionally found. As greater depths are progressed the grain is nearly sorbitic in nature.

FIG. 20

Etched. A. S. & W. Co. Weld x150. Metal adjacent to edge shows very fine grain structure of eutectoid composition.

FIG. 21

Etched. A. S. & W. Co. Weld x150. Normal as rolled structure of near eutectoid composition.

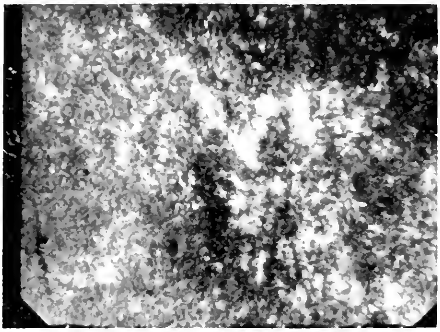


FIG. 22

Weld by A. S. & W. Co. x2000. High power resolution shows that structure near weld has sorbitic structure adjacent to weld.

FIG. 23

Weld by A. S. & W. Co. x2000. High power resolution of structure between sorbitized area and natural as rolled rail, not so much tendency towards sorbite.

FIG. 24

Weld by A. S. & W. Co. x2000. Normal pearlite in eutectoid rail steel as rolled.

Appendix E

(10) STUDY OF THE EFFECT OF VARIOUS INTENSITIES AND REPETITIONS OF WHEEL LOADS UPON RAILS

W. C. Cushing, Chairman, Sub-Committee; J. E. Armstrong, A. F. Blaess, F. L. C. Bond, C. B. Bronson, C. F. W. Felt, Hunter McDonald, A. W. Newton, G. J. Ray, F. M. Waring, J. B. Young, J. B. Emerson.

By John B. Emerson, Engineer of Tests

The assignment of this subject by the Board of Direction for study is considered by the Rail Committee an effort in a new direction toward accumulating data concerning the condition primarily responsible for the deterioration of good-wearing rails in track, as well as the development of most of the dangerous rail failures.

Conditions of manufacture, metallurgy and chemistry, as well as size and proportioning of rail sections, have an undoubted large bearing on the resistance of the rail to wear and failure. The design of the car wheel, including not only the contour and taper of the tread, but also the diameter of the wheel, must further exert a considerable influence. However, development of failures from errancies of design or composition must usually await the strains set up through the rolling impingement of the load.

Sharply diverse opinions have been expressed concerning the relative importance of the quantity of load in itself and the design and metallurgical integrity of the rail and wheel structure. It has been asserted upon the one side that rail failures are principally a function of excessive wheel loads; that is, loads impinging upon the rail through restricted areas of contact in excess of the ability of even the best made steel to withstand. Upon the other hand, the record shows that rail failures per unit of life of rail in track have decreased over the period of the last ten or twelve years to approximately one-quarter of the early extent, while the record also shows that the wheel loadings have nearly doubled during that period and the traffic density on the average has vastly increased. While it is fair to assume that unquestionable improvement in design and metallurgy must be given its share of credit for the improvement, it would appear that this alone could not have accomplished such a result against the great increase in load and traffic density, if it were true that the load, which was characterized as excessive ten years ago, was really at that time beyond the endurance limit.

It is believed by the Rail Committee that the assignment for study in the year 1924 of the subject "Determine the maximum permissible wheel load upon steel rail" was not primarily in the belief that the Committee would find it possible to determine such loads, but was rather intended to crystallize the discussions and research concerning the problem. The Rail Committee reported last year its recognition that successive wheel loads must set up cumulative strains of surface compression, balanced by interior tension, and further recognized that in the development of such strains both the intensity of the load and its number of repetitions are the important elements. Granted the presence of such strains and stresses, it is evident that under the general fatigue of traffic, failures must develop, the points of origin being irregularities of structure. The Rail Committee further reported its belief that the problem should be attacked by the endeavor to secure data on the relation between various intensities and repetitions of wheel loads upon rail, to the tensile stresses set up in the zone of interior failure origin.

Earnest efforts has been devoted toward determining upon and financing such a program of investigation without success. The most favorable method involves the use of standard rail loaded through a standard car wheel on a test track, but the setting up of the apparatus and the number of observations necessary predicates an expense of between $25,000 and $50,000. Such a sum is not available. We have further not been able to prepare a satisfactory program for the determination of the general principles of mechanics involved through cold rolling steel strips. The Rail Committee, therefore, desires to submit as its report an analysis of the various steps so far taken toward the solution of the problem, and a statement of the principles it believes are sufficient toward its intelligent consideration.

In the year 1885 the American Society of Civil Engineers adopted the following resolution:

> "Whereas, The relation which the form of the head of a rail should bear to the section of a car-wheel tread and flange has recently been in dispute, it being asserted on the one hand that they should have as long a line of contact as possible, and, on the other hand, that such long contact would be dangerous and injurious.
>
> "Resolved, That a Committee be appointed to report, to what extent and at what points it is expedient that their sections should be such as to bring them normally in contact, and to what extent and at what points it is not expedient that they should be so in contact."

It will be observed that in this investigation the question of the intensity of pressure, which is a function not only of the load, but also of the area of contact with the rail, was brought to the fore. In their report they considered primarily resistance to abrasion, but reached the conclusion that direct pressure and distintegration of the fibers from the effect of the insistent weight was not an important cause of wear.

In 1889, D. J. Whittemore, Chief Engineer, Chicago, Milwaukee & St. Paul Railway, in a report to American Society of Civil Engineers, emphasized the fact that the trouble with rails was not wear, but *destruction* from loads. Even forty years ago the growing load caused concern, as he states that "present practice imposes from two to three times the weight on railway wheels that was customary a few years ago." In the discussion of Mr. Whittemore's paper, Mr. Thomas Rodd clearly states the necessities of the situation as follows:

> "The loads have been increased. . . we know very well that an increase in freight car capacity must be followed by an increase in the hauling power and consequent weight of the engines. I take

> it that we have to provide for actual loadings—not for the present loads only, but for greater loads than the present; and I feel sure that any effort to reduce the loads would be futile. Engineers could not, even should they wish to do so, stand in the way of progress in railway transportation."

In closing the discussion, Mr. Whittemore expressed the view that rails were failing from excessive loads, and exhibited an application of the Grashof formula for determining constants for rollers on plane surfaces to show:

> "that driving wheels of locomotives, as then loaded, must have a diameter of about 17 feet to keep the contact between them and the rail within the elastic limit. Calculations made since convince me that this was an underestimate.
>
> "The fact is that there is hardly a wheel turning under our freight cars when loaded to their scheduled capacity, or a driver under our locomotives, that does not strain the metal in the rail beyond its modulus of resistance. From the tests given we can safely assume that for the majority of our fails this modulus can be taken at 45,000 lb. In many instances it falls below 40,000. With a modulus of 45,000 lb. the car wheel can sustain about 6,000 lb. within the elastic limit, and this approximates to the weight on passenger equipment; hence the high service shown for the steel tired wheel."

Mr. Whittemore further advocated cylindrical wheels with flat topped rails, and thereupon the weight of discussion became turned to the intensity of stress upon the top of the rail head.

In the early nineties, J. B. Johnson, by an admirable original research, found that Mr. Whittemore's tables of allowable wheel loads for given radii and unit stresses were based upon an erroneous use of the Grashof formula. He performed experiments to obtain actual areas of contact by pressing polished wheel sections upon the polished cylindrical top surface of steel rail which was coated with wet chalk.

From these measurements it was believed:

1. That the area of contact increases directly with the load.
2. That the mean intensity of pressure is a constant for all loads.
3. That in these experiments this mean intensity of compressive stress, for all loads, was about 82,000 lb. per sq. in.
4. Since the maximum deformation (at the centers of these areas) is twice the average deformation (assuming the volumetric deformation to be that of a segment of a paraboloid of revolution), then the maximum compressive-stress intensity for all loads is about 164,000 lb. per sq. in.
5. Since no measurable permanent set was produced by any of these loads on either wheels or rail, it follows that the apparent elastic limits of the materials had not been reached for this condition of contact, although the ordinary elastic limit of the rail material, for a free flow, was about 50,000 lb. per sq. in.

He further emphasized that for stresses of compression:

> "The maximum stress in and also the elastic limit of steel rails under wheel loads is dependent on the radii of the wheel and the rail, and that the maximum stress is practically independent of

> the total load on the wheel. Also that the elastic limit is in the vicinity of 200,000 lb. per sq. in. for the ordinary locomotive drivers on the ordinary steel rails."

In 1914, a very interesting discussion of the general principles involved in the action of the wheel upon the rail was presented to the Institution of Civil Engineers of London by Messrs. Willcox and Sellon, with especial pertinence to the corrugation of rails in the British tramway systems. Either a softer wheel or a harder rail was considered necessary if stresses beyond the elastic limit were to be prevented in the rail. The full discussion may be found in Volume 197 of their Proceedings, page 79 to 183.

At about this same time James E. Howard, Engineer-Physicist of the Bureau of Safety of the Interstate Commerce Commission, developed a method of reading internal strains in the rail head by prick-punching progressively exposed surfaces in various planes, and measuring the expansion or contraction of the distance between the marks after taking off thin slices and allowing them to season. He clearly demonstrated the values of compression strains in balance with tension beneath.

The Rail Committee was assigned in 1917 the topic "Report on the rational relation between the intensity of pressure due to wheel loads and resistance of rail steel to pressure and deformation." It was at once recognized that the resistance of a steel rail to crushing in track under rolling wheel loads has little to do with the resistance of the rail head to crushing under loads applied in a compression testing machine, and that it was necessary to provide some means of measuring deformations produced by an approximation of service conditions through which the rolling load was applied by a car wheel rolling upon a rail. Through the courtesy of the Bethlehem Steel Company, the co-operation of their Sparrows Point plant was enlisted, and a testing machine was supplied which rolled a chilled iron car wheel by reciprocation over a steel rail with varying loads and numbers of repetitions. The program of test was as follows:

> "1. By an exploration of the interior of the head of the rail through holes, diagonal upward from the bottom towards the center of the head, and also at increasing depths from the top through the side of the head parallel with the base, after subjecting it to definite repetitions of rolling loads.
> 2. To define, so far as possible, the area of contact between the rail and the wheel at different periods throughout the test, both in the laboratory and in the track.
> 3. To determine the hardening effect of the rolling load on the contact and adjacent surfaces.
> 4. To determine the distribution of the intensity of pressure within the area of contact.
>
> "The distortion of the holes drilled in the head was measured by tapered, turned and ground steel plugs.
>
> "In the field, the areas and rolling contacts under drivers and wheels on the rails were taken on copper sheets of about 0.0015 inch in thickness."

While this investigation was perhaps the best financed and most exhaustive work ever performed in the study of this subject, it is recognized that the boring of holes in the section for the purpose of measuring deformation by the insertion of plug gages may have so altered the rate and flow of deformation as to render the results subject to challenge. In its report the Committee stated that:

> "for the present, the only conclusions that can be drawn from the tests which have been made are but indications.
>
> ### FIELD TESTS
>
> "1. That for this section and composition of rail, initial loads of 30,000 lb. or more per wheel of cast iron and chilled tread, of 33 inches in diameter, were too great for its transverse holes, and produced flow or closure at least 3/8 inch below the bearing surface.
>
> "2. The loads of 25,000 lb. produced but slight flow or closure in the three uppermost transverse holes, and this extending not more than 1/4 inch in depth.
>
> "3. That preliminary light loads, by cold-rolling the surface, may adapt the material to subsequent heavier loads.
>
> ### LABORATORY TESTS
>
> "4. The diagrams of the plotted tables show that the stresses in the metals are locally less severe than we had expected to find in the surfaces of the pressure zone contacts of the wheel tread and the rail head.
>
> "5. It is important, as the theory and evidence show, that the metal of the circumjacent layer of each pressure zone of contact for the wheel tread, also that of the rail head, is in position not only to utilize the elasticity of the metal to help carry a given load but to increase an area within the elastic limits of the metals nearly in proportion to the loads applied.
>
> "6. The action of the rolling wheels on the rail heads is a gradually applied load from zero to the maximum, then reducing again to zero, both for a unit length in the wheel tread or rail head, and is not a suddenly applied load, even for a mile-a-minute or faster train.
>
> "7. The round type of area of contact shows the greater average unit tensity of pressure.
>
> "8. The longitudinal oval, or the transverse oval type, indicates the lowest average unit intensity of pressure.
>
> "9. The longitudinal elliptical or transverse elliptical, in which the major axis is two or more times the width of the minor axis, indicates also a favorable average unit of intensity of pressure.
>
> "10. The transverse oval or elliptical under steel or cast-iron wheels is more favorable for the rail heads than the round.
>
> "11. The reciprocal relations of the loads carried on the metal of the wheel treads to the metal of the rail heads should be studied from the voluminous service tests now available."

The Rail Committee believes that the pertinence of the investigations heretofore conducted to the topic as now assigned lies largely in the relation between our present rolling loads and such rail failures as may lead to accident. In our rail classifications we list "Broken Rails" as our most serious type of failure. We divide this into two sub-classes, "Transverse Fissures," and "Ordinary Breaks." Such failures, in the judgment of the Committee, are the most dangerous because there is no external evidence of debilitation up to the time of rupture. These breaks occur usually in rail which has shown exceptional resistance to abrasion and flow.

Such rails, by virtue of this resistance, store up, in a more or less permanently located interior zone of the rail head, cumulative stresses of tension, which would, if the rail either abraded or flowed, be continually dissipated through the shifting of the zone. If there be a thermal crack, or the thermally produced stresses are high enough to approximate the quantities necessary to rupture, then the wheel loads with the general fatigue of service will early start the development of a transverse fissure around the particular thermal crack subjected to the greatest stress. The general stress in the zone is thereby relieved. If, on the other hand, conditions of brittleness exist throughout the rail section through improper chemistry or metallurgy, then the "ordinary break" ensues.

It has been repeatedly stated that reduction in wheel loads would yield freedom from "Broken Rails." The Rail Committee has accumulated considerable data bearing upon this question, which will be presented as a part of its report on "Transverse Fissures" to the Bureau of Standards investigation into "The Cause of Transverse Fissures." This will be available to members of the Association in the Rail Committee's report upon this subject, and for the uses of the present report, it will suffice to say that the relation between "Broken Rails" and "Wheel Loads" can not be reconciled without the interjection of the traffic density factor. In other words, if a particular heat of steel, or a group of heats in an individual rolling, shows a high fissure failure rate in early life under relative severity of loads and density of traffic, then that same heat or groups of heats appears to exhibit the same rate of failure in its later life in more restricted service.

In conclusion and summary, the Rail Committee believes that neither the quantity of the load nor the intensity of pressure are the sole contributing causes to failure in track of any given design, metallurgy or composition of steel rail. It further believes, provided the rail is resistant to abrasion and flow, that the stresses of surface compression balanced by interior tension are cumulative and that even our lightest normal wheel loads over a period of years will produce through cold rolling cumulative strains of notable penetration into the rail head.

Further work will have to take into consideration the number of repetitions of loads of various quantities and intensities before the fundamental data can be secured. A large number of strain readings must be taken from thin slices cut in various planes from the affected areas in order that the results may be fully trustworthy. The Rail Committee is unable to finance such work.

Appendix F

(11) STUDY BY THE READING COMPANY ON STRUCTURE OF TYPICAL 100-LB. AND 130-LB. RAILS*

W. C. Cushing, Chairman, Sub-Committee; J. E. Armstrong, A. F. Blaess, F. L. C. Bond, C. F. W. Felt, Hunter McDonald, A. W. Newton, G. J. Ray, F. M. Waring, J. B. Young, J. B. Emerson.

FOREWORD

This investigation was instituted in June, 1924, in order to substantiate, if possible, the opinion that the 130-lb. RE section rails were softer than the rails of lighter section, the 100-lb., for instance. If this could be proven, the reasons for the poor conditions reported of the 130-lb. rail after short service as compared with the 100-lb. rail, could then be readily understood.

In order to carry the investigation to an ultimate conclusion, it was found necessary to do practically all the microscopic work at a magnification of 4500 to 5000 diameters. This magnification was necessary to facilitate measurements and mathematical calculations. As few investigators have attempted work at this magnification, a technique had to be developed. This explains in a measure the length of time needed to obtain satisfactory results.

The rails used in this investigation were chosen at random from test pieces of various heats as received at the Laboratory. These are numbered as follows:

No.	*Lb.*	*Heat Number*	*Manufacturer*
1	100	2098-B	Carnegie Steel Company
2	130	11049-A	Bethlehem Steel Co., Steelton
3	130	12294-C	Carnegie Steel Company
4	100	85286-A	Bethlehem Steel Co., Steelton
5	130	N18317-A	Cambria Steel Company
6	100	11060-A	Bethlehem Steel Co., Steelton
7	130	12362-B	Carnegie Steel Company
8	100	3188-B	Carnegie Steel Company
A	130	5741-A	Bethlehem Steel Co., Steelton

(I) BRINELL HARDNESS TESTS

The test pieces were Brinelled on the top of the head, after which sections were cut. The faces of the heads were then Brinelled. The location of these impressions is shown in Diagram No. I.

No.	*Lb.*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*Av.*	*Top*
1	100	286	255	255	269	255	255	255	255	269	261.5	248
2	130	262	241	235	228	241	235	255	241	255	239.6	207
3	130	228	269	255	262	241	255	262	269	255	255.1	235
4	100	286	269	269	277	277	269	269	293	286	277.2	248
5	130	277	255	228	228	228	277	255	277	255	253.3	207
6	100	255	241	262	248	248	228	269	269	248	252.0	241
7	130	241	241	269	262	255	262	262	262	255	256.5	241
8	100	293	277	255	255	228	248	269	269	286	264.9	235
A	130	321	293	293	286	286	286	302	293	311	296.7	269

The average of the 100-lb. rails Nos. 1, 4, 6 and 8 is **263.9.**

The average of the 130-lb. rails Nos. 2, 3, 5 and 7 is **251.1.**

---

* By Omar V. Greene, Metallurgist.

While the 100-lb. rails are somewhat harder than the 130-lb. rails, there is a vast difference between the grain size of the 100 and the 130-lb. rails. The hardness in reality is nothing but a function of the grain size. Micrographs showing the measurements for grain size will follow.

It may be noted on the previous page that rail No. A, though a 130-lb. rail, is much harder than any of the rails tested. The rail is an erratic and is included only as a comparison to the regular run of rails. The hardness is, of course, due to its extremely fine grain size shown in Fig. 23 and 24. Incidentally the grain size shown here is as nearly ideal as is possible to obtain. The extraordinary hardness is due to a comparatively rapid cooling, evidently caused by an accidental event after its finishing and during the final cooling. Because of its unique history it is not included in the general averages of the Brinells given above.

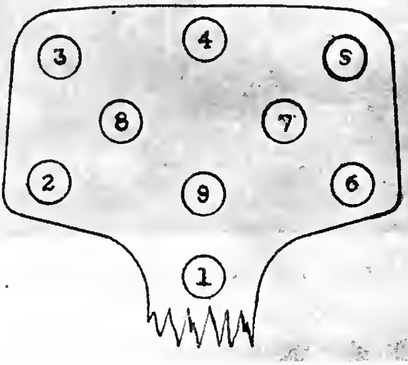


Diagram I.—Showing Location of Brinell Impressions

(II) DECARBURIZATION

Since one of the manifestations of the comparative softness of the 130-lb. rails was the flowing of the metal in the head, it was thought that the 130-lb. rails might show a greater decarburization at the surface than did the 100-lb. rails. The first microscopic survey deals with these measurements:

The nature of this decarburized surface is shown in Fig. 1. This condition is inherent in a ferrous material when heated and worked in an oxidizing atmosphere. It is, of course, abnormal when the heating has been excessive, i.e., particularly if the finishing temperature has been high.

FIG. I.—SHOWING TYPICAL DECARBURIZATION AT SURFACE X100
RAIL NO. 7

Specimens when measured gave the following results:

No.	*Lb.*	*Av. Depth of Decarburization, Inches*
1	100	.0075″
4	100	.0225″
6	100	.0225″
8	100	.0075″
2	130	.01375″
3	130	.0175″
5	130	.0250″
7	130	.0100″
A	130	.0125″

It is evident from the above that there is no abnormal decarburization in the 130-lb. rails. Actually the average decarburization of all the 130-lb. rails is only .006 inch greater than that of the 100-lb. rails. Another group of specimens might reverse this small difference and the 100-lb. rails show a slightly greater decarburization than the 130-lb.

(III) GRAIN SIZE

All the rails tested, having nearly a eutectoid composition, are pearlitic. The crystalline habit of pearlite may be briefly described as follows: Eutectoid pearlite which separates at 723°C. is composed of two substances, whose solubility curves intersect at that temperature and at an ultimate composition of .85 per cent carbon. These two substances are cementite (Fe_3C) and ferrite. The intimate mixture or aggregate of these two components is formed in this manner: We shall assume when crystallization starts a particle of cementite is thrown out of solution first; the supersaturation with reference to the remaining mass will increase with respect to the ferrite. Therefore, a corresponding amount of ferrite must be thrown out, and so on. Oscillating between the two, the whole grain will undergo the transformation and finally show alternate layers of cementite and ferrite. These layers lodge themselves, as is usually the case with secondary deposits, parallel to the crystallographic planes of the crystalline mass of the grain. As the alpha iron or ferrite crystallizes in cubes, we may assume that these layers will arrange themselves parallel to the faces of the cubes. The first lamella selects one of the faces and the others follow suit. If we imagine two dissimilar packs of cards in a square sided box, it will illustrate the packing of the lamellæ of cementite and ferrite in a pearlite grain. While this is actually the first order pearlite grain, some of which can be seen in Fig. 1 outlined by the white borders of ferrite produced by the decarburization, it is of little interest for our present purpose. Our attention, however, is centered on the spacing or packing of the second order crystallization. As the variations in the density of the lamellæ of cementite and

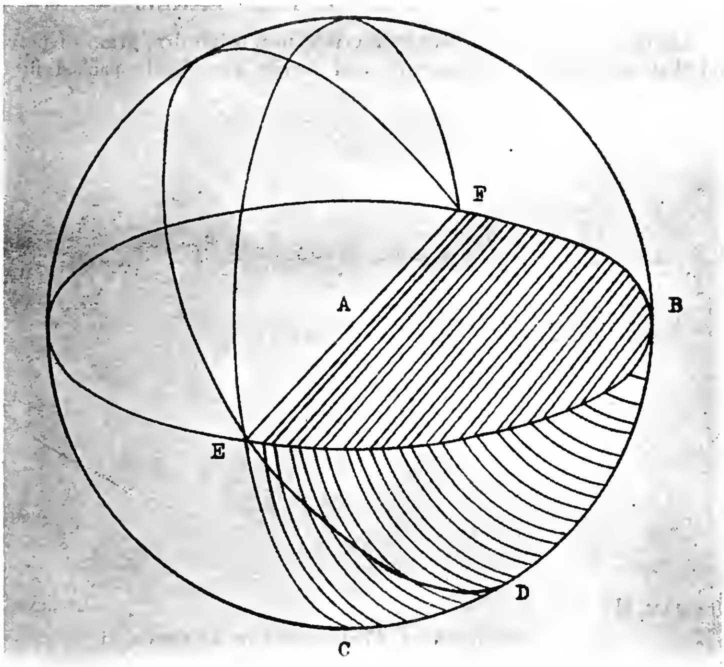


Diagram II.—Showing the Assumed Relations of the Lamellæ and Inscribed Sphere of Idealized Pearlitic Grain ferrite will determine whether the material will be relatively soft or hard, and not primarily the size of the containing grain, the former will be what is referred to when grain size is mentioned.

It is important to note that the whole mass of the pearlite of an alloy is contained in these first order grains and that the orientation of the lamellæ are different in each grain. Therefore, what is seen on a micrograph is a picture of one of the sections only. As what is of real importance is the arrangement of the lamellæ in space, the stereometric relations of the various grains on the basis of their traces on various sections must be developed.

(IV) THE STEREOMETRY OF THE PEARLITE GRAIN

Let us assume that a sphere is inscribed in a polyhedral grain of pearlite, and that the lamellæ of cementite and ferrite are closely packed in that sphere parallel with one another and with the first meridian. This can be readily understood by referring to Diagram II. Lamellæ are drawn in only one-fourth of the sphere but sufficient to show that the equatorial plane is perpendicular to the lamellæ and that the edges of the lamellæ show a series of equidistant parallel lines.

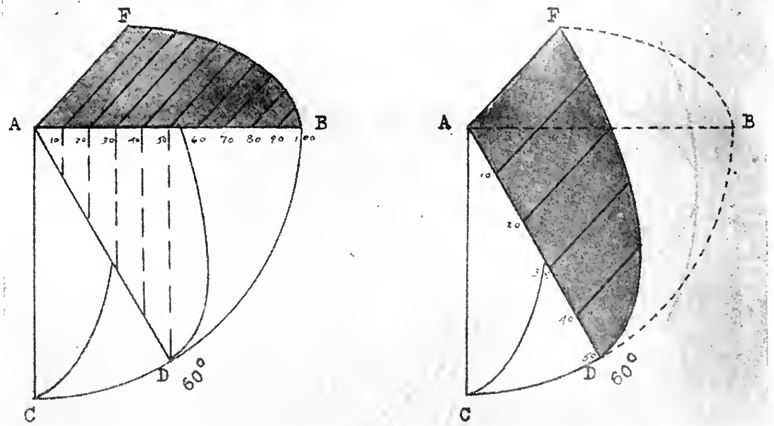


Diagram III Diagram IV

Quadrant Sections, Corollaries of Diagram II

In order to further develop Diagram II, Diagrams III and IV must be considered. If we assume the lamellæ in the sphere to be 200, then the quadrant section as Diagram III will show 100 lines, plane ABF. However, if a section is cut at an angle of 60° to this normal plane, Diagram IV, plane ADF, only 50 lines will appear and, of course, the apparent spacing between the lamellæ, as can be seen, will be considerably increased. This explains the reason why a section cut, polished and etched for microscopic examination, shows some grains with extremely fine lamination and others very loosely packed, giving comparatively coarse laminations. This is amplified in Diagram V.

It is evident in Diagram V as in Diagrams II and III that on a section normal to the lamellæ, they will be seen as closely packed parallel lines.

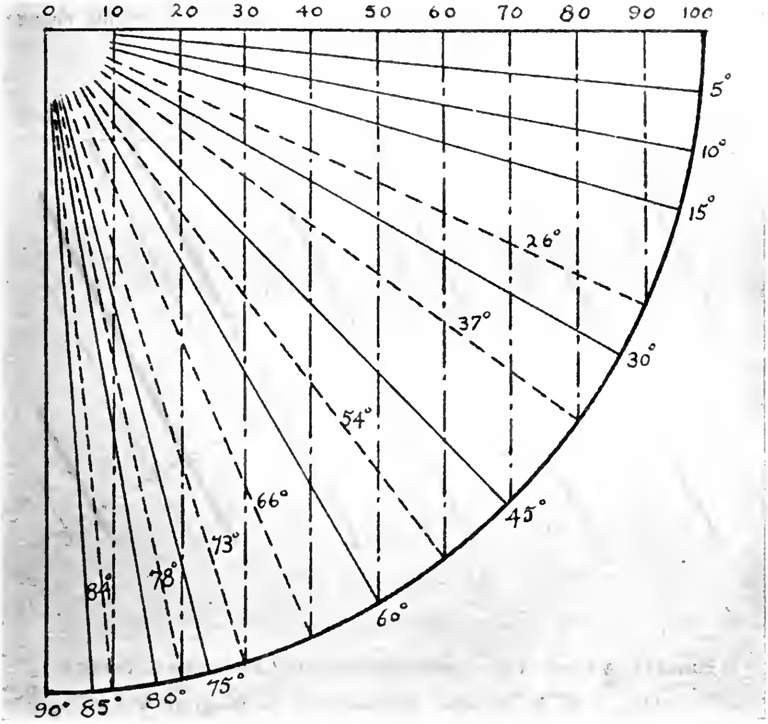


Diagram V.—Quadrant Section of Ideal Pearlite Grain

(From N. T. Belaiew, Journal of Iron and Steel Institute, 1922, No. I, Vol. C. V., pp. 201-27, London, England)

If, however, the section runs parallel to the lamellæ, Diagram V, only one lamella will be seen. Between these extreme cases are many intermediate.

If we consider a section inclined to the equatorial or normal plane at an angle ϕ equal to 26°, Diagram V shows 90 instead of 100 lamellæ. The apparent thickness and distance between the lamellæ will slightly increase (by 10 per cent). Consecutive sections at 37°, 45°, and 54° will show respectively 80 per cent, 70 per cent, and 60 per cent of the lamellæ. A section at an angle of 60° will show only 50 per cent of the lamellæ as before mentioned, and the distance increasing between them in the ratio of 2 to 1. (Diagrams III and IV.) However, with these angles of inclination the character of the laminations will remain much the same, and the pearlite will be seen only less closely packed. This may be seen in Fig. 2 to 6 incl., 11, 12, 14, 17, and 23. The same is true of the section at 66°, where only 40 per cent of the lamellæ are present, Diagram V. The next sections at 73° and 78° begin to change in appearance. For example, if Fig. 7 is compared to the preceding ones (2 to 6) or Fig. 21 and 24, a definite change will be seen to be taking place. Finally a section inclined at an angle of 84° will show only 10 per cent of the lamellæ and at 87° only 5 per cent. At these angles the lamellæ assume very peculiar structures. By comparing Fig. 8, 9 and 10 with the preceding ones, the difference at these angles is evident. Fig. 13, 16, 19 and 22 show the same characteristics. To make the point more clear consider Fig. 20 where the angle of inclination ϕ is zero for this particular specimen and Fig. 13 where ϕ is 80°. Different views of the same specimen show this even to better advantage. The dark grain in Fig. 2 in which ϕ equals zero there appear 54 lamellæ in 80 mm. In Fig. 9, which is a different view of the same specimen, the angle is 85°45′, and from the above we should expect to find a little less than 10

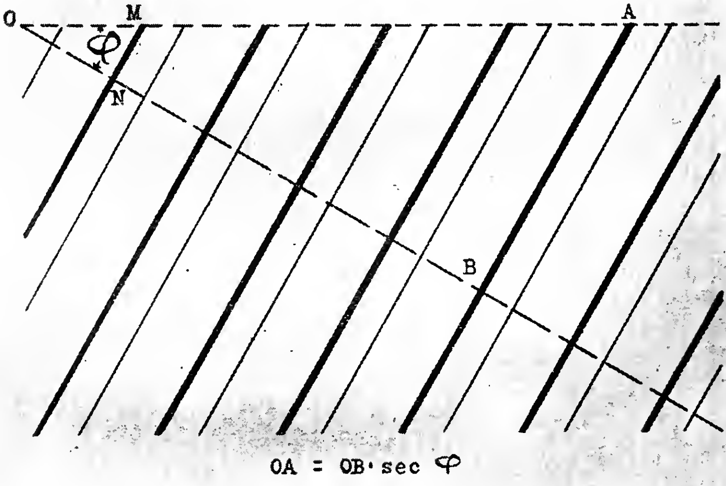


Diagram VI.—A Transverse Section of Cementite Lamellæ

(From N. T. Belaiew. Reference as in Diagram V.)

per cent of the lamellæ present in the same distance (7.3 per cent). This will give nearly 4 lamellæ in 80 mm., which is what is found on the section in Fig. 9. These two figures show how simple stereometric relations may alter the familiar aspect of the pearlite lamellæ. They also show how the angle of inclination ϕ may be computed from the number N of the cementite lamellæ in the grain.

(V) DETERMINATIONS OF THE VALUES OF THE ANGLE ϕ

As before mentioned, ϕ is the angle of inclination of the secant plane, i.e., the angle between that plane and the equatorial section. The position of a plane in space is determined by two angles, the angle of inclination of the plane to the axial plane (plane EBFA, Diagram II) and the angle of deviation, i.e., the angle between the axis EA or AF and the trace of the secant plane on the axial plane EBFA, Diagram II. Here as the axial plane coincides with the equatorial plane, the angle of inclination is ϕ, and the angle of deviation $\theta = O$, for it is a symmetric section as the trace of the secant plane coincides with the axis EAF. Thus the position of the plane in space will be determined by values of the angle ϕ.

If the distance between two adjacent cementite lamellæ is denoted by Δ, then the apparent distance between them on a section inclined at an angle ϕ will be $\Delta\phi$, and as the angle of inclination of the normal plane is zero, we may denote the actual distance between two lamellæ as Δ_o. Let a series of parallel lamellæ be cut by a secant plane at an angle ϕ, Diagram VI.

For the triangle AOB we have the following relations:

$$OA = OB \sec \phi$$

$$\text{Sec } \phi = \frac{OA}{OB}$$

$$\text{Cos } \phi = \frac{OB}{OA}$$

But $OB = 5ON$ and $OA = 5OM$, where $ON = \Delta_o$ and $OM = \Delta\phi$.

Therefore $\text{Cos } \phi = \dfrac{\Delta_o}{\Delta\phi}$

The values for the angle ϕ of the following micrographs were all calculated by this last formula. The Δ's are easily measured on micrographs of suitable magnification. In the determination of the Δ_o it is necessary to find a grain such that the angle of inclination ϕ is zero, i.e., a section that is as nearly normal as possible to the lamellæ. Δ_o and $\Delta\phi$ are measured in miscrons, which is 1/1000 mm., (μ). As the values of μ for Δ_o fall considerably below .5μ, magnifications of from 4500 to 5000 were necessary for accurate measurements. In calculating the values for $\Delta\phi$ such portions of the grain where a certain number of lamellæ are seen to be running parallel to one another are used.

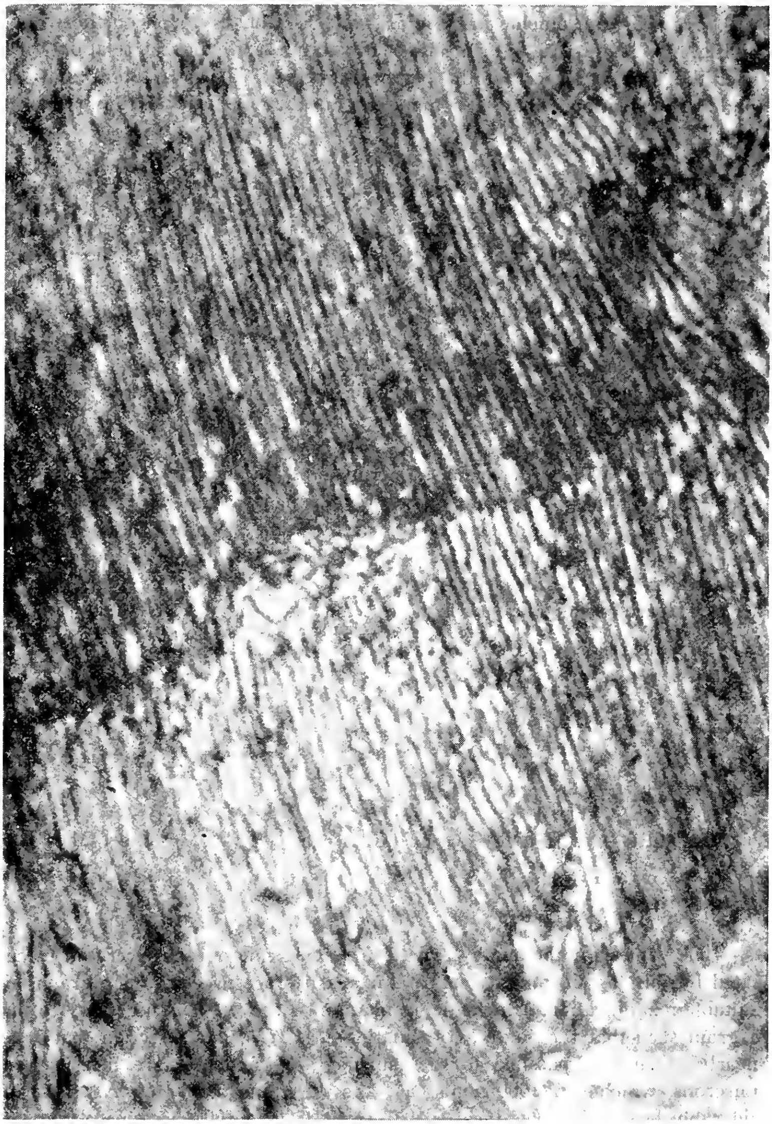


Fig. 2.—Rail No. 1×4500. ϕ for the Upper Grain is 0°. For the Lower Grain $\phi = 24°$.

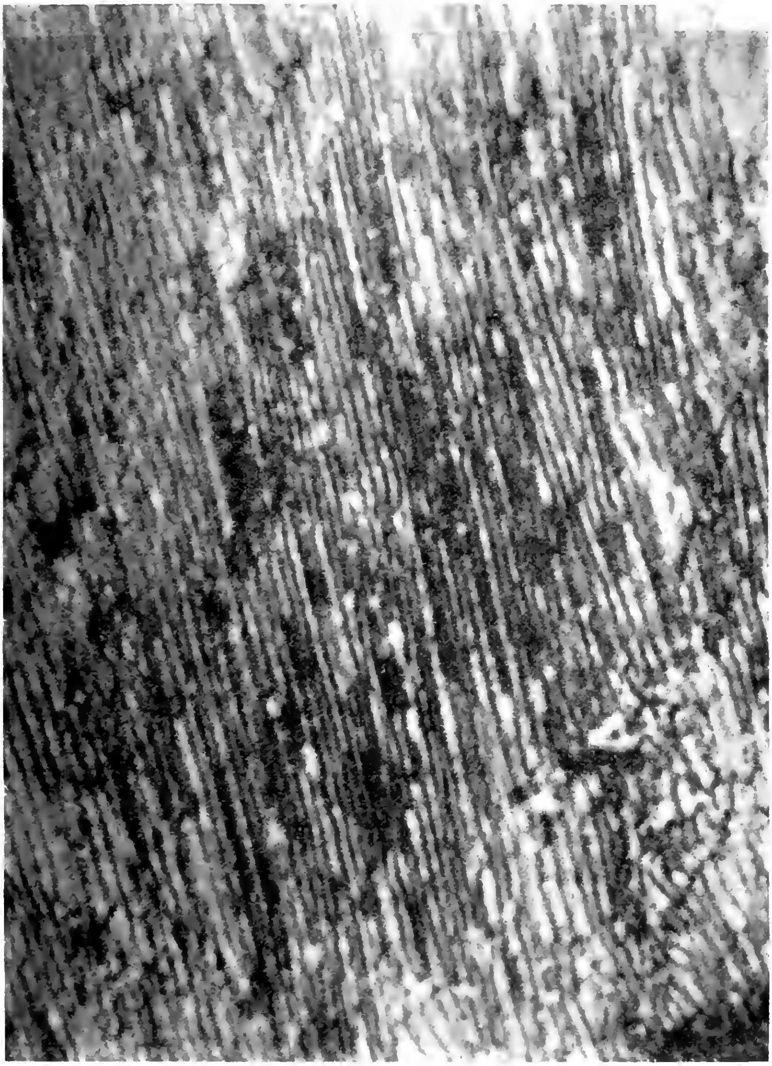


FIG. 3.—RAIL NO. 1×4500. $\phi = 41°$.

FIG. 4—RAIL NO. 1 × 4500. $\phi = 43°$.

FIG. 5.—RAIL NO. 1 × 4500. $\phi = 47°$.

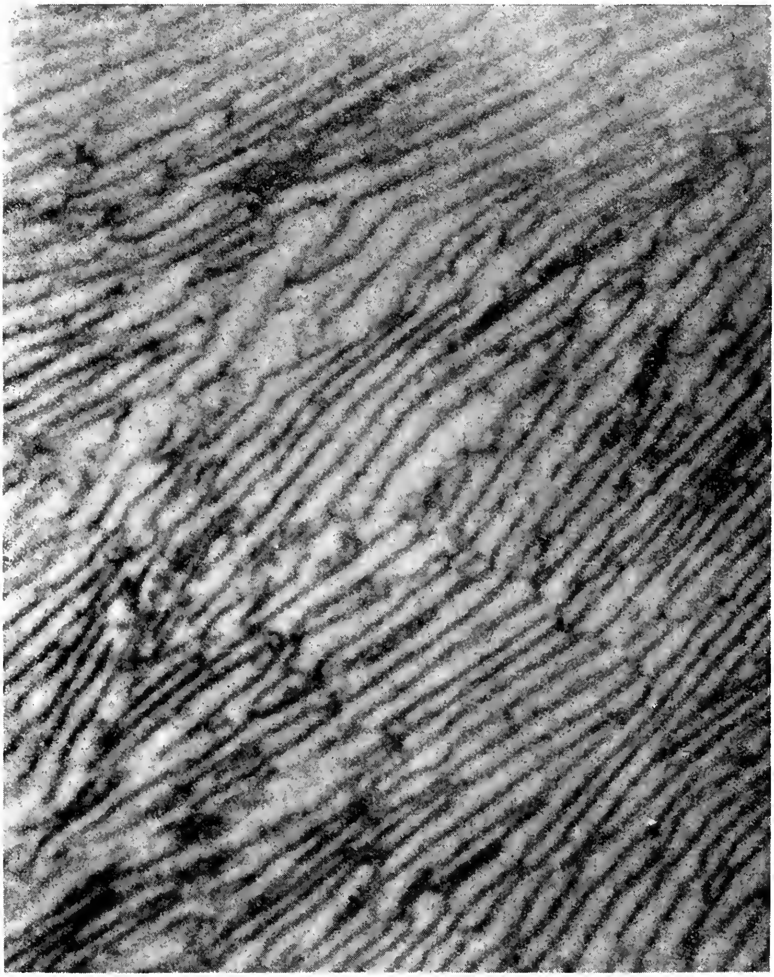


Fig. 6.—Rail No. 1 × 4500. $\phi \doteq 65°$.

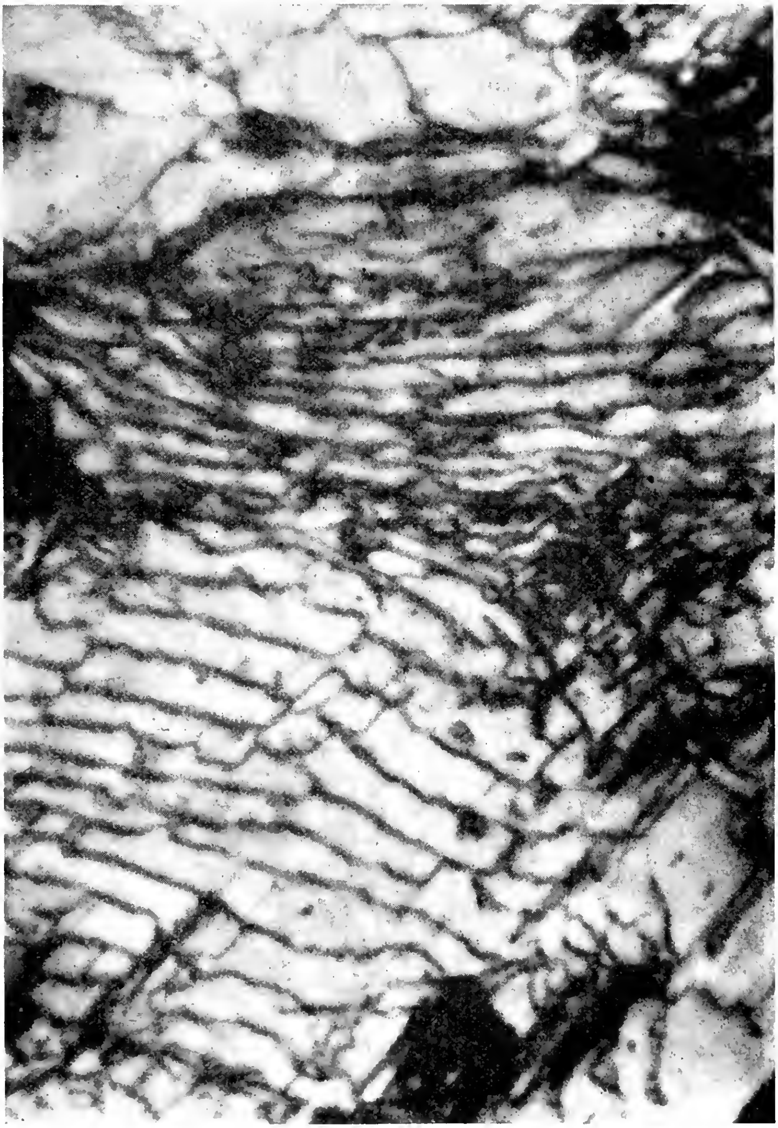


Fig. 7.—Rail No. 1 × 4500. $\phi = 79°$.

FIG. 8—RAIL NO. 1 × 4500. IN UPPER RIGHT-HAND GRAIN. $\phi = 82°$.

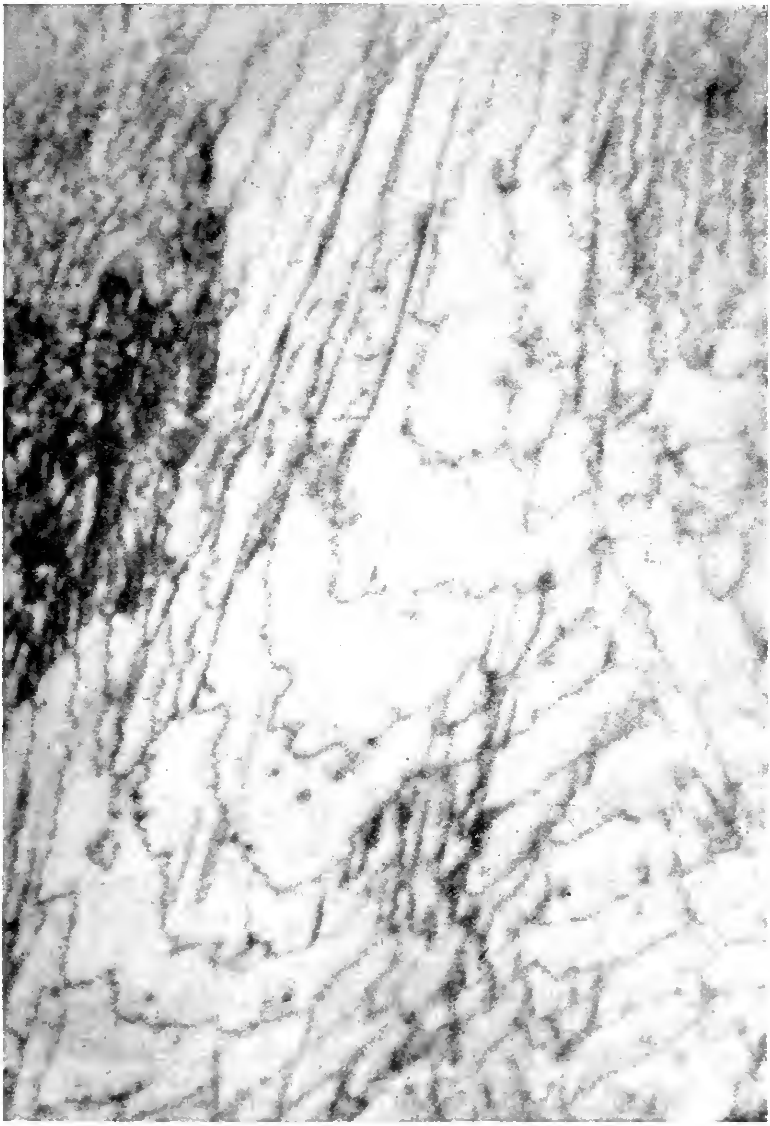


FIG. 9.—RAIL No. 1 × 4500. $\phi = 85° 45'$.

A

FIG. 10.—RAIL NO. 1 × 2200. ϕ AT MIDDLE IS ABOUT 84°.

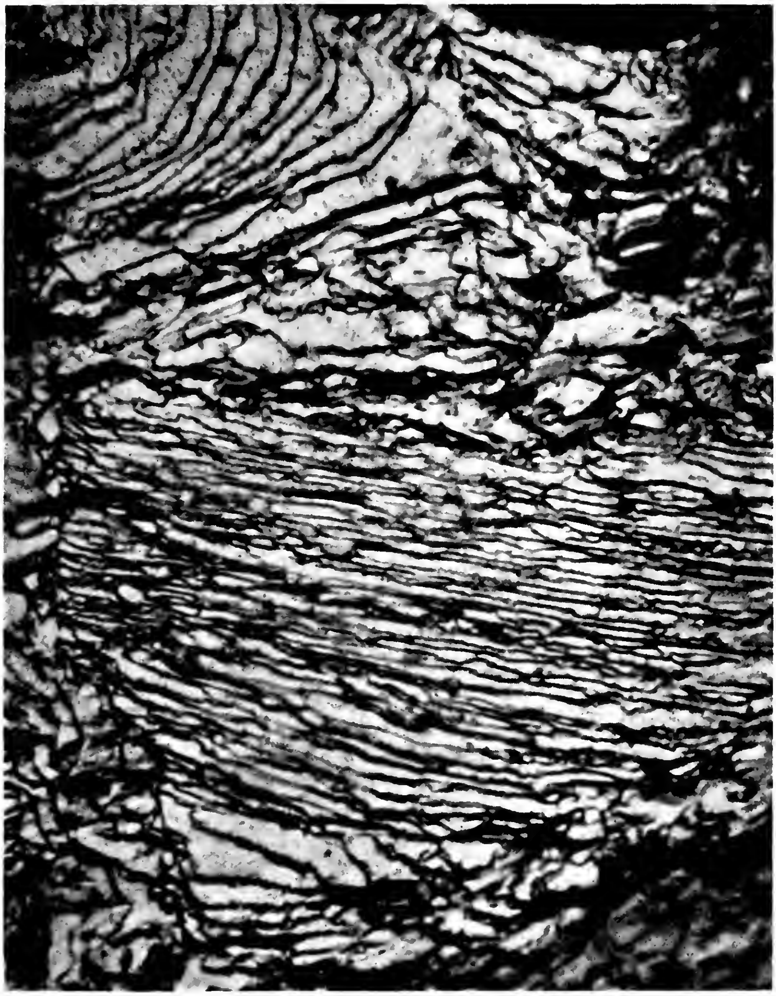


FIG. 11.—RAIL No. 2 × 2500. $\phi = 55°$.

Fig. 12.—Rail No. 2 × 5000. $\phi = 61°$.

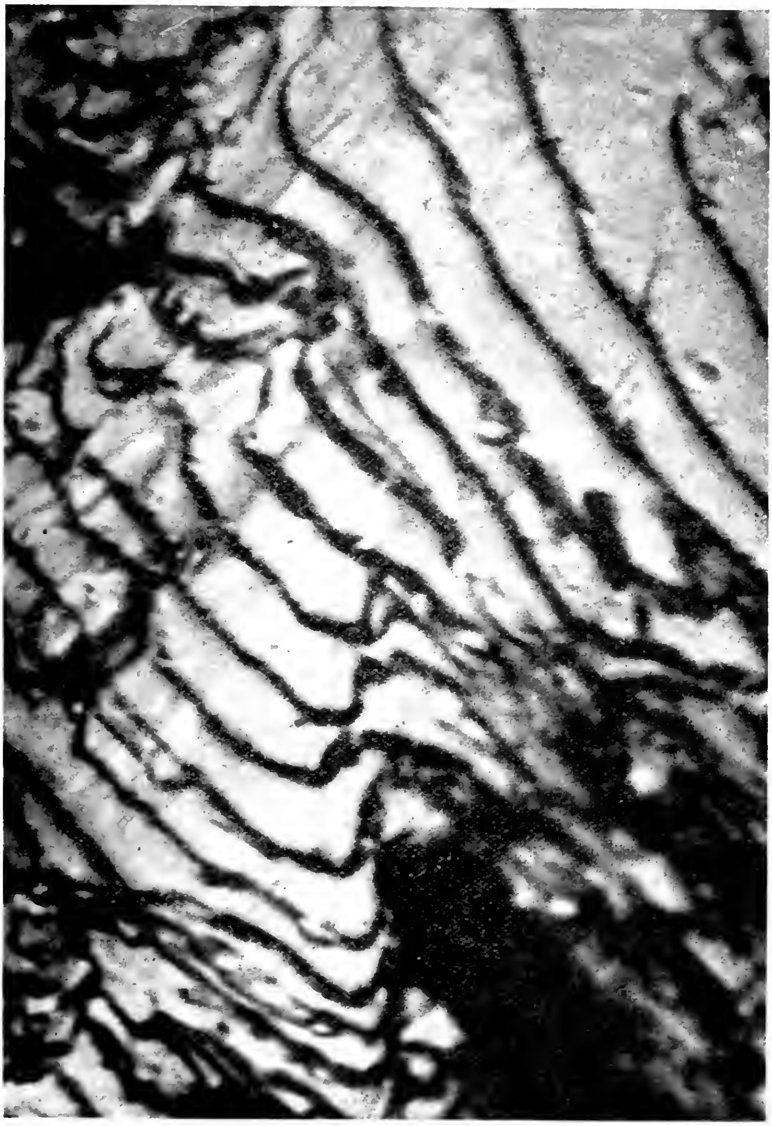


FIG. 13.—RAIL NO. 2 × 5000. $\phi = 80°$.

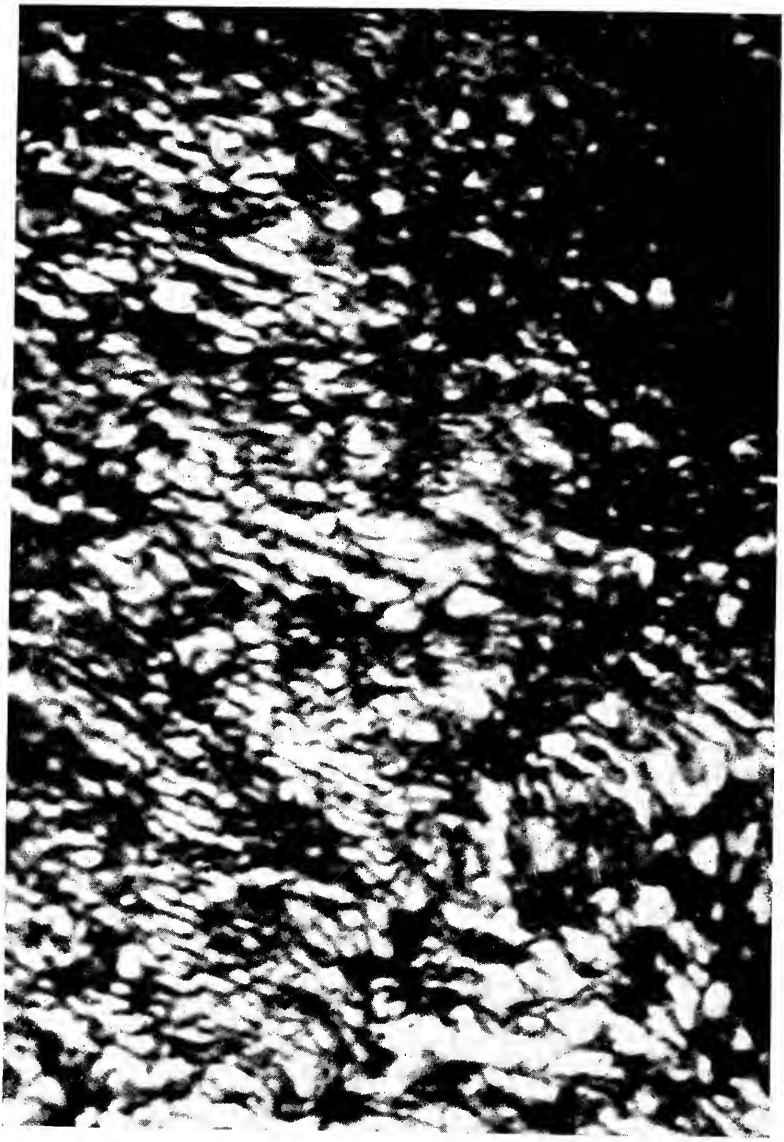


FIG. 14.—RAIL NO. 3 × 5000. $\phi = 42°$.

Fig. 15.—Rail No. 3 × 5000. ϕ For Fine Grain $= 29°$.
For Coarse Grain $\phi = 68°$.

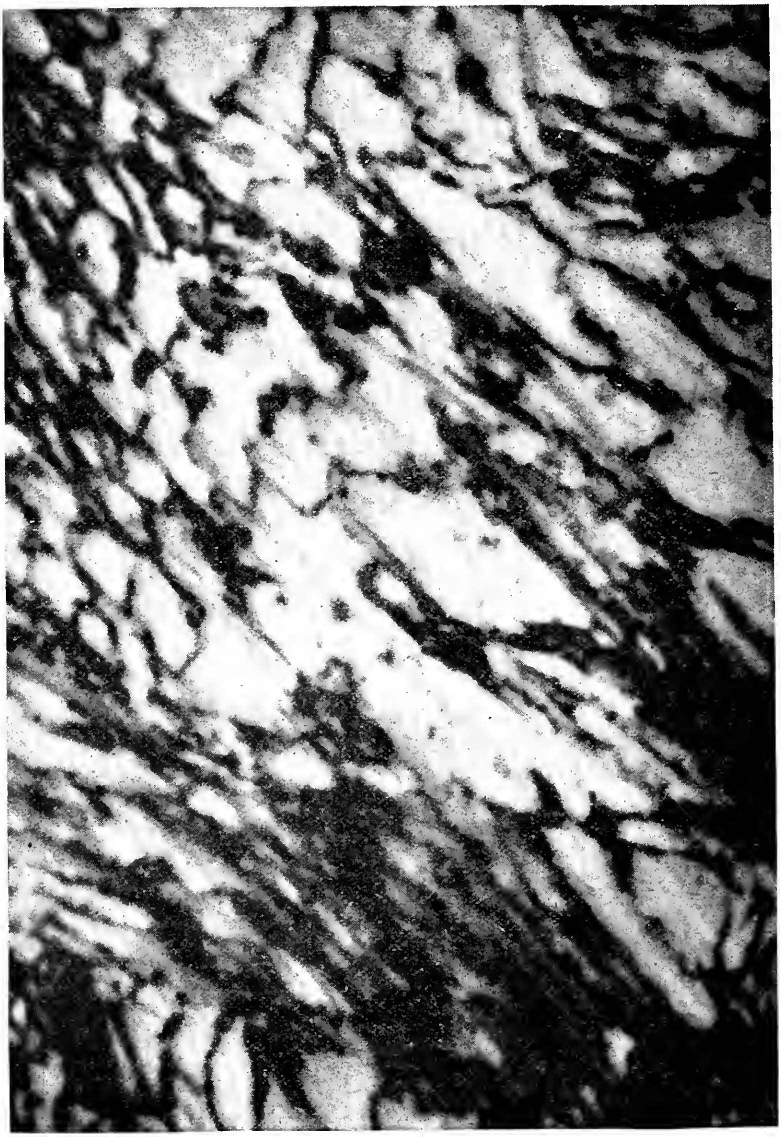


FIG. 16.—RAIL No. 3 × 5000. $\phi = 86°$.

FIG. 17.—RAIL NO. 4 × 5000. $\phi = 60°$.

Fig. 18.—Rail, No. 4 × 5000. ϕ For Dark Series of Lamellae = 69°.

FIG. 19.—RAIL NO. 5 × 5000. $\phi = 83°$.

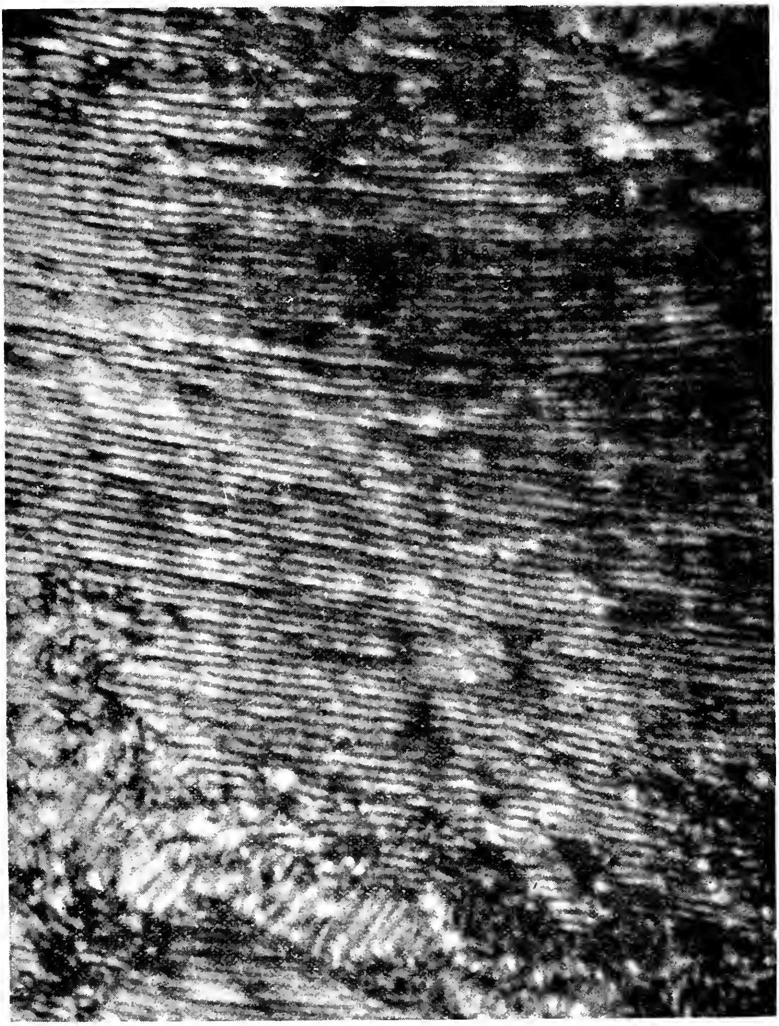


FIG. 20.—RAIL No. 6 × 5000. $\phi = 0°$.

FIG. 21.—RAIL NO. 7 × 5000. $\phi = 74°$.

FIG. 22.—RAIL NO. 8 × 5000. $\phi = 80°$.

Fig. 23.—Rail No. A × 5000. $\phi = 48°$.

Fig. 24.—Rail No. A × 5000. $\phi = 75°$.

(VI) THE MICROSCOPIC WORK

The foregoing micrographs are only a few of those taken for the purpose of measurement, but are sufficient to show the characteristic structure of the rails tested.

The results of the measurements are as follows:

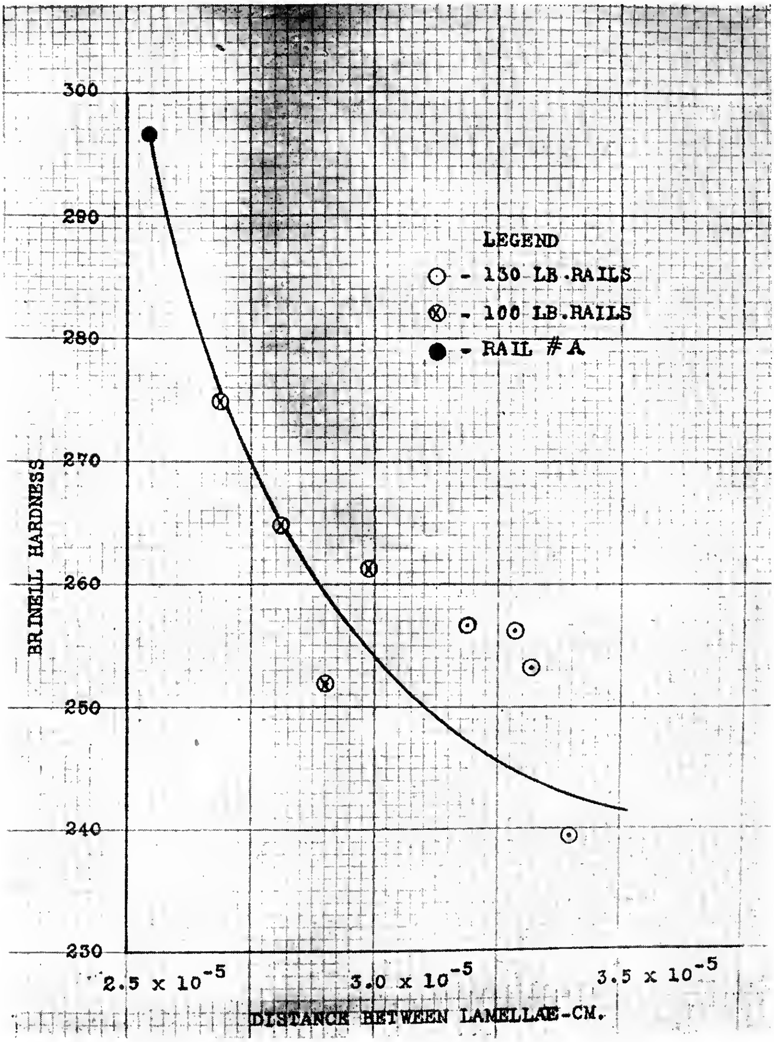
No.	*Lb.*	μ	Δ_0 *cm.*	*Actual Lamellæ per in.*
1	100	.298	.0000298	85,000
2	130	.339	.0000339	75,000
3	130	.318	.0000318	80,000
4	100	.268	.0000268	95,000
5	130	.332	.0000332	76,500
6	100	.290	.0000290	87,500
7	130	.328	.0000328	77,500
8	100	.282	.0000282	90,000
A	130	.254	.0000254	100,000

The rails were examined unetched, both longitudinally and cross-section, for segregation, i.e., non-metallic inclusions. As none of the rails exhibited anything abnormal, no micrographs were taken.

From Diagram VII it is evident that as the Brinell Hardness increases the distance between the lamellæ decreases. It may also be noted that 100-lb. rails all have a smaller grain size than the 130-lb. rails with the exception of rail A which, as before mentioned, is an erratic. In the following table the Brinell hardness is compared to the values of μ and the analyses of the various rails.

No.	*Lb.*	*Average Brinell*	*Distance between Lamellæ* μ	*C*	*P*	*Mn*	*S*	*Si*
4	100	275.0	.268	.790	.025	.780	.044	.230
8	100	264.9	.282	.803	.034	.788	.043	.153
1	100	261.5	.298	.750	.036	.741	.032	.117
6	100	252.0	.290	.710	.034	.831	.063	.212
3	130	256.8	.318	.830	.037	.670	.035	.160
7	130	256.5	.328	.810	.020	.733	.025	.198
5	130	253.3	.332	.730	.018	.764	.050	.150
2	130	239.6	.339	.690	.020	.793	.078	.225
A	130	296.7	.254	.810	.026	.783	.040	.289

The above is arranged in order of hardness and it is evident, as before mentioned, that with slight discrepancies, as the hardness decreases, μ, the distance between the lamellæ increases, and the pearlite becomes coarse. Thus the 130-lb. rails are softer and have a coarser pearlite than the 100-lb. rails. If the carbon content be compared to the hardness and μ, a rather obvious fact may be noted. For instance, rail A compared to rail 7 shows that both have exactly the same carbon content but have wide differences in hardness and grain size. Also, if rails 4 or 8 be compared to rail 7, or rail 1 compared to rail 5, the carbons are seen to be nearly the same, but the 130-lb. rails referred to are softer and have a much coarser pearlite. From this it is evident that the coarseness of the pearlite with its attend-



Diargram VII—Curve Showing Relation Between Brinell Hardness and Grain Size.

ing softness, is dependent not on the carbon content but on the velocity of the cooling through the transformation range (A_{r1}).

(VII) RECAPITULATION

1. The 130-lb. rails as a class are softer than the 100 lb. rails.

2. The average decarburization at the surface is practically the same for both the 130 and 100-lb. rails. Showing that the excessive metal flow of the 130-lb. rails is not due to abnormal decarburization. This, however, does not show that the finishing temperatures of the 130-lb. rails was probably no greater than that of the 100-lb. rails in the same mill.

3. The 130-lb. rails have a coarser pearlite than the 100-lb. rails.

4. The carbon content has no influence on the coarseness of the pearlite. It follows that the carbon has no influence on the hardness, particularly in the case of rail steels whose average compositions are approximately eutectoid. Thus they are entirely pearlitic with no excess of ferrite that occurs below, or cementite that occurs above the eutectoid point, that would tend to soften or harden the steels, respectively.

(VIII) CONCLUSIONS

From the foregoing evidence the 130-lb. rails are seen to be softer than the 100-lb. rails. However, there is another point that deserves to be mentioned.

In service the comparative softness of the 130-lb. rails is accentuated by the fact that these rails present a stiffer, stronger girder than the 100-lb. rails and do not assume the same deflection under passing loads as do the 100-lb. rails. Consequently, we should expect the cold work of the passing loads to produce an excessive metal flow, which is the case.

The coarse pearlitic structure, which is the cause of the comparative softness of the 130-lb. rails, may be explained by the following significant fact. The 130-lb. rails have a considerably greater mass than the 100-lb. rails. Thus, after finishing, the retarding effect on the cooling produced by this greater mass will allow the pearlite to become quite coarse with characteristic softness. To be sure the 130-lb. rails have received slightly less work than the 100-lb. rails, but this effect on the condition of the pearlite is not as important as the influence of the mass.

Before discussing suggestions for the improvement of the condition of the 130-lb. rails, the idea that increasing the carbon content will alleviate the trouble, will be shown to be erroneous. As has been mentioned, most of the rail steels lie in the eutectoid range having a matrix entirely of pearlite, and that with appreciably higher carbon above this range, a second constituent cementite will appear in the matrix, which will make the steel harder. Though a considerable amount of cementite may be present, the matrix will still be pearlite whose coarseness or fineness is not effected by the carbon content but merely by the velocity of the cooling. Thus, while the presence of the cementite may tend to harden the steel, its influence may be entirely offset if the pearlite containing it is coarse. However, if we assume the pearlite in a steel containing appreciable amounts of cementite, for instance, one with carbon of 1.00 per cent, to be of the same grade as that of the 130-lb. rails investigated here, the steel will be very hard. This method of producing the desired hardness has certain obvious disadvantages when we consider the hard, brittle mineralogical characteristics cementite possesses. Thus, the extra hardness produced by cementite means a sacrifice of toughness for brittleness. As steels to be used in the exacting service of railroad rails are obviously out of this category, the increasing of the carbon content would indeed be disastrous.

Since the required hardness with necessary toughness can only be obtained by increasing the fineness of the lamellæ of the pearlite grain, the problem of making 130-lb. rails more serviceable narrows down to the following possibilities: Using the same section, the desired structure may be obtained by increasing the velocity of the cooling in the transformation range by quenching in air or water. Quenching in air is what is generally practiced in the Sorbitic process and the sorbite thus produced is nothing more or less than an extremely fine-grained pearlite. Another aid would be the lowering of the finishing temperature as is used in some mills, for a high finishing temperature promotes the growth of coarsely laminated pearlite, while finishing at a somewhat lower temperature produces a finer grained pearlite. The wider spacing of the rails on the cooling bed will also have a beneficial effect. Steel makers that these two suggestions apply to will of course frown on them, as they would tend to make their production appreciably slower.

Probably the most pertinent suggestion is that the mass of metal in the head be decreased or the shape of the section altered. The former will automatically increase the velocity of the cooling through the transformation, making a fine grain. The latter will also have the same result provided the alterations are such that the section will cool more uniformly than it does at present.

The rails rolled with a high manganese content cannot be included here, as none of them have been investigated. However, this rail would not be entirely comparable to the simple carbon steels investigated here, as the high manganese rail is in the alloy steel class and has many characteristics peculiar to it alone.

Finally, the most appropriate combinations of conditions for improving the condition of the 130-lb. rails from both an economic and metallurgical standpoint would be the reduction of the mass in the head and the lowering of the finishing temperature in mills where it is applicable.

ACKNOWLEDGMENT

The author wishes to acknowledge his indebtedness to Mr. N. T. Belaiew's paper published in the Journal of Iron and Steel Institute, 1922, No. 1, Vol. CV, pp. 201-27, for the development of the theory relating to grain size.

Appendix G

(12) STANDARD SPECIFICATION FOR THE MANUFACTURE OF OPEN-HEARTH STEEL GIRDER RAILS OF PLAIN, GROOVED AND GUARD TYPES

Earl Stimson, Chairman, Sub-Committee; E. E. Adams, J. E. Armstrong, C. B. Bronson, E. A. Hadley, C. R. Harding, J. D. Isaacs, A. W. Newton, J. R. Onderdonk, Louis Yager, J. B. Young, G. J. Ray, J. B. Emerson.

These Specifications are intended to cover the manufacture of Open-Hearth Steel Girder Rails of Plain, Grooved and Guard Types, of the classes specified.

Girder Guard Rails shall be Class A.

Plain and Grooved Girder Rails under one hundred and thirty-five (135) lb. in weight per yard shall be specified either Class A or Class B.

Plain and Grooved Girder Rails of one hundred thirty-five (135) lb. in weight per yard and heavier shall be Class C unless otherwise specified.

I. MANUFACTURE

Process

101. The steel shall be made by the open-hearth process. The entire process of manufacture and testing shall accord with the best current practice.

Bled Ingots

102. Bled ingots, and ingots or blooms which show the effect of injurious treatment, shall not be used.

Discard

103. A sufficient discard from the top of each ingot shall be made at any stage of the manufacture to obtain sound rails. When finished rails show piping, they may be cut to shorter lengths until all evidence of this is removed.

II. CHEMICAL PROPERTIES AND TESTS

Chemical Composition

201. The steel shall conform to one of the following requirements as to chemical composition, as specified in the order.

	Class A	Class B	Class C
Carbon, per cent	0.60–0.75	0.70–0.85	0.75–0.90
Manganese, per cent	0.60–0.90	0.60–0.90	0.60–0.90
Silicon, per cent	0.15–0.40	0.15–0.40	0.15–0.40
Phosphorus, per cent	Not over 0.04	Not over 0.04	Not over 0.04

Ladle Analyses

202. To determine whether the material conforms to the requirements specified in Section 201, an analysis shall be made by the manufacturer from a test ingot taken during the pouring of each melt. Drillings for analysis shall be taken not less than one-eighth (⅛) inch beneath the surface of the test ingot. A copy of this analysis shall be given to the purchaser or his representative.

Check Analyses

203. A check analysis for information only may be made as information from time to time by the purchaser from a test ingot or drillings therefrom furnished by the manufacturer.

III. PHYSICAL PROPERTIES AND TESTS

Impression Test Specimens

301. (a) Four representative sections of rail from each melt shall be selected by the inspector as test specimens.

(b) Excess scale on the head or web of the section shall be carefully removed.

Impression Test

302. (a) The head of each specimen shall be subjected to a pressure of one hundred thousand (100,000) lb. (45.359KG), for a period of fifteen (15) seconds applied through a hardened steel ball seventy-five hundredths (0.75) inch (19.05 mm.) in diameter.

Test Balls

(b) The steel test ball shall have a minimum Brinell hardness of six hundred (600) and it shall not be possible to attack the surface of the ball with an American Swiss Pillar File No. 2.

Permissible Variation in Test Balls

(c) When fractured, the ball shall show a fine, uniform grain, and the fracture shall resist file attack for at least one-third (⅓) of its depth from the surface of the ball. The permissible variation in the diameter of the ball shall not be greater than two-thousandths (0.002) inch over or under the standard size and the permanent deformation under the required loading shall not be greater than three-thousandths (0.003) inch.

Depths of Impressions

(d) The average depth of impression obtained on the four (4) specimens shall not be more than one thousand four hundred ninety-six tens of thousandths (0.1496) inch (3.8 mm.) for Class A rails, one thousand three hundred ninety-one tens of thousandths (0.1391) inch (3.5 mm.) for Class B rails, and one thousand three hundred thirty-eight tens of thousandths (0.1338) inch (3.4 mm.) for Class C rails.

Re-Tests

303. If the average of the impression tests on the head of the section from any melt fails to conform to the requirements specified in Section 302 (d) the manufacturer may at his option test each rail from such melt by making an impression test on the web, as described in Section 302 (a). Rails so retested which conform to the requirements as to depths of impression specified in Section 302 (d) shall be accepted.

IV. STANDARD SECTIONS, LENGTHS, AND WEIGHTS

Section

401. (a) The cold templet of the manufacturer shall conform to the specified section as shown in detail on the drawing of the purchaser, and shall at all times be maintained perfect.

(b) The section of the rail shall conform as accurately as posible to the templet, and within the following permissible variations:

(1) The height shall not vary more than one-sixty-fourth ($\frac{1}{64}$) inch under nor more than one thirty-second ($\frac{1}{32}$) inch over that specified.
(2) The over-all width of head and tram shall not vary more than one-eighth ($\frac{1}{8}$) inch from that specified. Any variation which would affect the gage line more than one thirty-second ($\frac{1}{32}$) inch will not be allowed.
(3) The over-all width of base shall not vary more than one-eighth ($\frac{1}{8}$) inch from that specified for widths less than six and one-half ($6\frac{1}{2}$) inches; three-sixteenths ($\frac{3}{16}$) inch under for a width of six and one-half ($6\frac{1}{2}$) inches; and one-quarter ($\frac{1}{4}$) inch under for a width of seven (7) inches.
(4) Any variation which would affect the fit of the splice bars, will not be allowed.
(5) The base of the rail shall be at right angles to the web; and the convexity shall not exceed one thirty-second ($\frac{1}{32}$) inch.

(c) When necessary on account of the type of track construction and notice to that effect has been given to the manufacturer, special care shall be taken to maintain the proper position of the gage line with respect to the outer edge of the base.

Length

402. (a) Unless otherwise specified, the lengths of rails at a temperature of sixty (60) deg. Fahr. shall be sixty (60) and sixty-two (62) feet for those sections in which the weight per yard will permit, excepting Girder Guard Rails, which shall be thirty (30) and thirty-two (32) feet unless otherwise specified.

(b) The lengths shall not vary more than one-quarter ($\frac{1}{4}$) inch from those specified.

(c) Shorter lengths, varying by one foot down to forty (40) feet for plain and grooved Girder Rails, and twenty-four (24) feet for Girder Guard Rails, will be accepted to the extent of ten (10) per cent by weight of each class on the order.

Weight

403. (a) The weight of the rails per yard as specified in the order shall be maintained as nearly as possible after conforming to the requirements specified in Section 401.

(b) The total weight of an order shall not vary more than five-tenths (0.5) of one (1) per cent from that specified.

(c) Payments shall be based on actual weights.

V. WORKMANSHIP AND FINISH

Straightening

501. (a) Rails on the hot beds shall be protected from water or snow and shall be carefully handled to minimize cold straightening.

(b) The distance between the rail supports in the cold-straightening presses shall not be less than forty-two (42) inches, except as may be necessary near the ends of the rails. The gag shall have rounded corners to avoid injury to the rails.

(c) Rails heard to snap or check while being straightened shall be at once rejected.

Finish

502. (a) Rails shall be smooth on the head, straight in line and surface without any twists, waves, or kinks, particular attention being given to having the ends without kinks or droop.

(b) All burrs or flow caused by drilling or sawing shall be carefully removed.

(c) Rails shall be free from gag marks and other injurious defects of cold-straightening.

(d) Any rails to be cold straightened showing sharp kinks, or greater camber than that indicated by the middle ordinate of eighteen (18) in sixty (60) shall be classed as No. 2 rails.

VI. DRILLING, MILLING AND PUNCHING

Drilling

601. (a) Circular holes for splice bar bolts, bonds and tie rods shall be drilled to conform to the drawings and dimensions furnished by the purchaser and within the following permissible variations:

(b) The diameter of the bolt holes shall not vary more than one thirty-second ($\frac{1}{32}$) inch over or under that specified. The diameter of the bond holes shall not be over the size specified, but may be one thirty-second ($\frac{1}{32}$) inch under. The diameter of the tie rod hole shall not be less than that specified but may be one-sixteenth ($\frac{1}{16}$) inch over.

(c) The location of the bolt and bond holes shall not vary more than one-sixteenth ($\frac{1}{16}$) inch either longitudinally or vertically from that specified. The location of the tie rod holes shall not vary more than one-quarter (¼) inch vertically and not more than one-half (½) inch longitudinally from that specified.

(d) Bond holes shall be truly cylindrical and not conical.

Milling

602. The ends of the rail shall be milled. The plane of the finished end surface shall (in the direction of the width of the rail) be at right angles to the gage with a permissible variation of one thirty-second ($\frac{1}{32}$) inch in six (6) inches and (in the direction of the height of the rail) be inclined to the plane of the base so that the top edge of the head will project beyond the bottom edge of the base not less than one thirty-second ($\frac{1}{32}$) inch nor more than three thirty-seconds ($\frac{3}{32}$) inch.

Punching

603. Unless otherwise specified by the purchaser, the tie rod holes in Class A rails may be punched, and when so made, they shall be free from burrs, fins, etc. Punched tie rods holes shall not be less in diameter than specified, but may be not over one-eighth ($\frac{1}{8}$) inch over size.

VII. CLASSIFICATION OF RAILS

No. 1 Rails

701. Rails which are free from injurious defects and flaws of all kinds shall be classed as No. 1 rails.

No. 2 Rails

702. (a) Rails which are rough on the head or which by reason of surface or other imperfections are not classed as No. 1 rails, shall be classed as No. 2 rails; providing they do not, in the judgment of the inspector, contain imperfections in such number and of such character as to render them unfit for No. 2 rail uses, and providing they conform to the requirements specified in Section 401.

(b) No. 2 rails will be accepted to the extent of ten (10) per cent by weight of the entire order.

VIII. MARKING AND LOADINGS

Marking

801. (a) The name or brand of the manufacturer, the year and month of manufacture, the letters "O.H.," the weight of the rail, and the section number, shall be legibly rolled in raised letters and figures on the web. The melt number shall be legibly stamped on each rail where it will not be covered subsequently by the splice bars.

(b) Both ends of all short-length No. 1 rails shall be painted green. Both ends of all No. 2 rails shall be painted white and shall have two heavy center-punch marks on the web at each end at such a distance from the end that they will not be covered subsequently by the splice bars.

Loading

802. (a) Rails shall be loaded in the presence of the inspector, and shall be handled in such a manner as not to bruise the flanges or cause injuries.

(b) Rails of each class shall be placed together in loading.

(c) Rails shall be paired as to length before shipment.

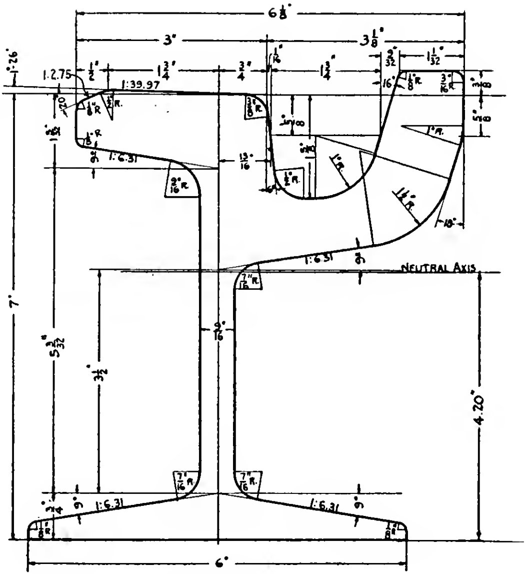
IX. INSPECTION

Inspection

901. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture prior to shipment, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

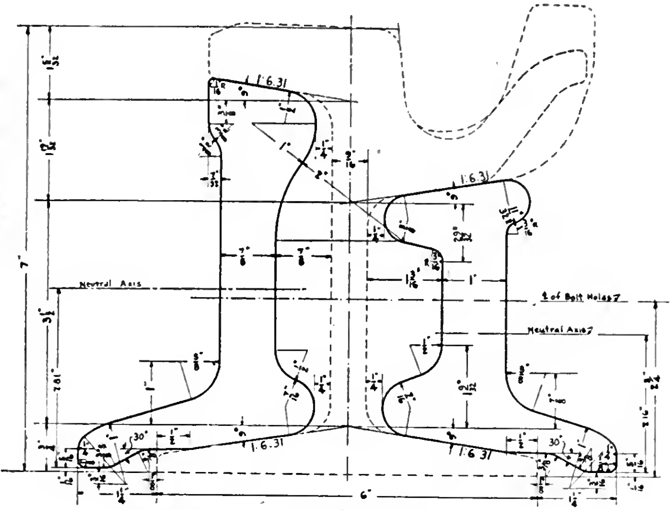
SECTIONS

AREA	Square Inches	Per Cent
Head	9.47	64.77
Web	2.00	13.68
Base	3.15	21.55
Total	14.62	100.0
Mom. of Inertia		87.7
Sec. Mod., Head		27.63
" " , Base		20.8
Ratio M.I. to Area		6.0
" Sec. Mod. " "		1.43
" Height to Base		1.17
" Base to Height		0.86



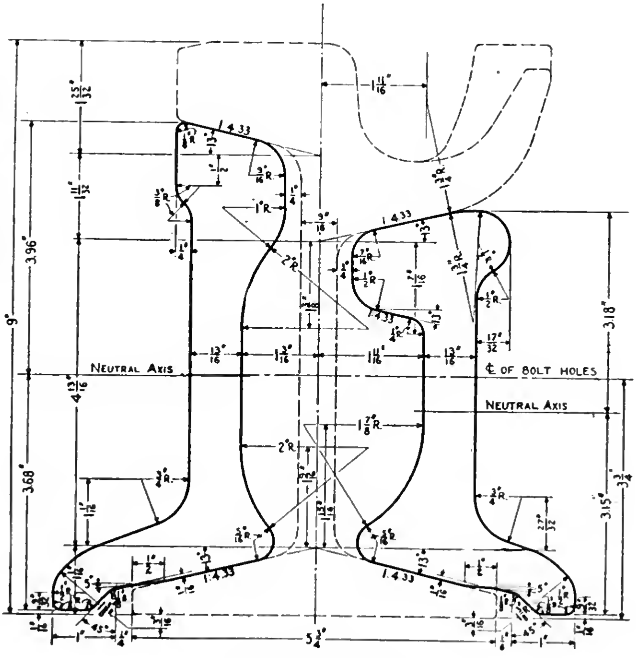
149# GG-7"

AREA	Sq. inches Outside Bar	Sq. inches Inside Bar
Total	7.93	7.18
Mom. of Inertia	29.42	14.07
Sec. Mod. above N.A.	8.89	5.81
" " below N.A.	10.47	6.51
Wt. per Inch	2.24	2.05
Ratio M.I. to Area	3.71	1.96
" Sec. Mod. to "	1.12	.81
Joint Stiffness	128 lb - 55.8%	
	149 lb - 69.6%	



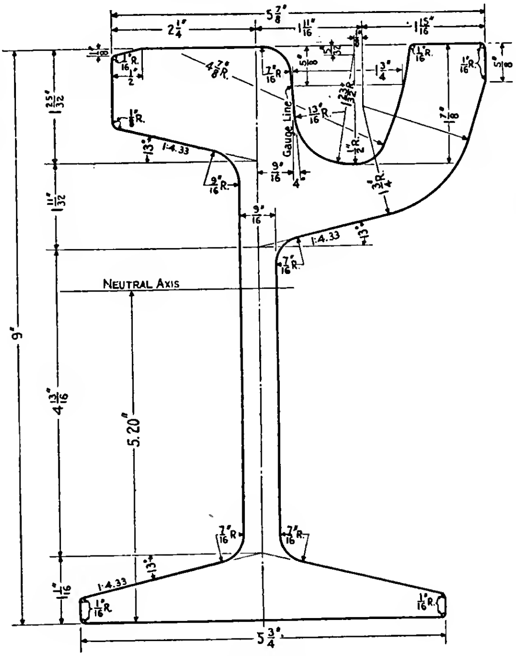
128# G-7" JOINT BARS

AREA	Sq. Inches Outside Bar	Sq. Inches Inside Bar
Total	9.39	9.04
Mom. of Inertia	53.4	36.3
Sec. Mod. above N.A.	13.6	11.4
" " below N.A.	14.6	11.5
Wt per Inch	2.64	2.55
Ratio M.I. to Area	5.72	4.03
" Sec. Mod " "	1.44	1.27
Joint Stiffness	159 lb - 54.8%	
	173 lb - 49.9%	



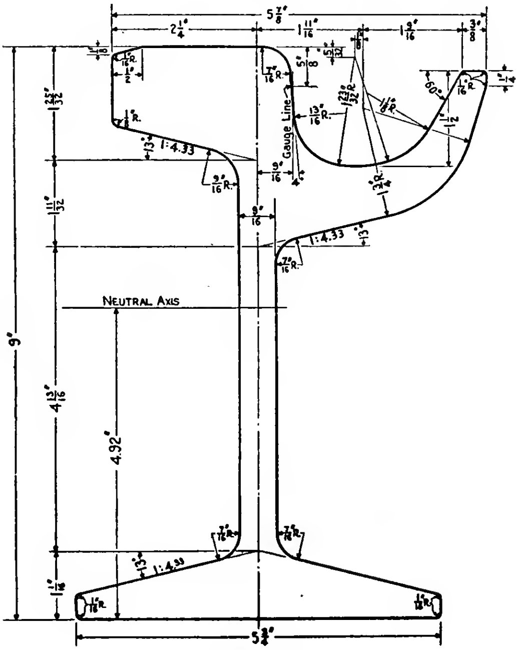
159# G-9" JOINT BARS

AREA	Square Inches	Per Cent
Head	9.98	58.71
Web	2.77	16.29
Base	4.25	25.00
Total	17.00	100.00
Mom of Inertia		180.2
Sec.Mod., Head		47.4
″ ″ , Base		34.7
Ratio M.I. to Area		10.60
″ Sec.Mod. ″ ″		2.04
″ Height to Base		1.57
″ Base to Height		0.64



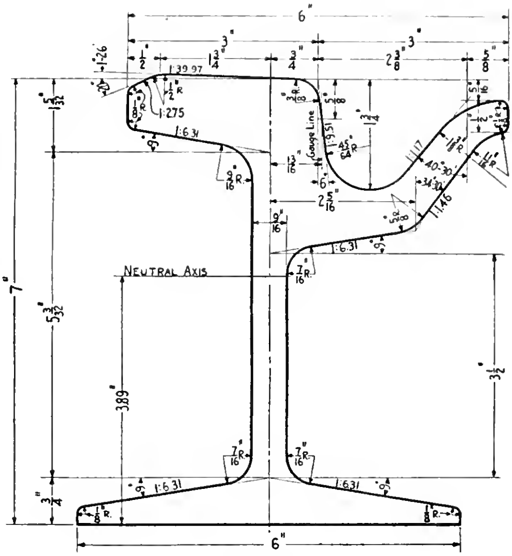
174# GG-9″

AREA	Square Inches	Per Cent
Head	8.61	55.09
Web	2.77	17.72
Base	4.25	27.19
Total	15.63	100.00
Mom. of Inertia		164.1
Sec.Mod., Head		40.2
″ ″ , Base		33.4
Ratio M.I. to Area		10.50
″ Sec.Mod. ″ ″		2.13
″ Height to Base		1.57
″ Base to Height		0.64



159# G-9″

AREA	Square Inches	Per Cent
Head	7.45	59.17
Web	2.10	16.68
Base	3.04	24.15
Total	12.59	100.00
Mom of Inertia	78.0	
Sec. Mod, Head	24.6	
" " , Base	20.1	
Ratio M.I. to Area	6.20	
" Sec. Mod " "	1.59	
" Height to Base	1.18	
" Base to Height	0.85	



128# G-7"

(For additional data on Girder Rails, see Report of Committee on Track, pp. 672-676.)

REPORT OF COMMITTEE V—TRACK

J. V. NEUBERT, *Chairman;*	C. R. HARDING, *Vice-Chairman;*
L. B. ALLEN,	J. DEN. MACOMB,
V. ANGERER,	F. H. MASTERS,
J. B. BAKER,	S. B. MCCONNELL,
S. BALKWILL,	C. E. MERWIN,
C. W. BREED,	W. W. MORRISON,
H. W. BROWN,	J. B. MYERS,
W. G. BROWN,	W. G. NUSZ,
H. G. CLARK,	J. B. LATIMER,
J. W. DEMOYER,	G. A. PEABODY,
L. W. DESLAURIERS,	W. H. PETERSEN,
W. J. HARRIS,	I. H. SCHRAM,
O. F. HARTING,	G. J. SLIBECK,
T. T. IRVING,	J. B. STRONG,
H. D. KNECHT,	E. D. SWIFT,
E. R. LEWIS,	J. R. WATT,
R. L. LONGSHORE,	W. P. WILTSEE,

Committee.

To the American Railway Engineering Association:

Your Committee respectfully presents herewith report on the subjects assigned, as follows:

(1) Revision of Manual (Appendix A).
(2) Detail plans of switches, frogs and crossings, including plans of self-guarded frogs (Appendix B).
(3) Specifications and design of wooden handles for track tools (Appendix C).
(4) Effect of brine drippings on track appliances and tests of tie plates subject to brine drippings (Appendix D).
(5) Canting of rail inward and taper of tread of wheels (Appendix E).
(6) Methods of determining recommendations for rail renewals (Appendix F).
(7) Plans for tie plates (Appendix G).
(8) Cause and prevention of rail battering; principles of rail joint design (Appendix H).
(9) Track construction in paved streets; specifications for girder rails (Appendix I).
(10) Use of nutlocks for rail joints, with special reference to heat treated bolts of large diameter (Appendix J).
(11) Outline of work for ensuing year. (The Committee's recommendations are given under "Recommendations for Future Work.")

Action Recommended

1. That the changes in the Manual outlined in Appendix A be approved and that revised version be substituted for the present recommendations in the Manual.

2. That the conclusions in Appendices B, C, G and I be adopted as recommended practice and published in the Manual as outlined in these reports.

3. That further data as outlined in Appendices B to J, inclusive, be received as information only.

Bulletin 283, January, 1926.

Recommendations for Future Work

(1) Revision of the Manual.

(2) Detail plans of switches and frogs, crossings and slip switches, including self-guarded frogs, conferring with Committee on Signals and Interlocking.

(3) Specifications and designs for foundations under railroad crossings, also for tie spacing and or timbering under crossings.

(4) Continue study of track construction in paved streets, collaborating with Committee on Rail on specifications for girder rails.

(5) Outline of work for ensuing year.

Reports on the following subjects being final, the Committee recommends that they be discontinued next year.

Subjects to be Discontinued

Specifications and design of wooden handles for track tools. (Present Subject No. 3.)

Effect of brine drippings on track appliances and tests of tie plates subject to brine drippings. (Present Subject No. 4.)

Canting of rail inward and taper of tread of wheels. (Present subject No. 5.)

Methods of determining recommendations for rail renewals. (Present Subject No. 6.)

Plans for tie plates. (Present Subject No. 7.)

Cause and prevention of rail battering; principles of rail joint design. (Present Subject No. 8.)

Use of nutlocks for rail joints, with special reference to heat treated bolts of large diameter. (Present Subject No. 10.)

Respectfully submitted,

The Committee on Track,

J. V. Neubert, *Chairman.*

Appendix A

(1) REVISION OF MANUAL

J. V. Neubert, Chairman, Sub-Committee; C. R. Harding, J. B. Baker, H. G. Clark, L. W. Deslauriers, T. T. Irving, J. deN. Macomb, E. D. Swift, J. R. Watt.

The Committee recommends the following changes in the Manual and to adopted plans:

Revise specifications for Switches, Frogs, Crossings and Guard Rails, adopted March, 1921, printed on pages 214-220, 1921 Manual, as follows:

Add to Section 14 (Bolts) the following paragraph:

> "Bolts with countersunk heads, button heads or cone heads shall be provided with locking necks or other effective locking means to keep bolts from turning."

Change Section 24, reading "Nut Locks. Nut locks shall be of good strong spring steel," to read:

> "24. Spring Washers. For heat treated or high tensile bolts, spring washers shown on trackwork plans shall conform to specifications of the American Railway Engineering Association for high spring pressure and where nutlocks (N.L.) are specified on present trackwork plans the term "spring washers" shall be understood."

Revise Plan No. 773, adopted March, 1925, Solid Manganese Steel Crossings, Angles below 40 deg. to 30 deg., inclusive, to specify in title instead of angles as given the following angles:

"Angles below 40 deg. to 25 deg., inclusive."

> Explanation: This change is recommended as detail of construction illustrated on this plan, it has been decided, will apply and is recommended for angles down to and including 25 deg. For plans of solid manganese crossings covering smaller angles, see Appendix B.

Omit specifications for Steel Tie Plates, printed in the 1921 Manual, beginning on page 203, and substitute the following specifications:

PROPOSED REVISED SPECIFICATIONS FOR STEEL TIE PLATES

1. These specifications cover two grades of steel tie plates, namely: soft and medium. The soft grade will be used unless otherwise specified.

I. MANUFACTURE

2. Steel may be made by the Bessemer or Open-Hearth process, or both.

II. CHEMICAL PROPERTIES AND TESTS

3 (a) The steel shall conform to the following requirements as to chemical composition:

(b) Phosphorus

Bessemer—not over 0.10 per cent.
Open-Hearth—not over 0.05 per cent.

(c) Carbon

Unless otherwise specified, the material will be furnished according to chemical composition only, in which case the minimum carbon shall be as follows:

Bessemer—soft grade—not under 0.08 per cent.
Bessemer—medium grade—not under 0.12 per cent.
Open-Hearth—soft grade—not under 0.15 per cent.
Open-Hearth—medium grade—not under 0.20 per cent.

4. A carbon determination shall be made of each melt of Bessemer steel, and three analyses every 24 hours representing the average of the elements carbon and phosphorus contained in the steel, one for each 8 hour turn respectively. These analyses shall be made from drillings taken at least ⅛ inch beneath the surface of a test ingot obtained during the pouring of the melts. The chemical composition thus determined shall be reported to the purchaser or his representative and shall conform to the requirements specified in Section 3.

5. An analysis of each melt of open-hearth steel shall be made by the manufacturer to determine the percentages of carbon and phosphorus. This analysis shall be made from drillings taken at least ⅛ inch beneath the surface of a test ingot obtained during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative and shall conform to the requirements specified in Section 3.

6. An analysis may be made by the purchaser from a finished tie plate representing each melt of open-hearth steel, and each melt or lot of 10 tons of Bessemer steel. The carbon content thus determined shall not be less than that specified in Section 3, and the phosphorus content shall not exceed that specified in Section 3 by more than 25 per cent.

III. PHYSICAL PROPERTIES AND TESTS

7. The bend test specimens specified in Section 8 shall bend cold through 180 deg. around a pin the diameter of which is equal to the thickness of the specimen for the soft grade, and to twice the thickness of the specimen for the medium grade, without cracking on the outside of the bent portion.

8. Bend test specimens shall be taken from the finished tie plates, or from the rolled bars, and longitudinally with the rolling. They shall be rectangular in section, not less than ½ inch in width between the planed sides, and shall have two parallel faces as rolled. They shall be free from ribs or projections. Where the design of the tie plates is such that the specimen cannot be taken between the ribs or projections, those ribs or projections shall, in preparing the specimen, be planed off even with the main surface of the tie plate.

9. If preferred by the manufacturer and approved by the purchaser, the following bend test may be substituted for that described in Section 7:

> A piece of the rolled bar shall bend cold through 90 deg. around a pin the diameter of which is equal to the thickness of the section where bent for the soft grade, and to twice the thickness of the section where bent for the medium grade, without cracking on the outside of the bent portion.

10. (a) One bend test shall be made from each melt of open-hearth steel, or from each melt or lot of 10 tons of Bessemer steel.

(b) If any test specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted.

IV. WORKMANSHIP AND FINISH

11. (a) The tie plate shall conform to the dimensions specified by the purchaser with the following permissible variations.

(b) For plates with shoulders parallel to the direction of rolling, a variation of 1/32 inch in thickness, 1/8 inch in rolled width, and 3/16 inch in sheared length will be permitted.

(c) For plates with shoulders perpendicular to the direction of rolling, a variation of 1/32 inch in thickness, 3/16 inch in rolled width, and 1/4 inch in sheared length will be permitted. The distance from the face of shoulder to the outside end of the plate shall not vary more than 1/8 inch and from the face of shoulder to the inside end not more than 1/4 inch.

(d) A variation of not more than 1/32 inch in the length of their sides and in the location of spike holes will be permitted.

12. The tie plate shall be smoothly rolled, true to templet, and shall be straight and out of wind on the surface which will form the bearings for the rail.

13. The finished tie plates shall be free from burrs and other surface deformation caused by the shearing and punching; they shall also be free from other injurious defects and shall have a workmanlike finish.

V. MARKING

14. The name or brand of the manufacturer, the section and the year of manufacture shall be rolled in raised letters and figures on the outside of the shoulder of the plates, and a portion of this marking shall appear on each finished tie plate.

VI. INSPECTION

15. The inspector representing the purchaser shall have free entry at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the tie plates ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the tie plates are being furnished in accordance with these specifications. All tests

(except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

16. Unless otherwise specified, any rejections based on tests made in accordance with Section 6 shall be reported within five working days from the receipt of samples.

17. Tie plates which show injurious defects subsequent to their acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

18. Samples tested in accordance with Section 6, which represent rejected tie plates, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

REFERENCE TO CHANGES FROM PRESENT SPECIFICATIONS FOR TIE PLATES

1. No change.
2. Revision of diction for both.
3 (a). A.R.E.A. used.
4. No change except revision to accord with present mill practice of working 3 turns per 24 hours.
5. Elimination of determinations manganese and sulphur.
6. No change.
7. No change.
8. No change.
9. No change.
10 (a). No change.
10 (b). No change.
Elimination of present A.R.E.A. tension tests.
11 (a). A.S.T.M. used.
11 (b). No change.
11 (c). A.R.E.A. used with revision of tolerances.
12. No change.
13. No change.
14. No change.
15. No change.
16. No change.
17. No change.
18. No change.
A.R.E.A. shipment clause eliminated.

Omit Specifications for Cut Steel Track Spikes, printed in the 1921 Manual, beginning on page 197, and substitute the following specifications:

PROPOSED REVISED SPECIFICATIONS FOR SOFT STEEL CUT TRACK SPIKES

I. MANUFACTURE

1. The steel may be made by the Bessemer or Open-Hearth Process, or both.

II. CHEMICAL PROPERTIES AND TESTS

2. (a) The steel shall conform to the following requirements as to chemical composition:

	Bessemer	*Open-Hearth*
Carbon, per cent not under............	0.06	0.12

(b) A carbon determination shall be made of each melt of Bessemer steel and three determinations shall be made every 24 hours, one for each 8-hour turn, respectively, representing the average carbon content in the steel. These analyses shall be made from drillings taken at least ⅛ inch beneath the surface of a test ingot obtained during the pouring of the melts. The chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Section 2.

(c) An analysis of each melt of open-hearth steel shall be made by the manufacturer to determine the percentage of carbon. This analysis shall be made from drillings taken at least ⅛ inch beneath the surface of a test ingot obtained during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Section 2.

III. PHYSICAL PROPERTIES AND TESTS

3. (a) The body of the full size finished spikes shall bend cold through 180 deg. flat on itself, without cracking on the outside of the bent portion.

(b) The head of the full size finished spikes shall bend backward to the line of the face of the spike, without cracking on the outside of the bent portion.

4. One bend test of each kind shall be made from each lot of 5 tons or fraction thereof.

IV. WORKMANSHIP AND FINISH

5. (a) The spikes shall conform to the dimensions specified by the purchaser with the following permissible variations.

(b) A variation of $\frac{3}{32}$ inch over and $\frac{1}{64}$ inch under the specified cross-section dimensions of the body of the spike will be permitted.

(c) A variation of $\frac{3}{16}$ inch over and $\frac{1}{32}$ inch under the specified dimensions of the head of the spike will be permitted.

(d) A variation of ⅛ inch from the specified length of the spike measured from the under side of the head to the point will be permitted.

(e) A variation of one degree in the specified angle of the under side of the head of the spike will be permitted.

6. The finished spikes shall be free from injurious defects and shall have a workmanlike finish.

V. INSPECTION

7. The inspector representing the purchaser shall have free entry at all times while work on the contract of the purchaser is being performed to all parts of the manufacturer's works which concern the manufacture of the spikes ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy himself that the spikes are being furnished in accordance with these specifications. All tests and inspections shall be made at the place of manufacture prior to shipment unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

8. Spikes which show injurious defects subsequent to their acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

REFERENCE TO CHANGES FROM PRESENT SPECIFICATIONS FOR CUT TRACK SPIKES

1. Slight revision in diction.
2 (a). A.S.T.M. added.
2 (b). A.S.T.M. added with elimination of elements of manganese, phosphorus and sulphur.
2 (c). A.S.T.M. added with elimination of elements of manganese, phosphorus and sulphur.
3 (a). No change.
3 (b). No change
4. A.S.T.M. used.
4 (b). of A.R.E.A. omitted.
5. of A.R.E.A. omitted.
5 (a). Revision in diction.
5 (b). A.R.E.A. with revision of application.
5 (c). A.R.E.A. used.
5 (d). A.R.E.A. used.
5 (e). No change.
6. No change.
7. No change.
8. No change.
10. of present A.R.E.A. omitted (Tensile Test).

Omit subject matter on top of page 203 in the 1921 Manual on tie plates, as information given there is duplicated and details covered more fully in tables and plans offered for adoption in Appendix G.

Appendix B

(2) DETAIL PLANS OF SWITCHES, FROGS AND CROSSINGS, INCLUDING PLANS OF SELF-GUARDED FROGS

C. R. Harding, Chairman, Sub-Committee; V. Angerer, J. B. Baker, S. Balkwill, C. W. Breed, L. W. Deslauriers, O. F. Harting, J. deN. Macomb, C. E. Merwin, J. B. Myers, J. V. Neubert, F. P. Patenall, G. A. Peabody, G. J. Slibeck, J. B. Strong, W. P. Wiltsee.

The plans and specifications presented in this Appendix and the revisions to the Manual in Appendix A coming under this subject have been prepared in conference with the Standardization Committee of the Manganese Track Society.

"A"—CROSSINGS, STEAM RAILROAD OVER ELECTRIC RAILWAY

Plan No. 778 of Manganese Steel Insert Crossings, Steam Railroad over Electric Railway, angles below 45 deg. to 30 deg., inclusive, is offered for adoption as recommended practice.

This plan is to complete the series of plans of crossings for steam railroad over electric railway. Solid manganese construction for steam railroad over electric railway crossings is recommended for angles 90 to 40 or 45 deg. as per Plans No. 776 and No. 777, adopted March, 1924. Manganese insert construction is recommended for angles below 40 or 45 deg. to 30 deg. as detailed on Plan No. 778 now offered. For bolted rail crossings, steam railroad over electric railway, we have Plans No. 716 and No. 717 for angles 90 to 30 deg., adopted March, 1925. The Committee recommends that crossings, steam railroad over electric railway, below 30 deg., particularly for narrow tread and shallow flange electric railway car equipment, be avoided.

In addition to collaboration with the M.T.S. Standardization Committee this plan (No. 778) was prepared in consultation with a number of the members of the Committee on Way Matters of the American Electric Railway Engineering Association and that Committee will offer it to the American Electric Railway Association.

Details for steam tracks on Plan No. 778 conform closely to Plan No. 762 of manganese steam railroad insert crossings, angles 45 to 35 deg., adopted March, 1922. Details for electric railway tracks conform to Plan No. 717 of bolted rail crossing, steam over electric railway, adopted March, 1925, in so far as details generally apply to manganese insert construction.

"B"—SOLID MANGANESE CROSSINGS, STEAM OVER STEAM RAILWAY

In 1925 progress was reported on plans of solid manganese steam railroad crossings for angles below 30 deg. In Appendix A of this report the Committee recommends that angles on Plan No. 773 of solid manganese steel crossings, adopted March, 1925, be changed to specify angles below 40 deg. to 25 deg., and also presents herewith as information to invite criticism and comment Plan No. 774 of Solid Manganese Steel Crossing, Double Rail Construction, angles below 25 deg. and above 14 deg. 15 min., and Plan No. 775 of Solid Manganese Steel Crossing, Single Rail Construction, angles 14 deg. 15 min. to 8 deg. 10 min., inclusive.

Below 25 deg., as will be noted on Plan No. 774, it is recommended that closure rails be introduced between solid manganese center frogs and end frogs of double rail construction above angle 14 deg. 15 min. The running rail in this range of angles is a short rail, but it is held securely in place as illustrated with continuous guard rail attached.

For angles 14 deg. 15 min. to 8 deg. 10 min. for tangent track it is recommended that the solid manganese center and end frogs be connected up with closure rails, single rail construction as illustrated in Plan No. 775.

Alternate designs are offered on both of these plans, which show construction that is being successfully used in different parts of the country. The Committee believes local conditions and volume of traffic make it advisable to offer the alternate designs for consideration and criticism; as, for instance, the alternate end frogs shown on Plan No. 775, which are illustrated as design No. 1 and design No. 2, conforming to details of solid manganese steel frogs, Plans No. 651 to No. 655, inclusive, adopted March, 1920, and Plan No. 656, received as information March, 1921. These alternates provide for shorter manganese castings, lighter in weight than manganese castings shown in assembled view of the crossing, and are recommended for consideration where the expense of heavier manganese castings might not be felt warranted.

"C"—TIE SPACING AND/OR TIMBERING UNDER CROSSINGS

The Committee offers as information to invite criticism and comment Plan No. 720 of tie layouts for crossings, which shows example "A" for crossings with continuous plates, angles 50 to 90 deg., "B" for crossings with corner plates, angles 50 to 90 deg.; "C" for crossings with corner plates, angles 65 to 75 deg.; and "D" for crossings with corner plates, angles 50 to 65 deg.

The Committee recommends that this subject be carried over as future work in connection with foundations for railroad crossings. It has been found that foundations under crossings and tie spacing and/or timbering are vital factors in the life of crossings, and that properly designed installations and proper maintenance are most essential for economy in the expense of maintaining railroad crossings. Otherwise well designed crossings, when there is lack of attention to these details, give comparatively short life.

"D"—TIE SPACING UNDER FROGS OF STANDARD NUMBERS

Plan No. 321, entitled "Tie Layout Standard Length Rigid Frogs for one-piece Guard Rail, 6 Ties, 19 inches to 20 inches Spacing, Suspended Joints, is offered as information to invite criticism and comment.

The extensive use of one-piece guard rails or guard rails with tie plates attached, in both cases for fixed tie spacing, has made desirable a uniform tie spacing for at least six ties under frogs of different numbers so the same guard detail may be ordered and used for any frog number. The Committee has found that 20 inches is the tie spacing in most common use for six-tie guard rails, though 19 inches and 19½ inches spacings are also used. With bolted rigid and railbound manganese steel frogs of present standard lengths a tie spacing of 19½ inches for the required five spaces can be used as shown on plan presented, and this will accommodate any of the guard rails above mentioned. Short six-tie guard rails are most commonly used with bolted rigid frogs. For spring rail frogs it would be necessary to change the detail of present design for 19½-inch spacing, as the design is involved in the tie spacing shown, while with the bolted rigid frogs and railbound manganese steel frogs the tie spacing can be changed without affecting the design.

"E"—STANDARDIZATION OF FROG FILLER SECTIONS

The Committee presents as information to invite criticism and comment Plan No. 325 of Frog Fillers, showing dimensions, Detail "D" for individual filler; Detail "E" for vertical web filler; and Detail "F" for tapered web filler.

These details with tables of dimensions cover filler sections for standard sections of rail in common use of 80-lb. and heavier weight.

It is the desire of the manufacturers to reduce the number of rolls and to standardize material and tolerance in dimensions. The backing of the American Railway Engineering Association is needed to make this move effective. The Committee therefore presents the following information and tentative specifications, preparatory to their adoption in 1927 if not changed:

Present Sections: A study was made of all sections of frog filler rolled in this country at the present time, ranging from filler for rail from 45-lb. to 130-lb. per yard. There are approximately 207 different sections rolled, 177 of which are of the double groove type and 30 of the solid bottom type.

There has been considered only filler sections for rail 80-lb. and above, and of these sections there are approximately 142 rolled, 112 being double groove and 30 solid bottom or single groove type.

Flangeways now vary from 1¾ inch to 2¼ inch in width. It is recommended that fillers be standardized for 1¾ inch, 1⅞ inch and 2 inch flangeways.

Single and Double Groove Fillers: Without question, the single groove type is the strongest and most logical design for a frog filler, and as the difference in the weight and cost is comparatively slight, it is recommended whenever it is available, and whenever new rolls are made, they should be for the single groove filler.

It is hoped that eventually the single groove will be adopted as the only standard, but it is felt that owing to the large amount of double groove filler and the large number of double groove rolls now in use, for the present both types will have to be recognized. The drawings, therefore, show both types; the single groove section being the preferred type is shown in a solid line, with the bottom groove of the double groove filler indicated by a dotted line.

SPECIFICATIONS FOR FROG FILLER SECTIONS

MANUFACTURE

Process

1. The steel shall be made by either or both the following processes: Bessemer or Open-Hearth.
2. Bars shall be hot rolled.

CHEMICAL PROPERTIES

3. Steel shall conform to A.S.T.M. specifications for commercial bar steel, in so far as they apply to this product, serial designation A-80-24, of the following grades:

	Open-Hearth	*Bessemer*
Carbon	.15 to .30	.12 to .25

PERMISSIBLE VARIATIONS IN DIMENSIONS

4. The fishing height of filler shall not exceed that shown in drawings by more than 1/64 inch and shall not underrun by more than 1/32 inch.
   Width of filler between rail webs shall be nothing under to 1/16 inch over dimensions shown.
   Depth of flangeway groove may be 1/16 inch under or 1/8 inch over dimensions given on drawing.

Grouping: In order to reduce the large number of sections now rolled, fillers recommended as standard have been grouped as shown on Drawing No. 325.

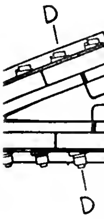
"F"—DETAILS OF DERAIL SWITCH POINT CONNECTIONS

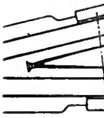
The Committee offers for adoption as recommended practice Plan No. 213 (dated November, 1925), of Details for Split Switch Point Derail. Plan No. 213, dated November, 1924, was offered last year as information to invite criticism, and it is now presented with some minor revisions for adoption.

The Committee has conferred with a number of the larger railroads as well as with the manufacturers in the matter of derail switch installations and has found that the arrangement for stock rail and provisions for guard rails are not uniform, being largely fixed by local conditions and local laws. References on the plan make provisions for utilizing A.R.E.A. switch points and fixtures that have been adopted as standard.

"G"—REVIEW PRESENT STANDARDS

The Committee offers as information Index Sheets, pages I and II, dated March, 1925, and page III, dated March, 1926—pages I and II listing all latest plans and specifications that have been offered by the Track Committee and adopted (giving dates) or received as information (giving dates) by the Association; page III giving revisions that did not appear in

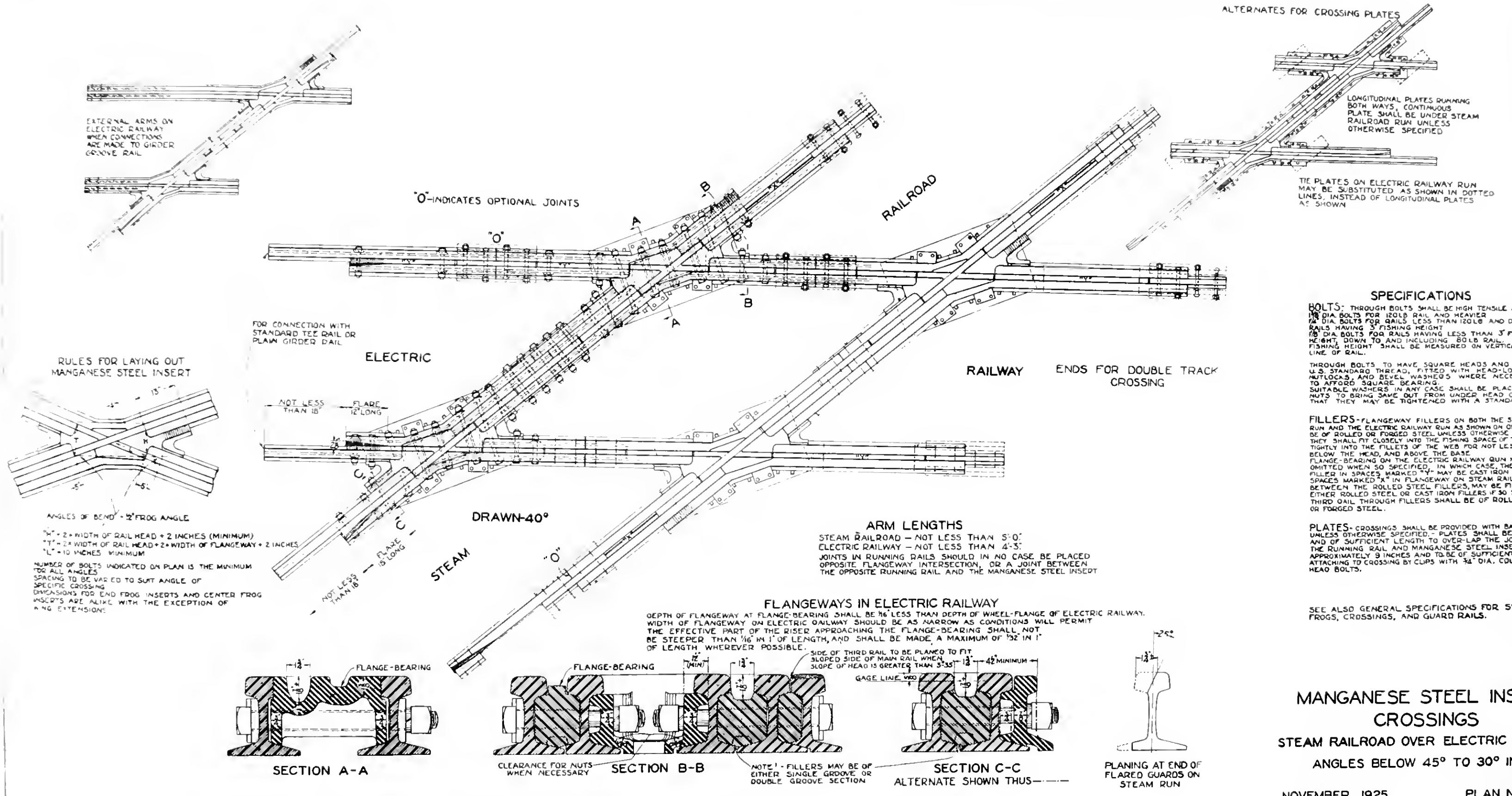




'o 17°-29"

N AT 14°-16'

Ezhibit B-1



EXTERNAL ARMS ON ELECTRIC RAILWAY WHEN CONNECTIONS ARE MADE TO GIRDER GROOVE RAIL

"O"-INDICATES OPTIONAL JOINTS

LONGITUDINAL PLATES RUNNING BOTH WAYS, CONTINUOUS PLATE SHALL BE UNDER STEAM RAILROAD RUN UNLESS OTHERWISE SPECIFIED

TIE PLATES ON ELECTRIC RAILWAY RUN MAY BE SUBSTITUTED AS SHOWN IN DOTTED LINES, INSTEAD OF LONGITUDINAL PLATES AS SHOWN

RULES FOR LAYING OUT MANGANESE STEEL INSERT

ANGLES OF BEND = ½ FROG ANGLE

"H" = 2 × WIDTH OF RAIL HEAD + 2 INCHES (MINIMUM)
"T" = 2 × WIDTH OF RAIL HEAD + 2 × WIDTH OF FLANGEWAY + 2 INCHES
"L" = 10 INCHES MINIMUM

NUMBER OF BOLTS INDICATED ON PLAN IS THE MINIMUM FOR ALL ANGLES
SPACING TO BE VARIED TO SUIT ANGLE OF SPECIFIC CROSSING
DIMENSIONS FOR END FROG INSERTS AND CENTER FROG INSERTS ARE ALIKE WITH THE EXCEPTION OF WING EXTENSIONS

ARM LENGTHS

STEAM RAILROAD — NOT LESS THAN 5'-0".
ELECTRIC RAILWAY — NOT LESS THAN 4'-3".

JOINTS IN RUNNING RAILS SHOULD IN NO CASE BE PLACED OPPOSITE FLANGEWAY INTERSECTION, OR A JOINT BETWEEN THE OPPOSITE RUNNING RAIL AND THE MANGANESE STEEL INSERT

FLANGEWAYS IN ELECTRIC RAILWAY

DEPTH OF FLANGEWAY AT FLANGE-BEARING SHALL BE 1/16" LESS THAN DEPTH OF WHEEL-FLANGE OF ELECTRIC RAILWAY.
WIDTH OF FLANGEWAY ON ELECTRIC RAILWAY SHOULD BE AS NARROW AS CONDITIONS WILL PERMIT
THE EFFECTIVE PART OF THE RISER APPROACHING THE FLANGE-BEARING SHALL NOT BE STEEPER THAN 1/16" IN 1" OF LENGTH, AND SHALL BE MADE A MAXIMUM OF 1/32" IN 1" OF LENGTH WHEREVER POSSIBLE.

SIDE OF THIRD RAIL TO BE PLANED TO FIT SLOPED SIDE OF MAIN RAIL WHEN SLOPE OF HEAD IS GREATER THAN 5°-35'

NOTE ! - FILLERS MAY BE OF EITHER SINGLE GROOVE OR DOUBLE GROOVE SECTION

SPECIFICATIONS

BOLTS: THROUGH BOLTS SHALL BE HIGH TENSILE STEEL
1⅛" DIA. BOLTS FOR 120LB RAIL AND HEAVIER
1" DIA. BOLTS FOR RAILS LESS THAN 120LB AND DOWN TO RAILS HAVING 3" FISHING HEIGHT
⅞" DIA. BOLTS FOR RAILS HAVING LESS THAN 3" FISHING HEIGHT, DOWN TO AND INCLUDING 80LB RAIL.
FISHING HEIGHT SHALL BE MEASURED ON VERTICAL CENTER LINE OF RAIL.

THROUGH BOLTS TO HAVE SQUARE HEADS AND NUTS, WITH U.S. STANDARD THREAD, FITTED WITH HEAD-LOCKS, NUTLOCKS, AND BEVEL WASHERS WHERE NECESSARY TO AFFORD SQUARE BEARING.
SUITABLE WASHERS IN ANY CASE SHALL BE PLACED UNDER NUTS TO BRING SAME OUT FROM UNDER HEAD OF RAIL SO THAT THEY MAY BE TIGHTENED WITH A STANDARD WRENCH

FILLERS-FLANGEWAY FILLERS ON BOTH THE STEAM RAILROAD RUN AND THE ELECTRIC RAILWAY RUN AS SHOWN ON DRAWING, SHALL BE OF ROLLED OR FORGED STEEL UNLESS OTHERWISE SPECIFIED. THEY SHALL FIT CLOSELY INTO THE FISHING SPACE OF THE RAIL AND TIGHTLY INTO THE FILLETS OF THE WEB FOR NOT LESS THAN ½" BELOW THE HEAD, AND ABOVE THE BASE
FLANGE-BEARING ON THE ELECTRIC RAILWAY RUN MAY BE OMITTED WHEN SO SPECIFIED, IN WHICH CASE, THE FLANGEWAY FILLER IN SPACES MARKED "Y" MAY BE CAST IRON
SPACES MARKED "X" IN FLANGEWAY ON STEAM RAILROAD RUN, BETWEEN THE ROLLED STEEL FILLERS, MAY BE FILLED WITH EITHER ROLLED STEEL OR CAST IRON FILLERS IF SO SPECIFIED
THIRD RAIL THROUGH FILLERS SHALL BE OF ROLLED STEEL OR FORGED STEEL.

PLATES- CROSSINGS SHALL BE PROVIDED WITH BASE PLATES UNLESS OTHERWISE SPECIFIED.- PLATES SHALL BE ¾" THICK AND OF SUFFICIENT LENGTH TO OVER-LAP THE JOINTS BETWEEN THE RUNNING RAIL AND MANGANESE STEEL INSERT APPROXIMATELY 9 INCHES AND TO BE OF SUFFICIENT WIDTH FOR ATTACHING TO CROSSING BY CLIPS WITH ¾" DIA. COUNTERSUNK HEAD BOLTS.

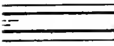
SEE ALSO GENERAL SPECIFICATIONS FOR SWITCHES, FROGS, CROSSINGS, AND GUARD RAILS.

MANGANESE STEEL INSERT CROSSINGS

STEAM RAILROAD OVER ELECTRIC RAILWAY
ANGLES BELOW 45° TO 30° INCL.

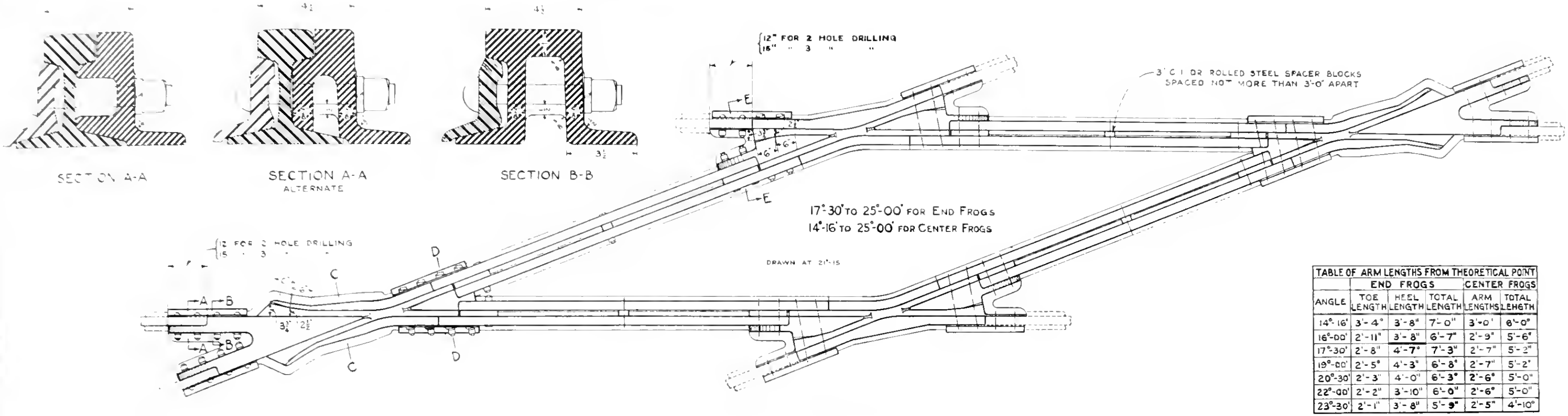
NOVEMBER 1925
PLAN NO. 778

HEARED AN



OF CONNE
IONAL WITH

Exhibit B-2



SECTION A-A

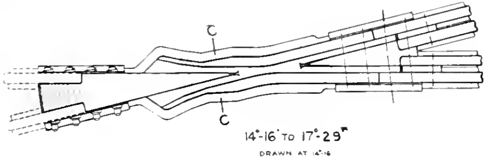
SECTION A-A
ALTERNATE

SECTION B-B

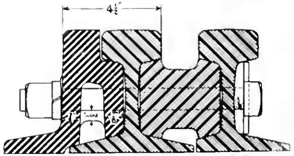
17°-30' TO 25°-00' FOR END FROGS
14°-16' TO 25°-00' FOR CENTER FROGS

TABLE OF ARM LENGTHS FROM THEORETICAL POINT					
	END FROGS			CENTER FROGS	
ANGLE	TOE LENGTH	HEEL LENGTH	TOTAL LENGTH	ARM LENGTHS	TOTAL LENGTH
14°-16'	3'-4"	3'-8"	7'-0"	3'-0"	6'-0"
16°-00'	2'-11"	3'-8"	6'-7"	2'-9"	5'-6"
17°-30'	2'-8"	4'-7"	7'-3"	2'-7"	5'-2"
19°-00'	2'-5"	4'-3"	6'-8"	2'-7"	5'-2"
20°-30'	2'-3"	4'-0"	6'-3"	2'-6"	5'-0"
22°-00'	2'-2"	3'-10"	6'-0"	2'-6"	5'-0"
23°-30'	2'-1"	3'-8"	5'-9"	2'-5"	4'-10"

NOTE ;- FOR INTERMEDIATE ANGLES USE LENGTHS SPECIFIED FOR NEXT SMALLER ANGLE.



14°-16' TO 17°-29'
DRAWN AT 14°-16



SECTION E-E
ALTERNATE

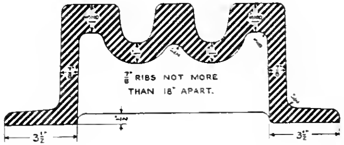
NOTES

IT IS RECOMMENDED THAT NEW RAILS OF THE HIGHEST ABUTTING SECTION BE INSTALLED AGAINST ALL EXTERNAL ARMS OF CROSSING.

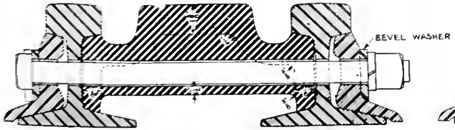
HEIGHT OF MANGANESE AND RAILS TO CONFORM TO HIGHEST ABUTTING RAIL.

FOR HEAVY SERVICE A HEIGHT OF NOT LESS THAN 6" IS RECOMMENDED.

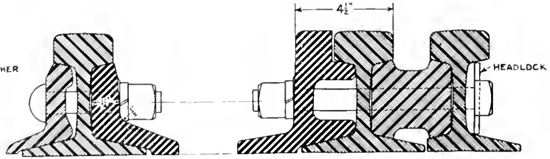
SPECIAL SPLICE BARS AND BOLTS TO BE FURNISHED WITH CROSSING.



SECTION C-C



SECTION D-D



SECTION E-E

SOLID
MANGANESE STEEL CROSSING
ANGLES BELOW 25°-00' AND ABOVE 14°-15'
DOUBLE RAIL CONSTRUCTION

DEC. 1925 **PLAN 774**

ES NOT RECOM

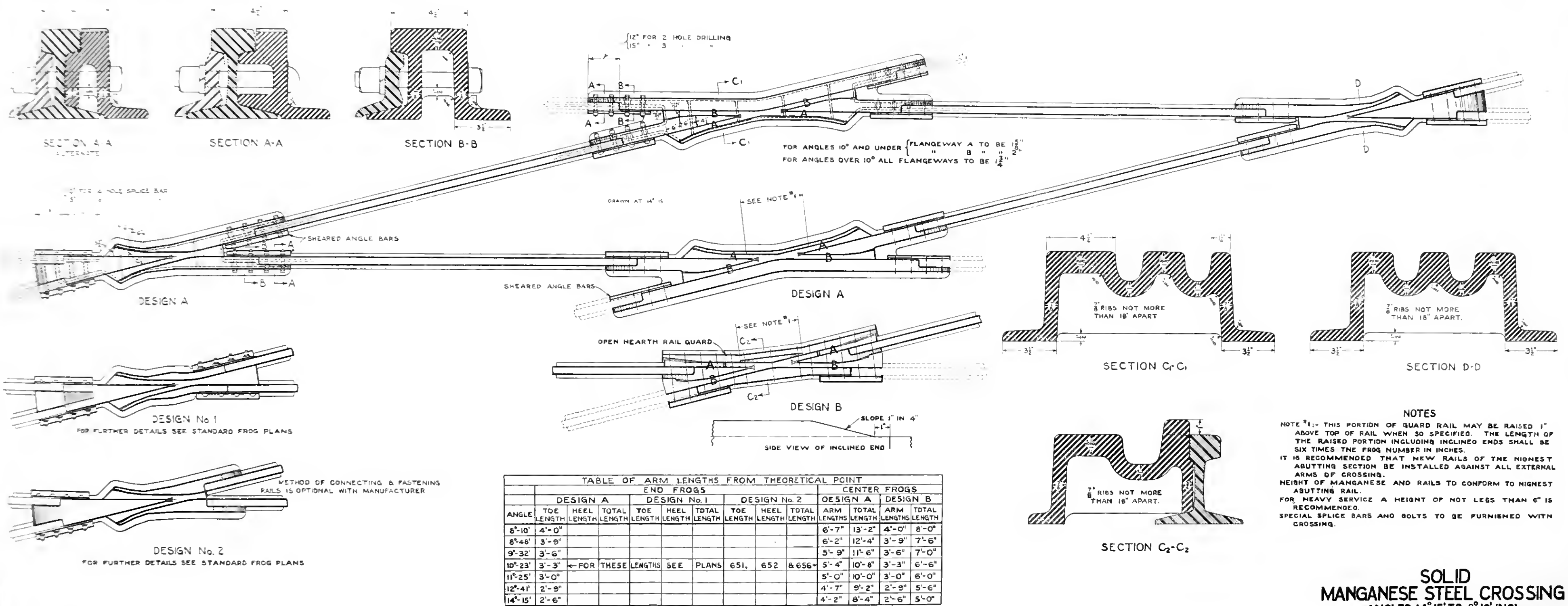


TABLE OF ARM LENGTHS FROM THEORETICAL POINT

	END FROGS									CENTER FROGS			
	DESIGN A			DESIGN No. 1			DESIGN No. 2			DESIGN A		DESIGN B	
ANGLE	TOE LENGTH	HEEL LENGTH	TOTAL LENGTH	TOE LENGTH	HEEL LENGTH	TOTAL LENGTH	TOE LENGTH	HEEL LENGTH	TOTAL LENGTH	ARM LENGTHS	TOTAL LENGTH	ARM LENGTHS	TOTAL LENGTH
8°-10'	4'-0"									6'-7"	13'-2"	4'-0"	8'-0"
8°-48'	3'-9"									6'-2"	12'-4"	3'-9"	7'-6"
9°-32'	3'-6"									5'-9"	11'-6"	3'-6"	7'-0"
10°-23'	3'-3"	←FOR	THESE	LENGTHS	SEE	PLANS	651,	652	& 656→	5'-4"	10'-8"	3'-3"	6'-6"
11°-25'	3'-0"									5'-0"	10'-0"	3'-0"	6'-0"
12°-41'	2'-9"									4'-7"	9'-2"	2'-9"	5'-6"
14°-15'	2'-6"									4'-2"	8'-4"	2'-6"	5'-0"

NOTE;- FOR INTERMEDIATE ANGLES USE LENGTHS SPECIFIED FOR NEXT SMALLER ANGLE.

NOTES

NOTE #1;- THIS PORTION OF GUARD RAIL MAY BE RAISED 1" ABOVE TOP OF RAIL WHEN SO SPECIFIED. THE LENGTH OF THE RAISED PORTION INCLUDING INCLINED ENDS SHALL BE SIX TIMES THE FROG NUMBER IN INCHES.

IT IS RECOMMENDED THAT NEW RAILS OF THE HIGHEST ABUTTING SECTION BE INSTALLED AGAINST ALL EXTERNAL ARMS OF CROSSING.

HEIGHT OF MANGANESE AND RAILS TO CONFORM TO HIGHEST ABUTTING RAIL.

FOR HEAVY SERVICE A HEIGHT OF NOT LESS THAN 6" IS RECOMMENDED.

SPECIAL SPLICE BARS AND BOLTS TO BE FURNISHED WITH CROSSING.

SOLID
MANGANESE STEEL CROSSING
ANGLES 14°-15' TO 8°-10' INCL.
SINGLE RAIL CONSTRUCTION

DEC. 1925 **PLAN 775**

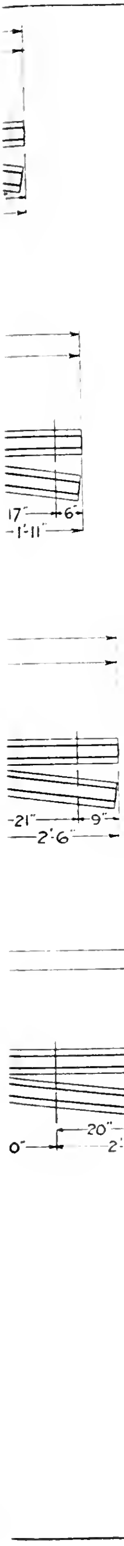
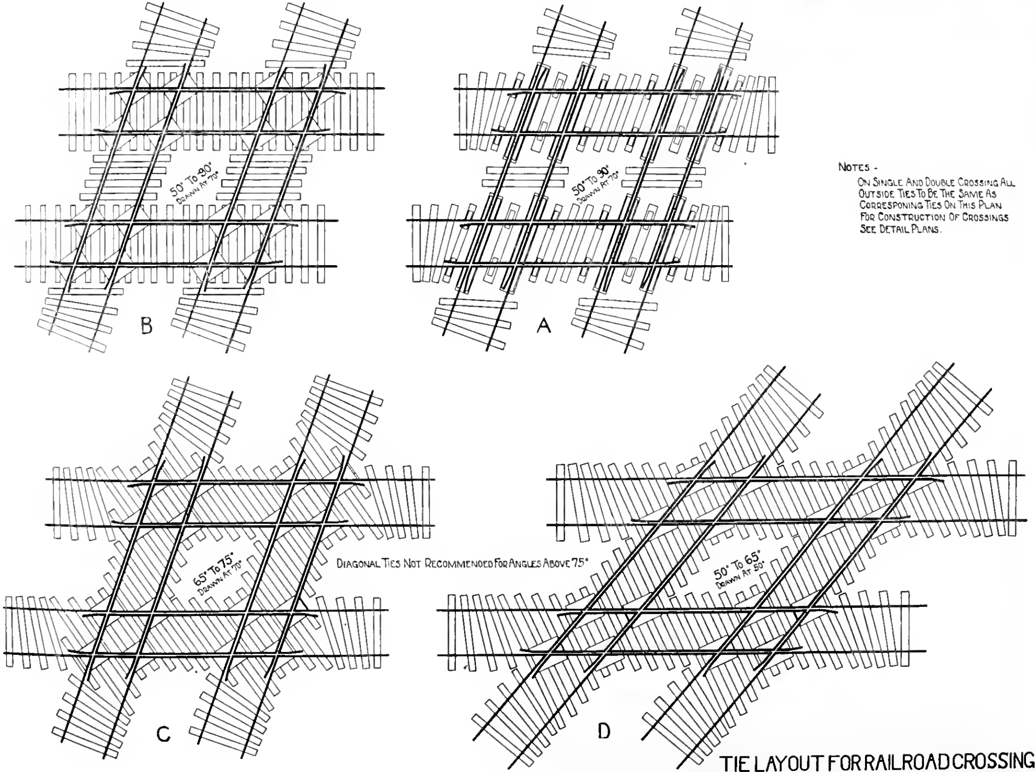

17"
6"
1'-11"
-21"
9"
2'-6"
20"
0"
2'-

Exhibit B-4



NOTES -

ON SINGLE AND DOUBLE CROSSING ALL OUTSIDE TIES TO BE THE SAME AS CORRESPONING TIES ON THIS PLAN
FOR CONSTRUCTION OF CROSSINGS SEE DETAIL PLANS.

TIE LAYOUT FOR RAILROAD CROSSINGS

ANGLES 50° TO 90°

DECEMBER 1925

PLAN 720

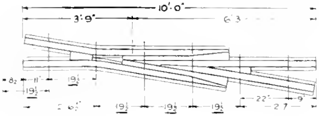
CHES			FLANGE WAY
D	K	L	G
$1\frac{97}{128}$	$3\frac{63}{64}$	$\frac{7}{8}$	2
$1\frac{19}{32}$	$3\frac{21}{32}$	$\frac{7}{8}$	2
$1\frac{83}{128}$	$3\frac{27}{32}$	$\frac{7}{8}$	2
$1\frac{43}{64}$	$3\frac{31}{32}$	$\frac{7}{8}$	2
$1\frac{43}{64}$	$3\frac{107}{128}$	$\frac{7}{8}$	2
$1\frac{11}{16}$	$3\frac{43}{64}$	$\frac{7}{8}$	2

FLANGE WAY	INCHES	
G	A	D
$1\frac{7}{8}$	$3\frac{3}{4}$	$1\frac{55}{64}$
$1\frac{7}{8}$	$3\frac{3}{4}$	$1\frac{55}{64}$
$1\frac{29}{32}$	$3\frac{3}{4}$	$1\frac{55}{64}$
$1\frac{29}{32}$	$3\frac{3}{4}$	$1\frac{55}{64}$
$1\frac{7}{8}$	$3\frac{13}{16}$	$1\frac{13}{16}$
$1\frac{117}{128}$	$3\frac{13}{16}$	$1\frac{13}{16}$
$2\frac{1}{128}$	$3\frac{13}{16}$	$1\frac{13}{16}$
2	$3\frac{13}{16}$	$1\frac{13}{16}$
$1\frac{117}{128}$	$3\frac{13}{16}$	$1\frac{13}{16}$
$1\frac{57}{64}$	$3\frac{43}{64}$	$1\frac{45}{64}$
$1\frac{7}{8}$	$3\frac{43}{64}$	$1\frac{45}{64}$
$1\frac{7}{8}$	$3\frac{57}{64}$	$1\frac{3}{4}$
$1\frac{119}{128}$	$3\frac{57}{64}$	$1\frac{3}{4}$

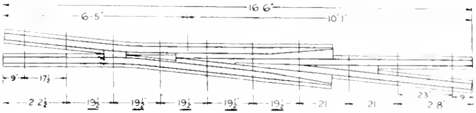
NGE Y	INCHES		
	A	a	D
	$3\frac{95}{128}$	$3\frac{77}{128}$	$1\frac{11}{16}$
	$3\frac{95}{128}$	$3\frac{77}{128}$	$1\frac{11}{16}$
	$3\frac{113}{128}$	$3\frac{25}{32}$	$1\frac{91}{128}$
	$3\frac{113}{128}$	$3\frac{25}{32}$	$1\frac{91}{128}$
	$3\frac{15}{16}$	$3\frac{7}{8}$	$1\frac{15}{16}$
	$3\frac{15}{16}$	$3\frac{7}{8}$	$1\frac{15}{16}$
	$3\frac{47}{64}$	$3\frac{41}{64}$	$1\frac{3}{4}$
	$3\frac{47}{64}$	$3\frac{41}{64}$	$1\frac{3}{4}$

Exhibit B-5

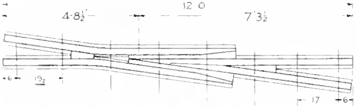
②



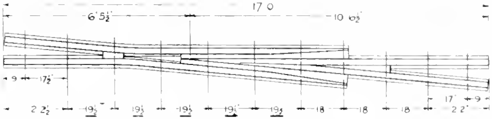
NO 6 FROG



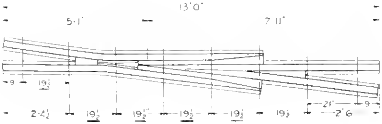
NO 10 FROG



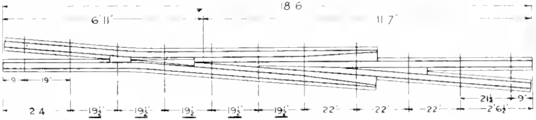
NO 7 FROG



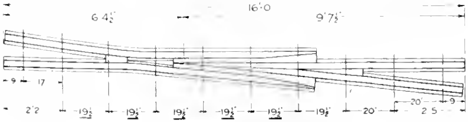
NO 11 FROG



NO 8 FROG



NO 12 FROG



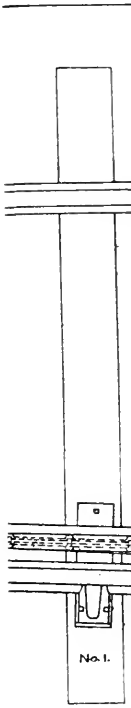
NO 9 FROG

NOTE
TIE SPACINGS UNDERLINED THUS, 19½" MUST BE ADHERED TO FOR ONE-PIECE 6 TIE GUARD RAIL, 19" TO 20" SPACING

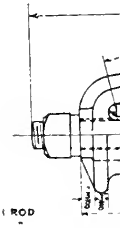
TIE LAYOUT
STANDARD LENGTH RIGID FROGS
FOR
ONE PIECE GUARD RAIL
6 TIES 19" TO 20" SPACING
SUSPENDED JOINTS

NOVEMBER 1925

PLAN NO. 321



E OMITTED, WHI
PLACED 17" FRO
OR INTERLOCKIN



FOR USE
80 RA-
107 N

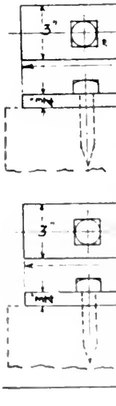
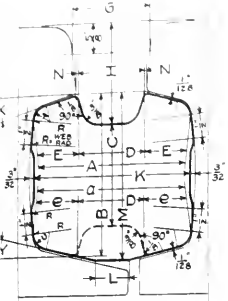
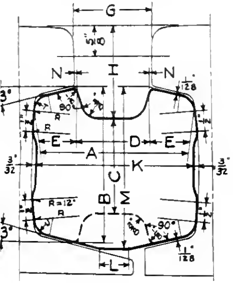


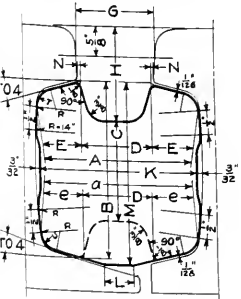
Exhibit B-6



DETAIL D
INDIVIDUAL ROLLS



DETAIL E
VERTICAL WEB GROUPING



DETAIL F
TAPERED WEB GROUPING

SECTION	FLANGE WAY G	INCHES A	a	D	K	L	FLANGE WAY G	INCHES A	a	D	K	L	FLANGE WAY G	DIMENSIONS IN INCHES A	a	D	K	L	E	e	N	H	B	C	M	T	U	R	X	Y
130-PS	1 3/4	3 127/128	3 57/64	1 61/128	3 55/64	3/4	1 7/8	4 15/128	4 1/64	1 97/128	3 63/64	7/8	2	4 31/128	4 9/64	1 113/128	4 7/64	1	1 23/128	1 33/256	1/16	2 1/8	4 19/64	3 3/64	4 13/32	9/16	13/16	16	18°	14°
100-PS	1 3/4	3 37/64	3 37/64	1 19/32	3 17/32	3/4	1 7/8	3 45/64	3 45/64	1 19/32	3 21/32	7/8	2	3 53/64	3 53/64	1 23/32	3 25/32	1	1 7/128	1 7/128	1/16	2 1/8	3 49/128	2 1/8	3 35/64	3/8	5/8	10	15°	13°
130-RE	1 3/4	3 105/128	3 11/16	1 67/128	3 23/32	3/4	1 7/8	3 121/128	3 13/16	1 83/128	3 27/32	7/8	2	4 9/128	3 15/16	1 99/128	3 31/32	1	1 19/128	1 21/256	1/16	2 1/4	4 7/16	2 57/64	4 17/32	9/16	13/16	14	1 TO 4	1 TO 4
105-DY	1 3/4	3 117/128	3 107/128	1 35/64	3 27/32	3/4	1 7/8	4 15/128	3 123/128	1 43/64	3 31/32	7/8	2	4 31/128	4 11/128	1 51/64	4 3/32	1	1 57/256	1 37/256	1/16	2 1/8	4 11/64	2 13/32	4 35/128	9/16	13/16	14	1 TO 4	1 TO 4
100-RA	1 3/4	3 87/128	3 43/64	1 35/64	3 67/128	3/4	1 7/8	3 113/128	3 51/64	1 43/64	3 103/128	7/8	2	4 1/128	3 59/64	1 51/64	3 119/128	1	1 27/256	1 1/16	1/16	2 1/8	4 5/64	2 63/128	4 63/128	7/16	7/16	14	1 TO 4	1 TO 4
90-GN	1 3/4	3 45/64	3 39/64	1 9/16	3 35/64	3/4	1 7/8	3 53/64	3 47/64	1 11/16	3 43/64	7/8	2	3 61/64	3 35/64	1 13/16	3 51/64	1	1 9/128	1 3/128	1/16	1 7/8	3 1/2	2 1/16	3 19/32	1/2	11/16	14	13°	13°

GROUP NUMBER	SECTION	FLANGE WAY G	INCHES A	D	K	FLANGE WAY G	INCHES A	D	K	FLANGE WAY G	DIMENSIONS IN INCHES A	D	K	E	N	H	B	C	L	M	T	U
1	85 AS	1 3/4	3 5/8	1 47/64	3 9/16	1 7/8	3 3/4	1 55/64	3 11/16	2	3 7/8	1 63/64	3 13/16	1 21/128	1/128	1 59/64	3 21/64	2	3/4	3 7/16	3/8	3/8
	85 CBQ	1 3/4	3 5/8	1 47/64	3 9/16	1 7/8	3 3/4	1 55/64	3 11/16	2	3 7/8	1 63/64	3 13/16	1 21/128	5/128 UNDER	1 59/64	3 21/64	2	3/4	3 7/16	3/8	3/8
	80 AS	1 25/32	3 5/8	1 47/64	3 9/16	1 29/32	3 3/4	1 55/64	3 11/16	2 1/32	3 7/8	1 63/64	3 13/16	1 21/128	3/128	1 7/8	3 13/64	1 7/8	3/4	3 5/16	3/8	3/8
	90 RB	1 25/32	3 5/8	1 47/64	3 9/16	1 29/32	3 3/4	1 55/64	3 11/16	2 1/32	3 7/8	1 63/64	3 13/16	1 21/128	1/128	1 63/64	3 13/64	1 7/8	3/4	3 5/16	3/8	3/8
2	90 AS	1 3/4	3 11/16	1 11/16	3 5/8	1 7/8	3 13/16	1 13/16	3 3/4	2	3 15/16	1 15/16	3 7/8	1	1/32	1 123/128	3 29/64	2 1/8	3/4	3 9/16	3/8	3/8
	100 RB	1 101/128	3 11/16	1 11/16	3 5/8	1 117/128	3 13/16	1 13/16	3 3/4	2 5/128	3 15/16	1 15/16	3 7/8	1	3/256	2 9/128	3 29/64	2 1/8	3/4	3 9/16	3/8	3/8
	100 CNW	1 113/128	3 11/16	1 11/16	3 5/8	2 1/128	3 13/16	1 13/16	3 3/4	2 17/128	3 15/16	1 15/16	3 7/8	1	1/16	1 125/128	3 35/64	2 7/32	3/4	3 83/128	3/8	3/8
	90 CNW	1 7/8	3 11/16	1 11/16	3 5/8	2	3 13/16	1 13/16	3 3/4	2 1/8	3 15/16	1 15/16	3 7/8	1	1/16	1 29/32	3 35/64	2 7/32	3/4	3 83/128	3/8	3/8
	100 P&R	1 101/128	3 11/16	1 11/16	3 5/8	1 117/128	3 13/16	1 13/16	3 3/4	2 5/128	3 15/16	1 15/16	3 7/8	1	3/256	2 9/128	3 29/64	2 1/8	3/4	3 9/16	3/8	3/8
3	100 CNW	1 49/64	3 35/64	1 37/64	3 1/2	1 57/64	3 43/64	1 45/64	3 5/8	2 1/64	3 51/64	1 53/64	3 3/4	63/64	15/256	1 125/128	3 35/64	2 7/32	3/4	3 83/128	3/8	3/8
	90 CNW	1 3/4	3 35/64	1 37/64	3 1/2	1 7/8	3 43/64	1 45/64	3 5/8	2	3 51/64	1 53/64	3 3/4	63/64	15/256	1 29/32	3 35/64	2 7/32	3/4	3 83/128	3/8	3/8
4	100 AS	1 3/4	3 49/64	1 5/8	3 3/4	1 7/8	3 57/64	1 3/4	3 7/8	2	4 1/64	1 7/8	4	1 9/128	1/16	2 1/16	3 23/32	2 3/8	3/4	3 107/128	5/16	5/16
	100 IRT	1 108/128	3 49/64	1 5/8	3 3/4	1 119/128	3 57/64	1 3/4	3 7/8	2 7/128	4 1/64	1 7/8	4	1 9/128	0	2 1/16	3 23/32	2 3/8	3/4	3 107/128	5/16	5/16

NOTE -
SINGLE GROOVE FILLER SHOWN IN SOLID LINES - THE BOTTOM GROOVE OF DOUBLE GROOVE FILLER SHOWN IN DOTTED LINES.

GROUP NUMBER	SECTION	FLANGE WAY G	INCHES A	a	D	K	FLANGE WAY G	INCHES A	a	D	K	FLANGE WAY G	DIMENSIONS IN INCHES A	a	D	K	E	e	N	H	B	C	L	M	T	U
5	90 RA	1 3/4	3 79/128	3 61/128	1 9/16	3 63/128	1 7/8	3 95/128	3 77/128	1 11/16	3 79/128	2	3 111/128	3 93/128	1 13/16	3 95/128	1 7/256	245/256	1/16	1 63/64	3 13/16	2 1/8	3/4	3 117/128	7/16	7/16
	90 SF	1 3/4	3 79/128	3 61/128	1 9/16	3 63/128	1 7/8	3 95/128	3 77/128	1 11/16	3 79/128	2	3 111/128	3 93/128	1 13/16	3 95/128	1 7/256	245/256	1/16	1 63/64	3 13/16	2 1/8	3/4	3 117/128	7/16	7/16
6	110 RE	1 3/4	3 97/128	3 21/32	1 75/128	3 83/128	1 7/8	3 113/128	3 25/32	1 91/128	3 99/128	2	4 1/128	3 29/32	1 107/128	3 115/128	1 11/128	1 9/256	5/128	2 1/4	4 3/32	2 11/32	3/4	4 15/64	7/16	11/16
	100 RE	1 51/64	3 97/128	3 21/32	1 75/128	3 83/128	1 59/64	3 113/128	3 25/32	1 91/128	3 99/128	2 3/64	4 1/128	3 29/32	1 107/128	3 115/128	1 11/128	1 9/256	1/16	2 3/16	3 31/32	2 7/32	3/4	4 5/64	7/16	11/16
7	100 GN	1 49/64	3 13/16	3 3/4	1 13/16	3 11/16	1 57/64	3 15/16	3 7/8	1 15/16	3 13/16	2 1/64	4 1/16	4	2 1/16	3 15/16	1	31/32	1/16 UNDER	2 1/32	3 41/64	2 3/16	3/4	3 99/128	7/16	11/16
	85 S00	2	3 13/16	3 3/4	1 13/16	3 11/16	2 1/8	3 15/16	3 7/8	1 15/16	3 13/16	2 1/4	4 1/16	4	2 1/16	3 15/16	1	31/32	1/16	1 7/8	3 35/64	2 3/32	3/4	3 87/128	7/16	11/16
8	85 NK	1 3/4	3 39/64	3 31/64	1 5/8	3 1/2	1 7/8	3 47/64	3 41/64	1 3/4	3 5/8	2	3 55/64	3 49/64	1 7/8	3 3/4	127/128	119/128	5/128	1 7/8	3 9/16	2 1/8	3/4	3 87/128	7/16	7/16
	85 S00	1 26/32	3 38/64	3 31/64	1 5/8	3 1/2	1 29/32	3 47/64	3 41/64	1 3/4	3 5/8	2 1/32	3 55/64	3 49/64	1 7/8	3 3/4	127/128	119/128	5/128	1 7/8	3 35/64	2 3/32	3/4	3 85/128	7/16	7/16

FROG FILLERS
FOR RAILS 80 LBS PER YD. AND HEAVIER

NOVEMBER 1925

PLAN NO. 325

ATE OF AC
By A

.... Adopte
.... Adopte
.... Adopte
.... Adopte
.... Adopte
.... Adopte
.... Adopte
.... Adopte

Split
.... Adopte
Split
.... Adopte

.... Adopte
.... Adopte
ates) Adopte
lates
.... Adopte
Over
.... Adopte
Over
.... Adopte
Over
ches) Adopte
Over
ches) Adopte

tches Adopte
tches Adopte
r for
.... Adopte

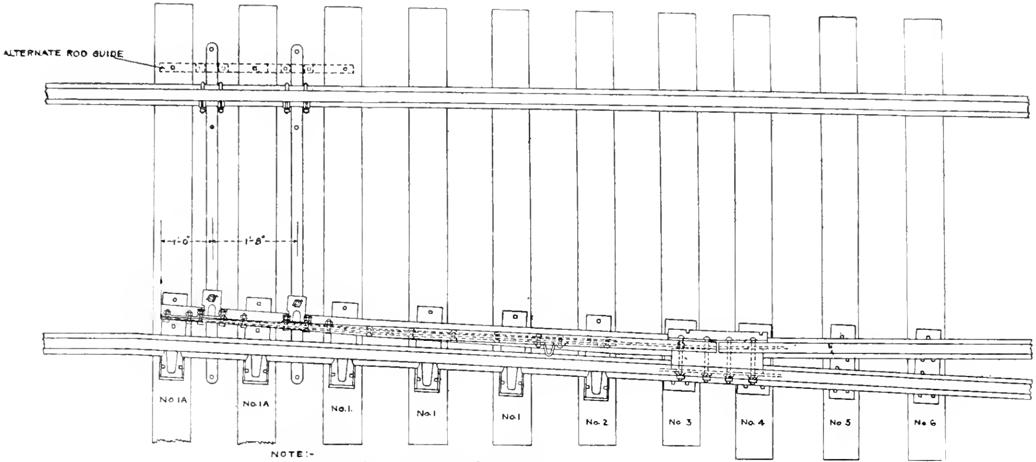
....*Inform

vitch
.... Adopte
.... Adopte
.... Adopte
.... Adopte

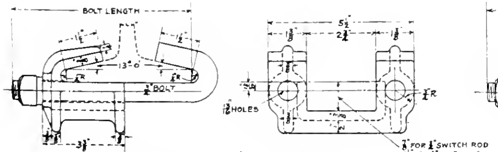
.... Adopte
.... Adopte
.... Adopte
.... Adopte
.... Adopte
.... Adopte
.... Adopte
.... Adopte
....*Inform

American Ra

Exhibit B-7

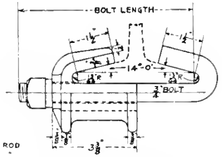


NOTE:-
ONE ROD MAY BE OMITTED WHEN SO SPECIFIED.
HEAD ROD TO BE PLACED 17" FROM POINT WHEN REQUIRED TO PROVIDE FOR INTERLOCKING CONNECTIONS.

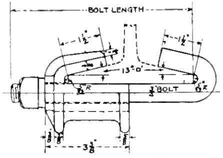


ROD GUIDE (MALL IRON OR CAST STEEL)

FOR USE WITH RAIL SECTIONS -
80RB - 85PS - 90RB - 100PS - 100RE - 100RG - 130PS - 130RE



FOR USE WITH RAIL SECTIONS:-
80RA - 90RA - 100RA - 100RE - 110RE - 107NH - 115DY



FOR USE WITH RAIL SECTIONS:-
70AS - 75AS - 80AS - 85AS - 90AS - 100AS - 75DY - 80DY - 85DY - 85PR - 100NH - 100DY - 105DY.

HOOK BOLTS FOR ROD GUIDE

BOLT LENGTH	RAIL SECTIONS
6 3/4"	70AS-75AS-80RA-80RB-85PS
7"	75DY-80DY-80AS-85DY-85PR-90RB
7 1/4"	85AS-90RA-100RB-100PS.
7 1/2"	90AS-100NH-100DY-105DY-100RE-100RG
7 3/4"	100AS-100RA-107NH-115DY-110RE
8 1/4"	130PS-130RE.

NOTES:-

LENGTHS OF SWITCH POINTS AND DETAILS OF SWITCH FITTINGS ARE TO BE IN CONFORMITY WITH PLANS 101, 102, 103 OR 104.

SPECIAL MATERIAL TO BE ORDERED IS ROD GUIDES AND HOOK BOLTS.

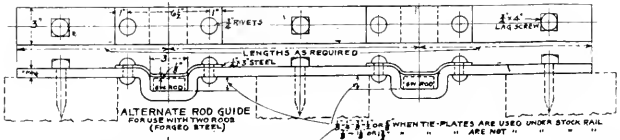
STANDARD MATERIAL TO BE ORDERED BY REFERENCES TO PRESENT PLANS AND SPECIFICATIONS, AS FOR INSTANCE, RIGHT OR LEFT HAND SWITCH POINT WITH TWO OR ONE NO. 1 SWITCH RODS AS MAY BE DESIRED, AND ONE-HALF SET OF PLATES AND BRACES, AND OTHER EQUIPMENT DESIRED AS PER PLAN No. 210 OR 211.

EXAMPLE:- PLAN No 101 - SPECIFICATION - A.

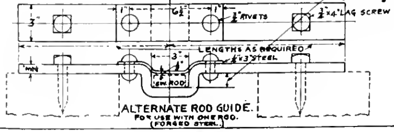
		DETAIL NO.
1 DOUBLE REINFORCED SWITCH POINT, 16'-6", COMPLETE WITH DETAILS:- (GIVE RAIL SECTION, SPLICE DRILLING AND HAND DESIRED)	FOR PLANING	2000
	FOR SWITCH CLIPS	1012
	FOR STOP	1024
2 (OR 1) SWITCH RODS No 1.		1010
9 BRACES		1023
9 SLIDE PLATES - 2 No. 1A AND 7 No. 1.		1020
2 HEEL PLATES -	1 No. 3-H	1040
	1 No. 4-H	1041
3 TURNOUT PLATES -	1 No. 5-H	1043
	1 No. 6-H	1046
	1 No. 7-H	1047

SPECIAL MATERIAL:-
2 (OR 1) ROD GUIDES, COMPLETE WITH HOOK BOLTS.
OR 1 (DOUBLE) OR (SINGLE) FORGED STEEL ROD GUIDE.

ARRANGEMENT OF STOCK RAIL EXTENSION AND PROVISION FOR GUARD RAILS WHERE REQUIRED, MAY BE INSTALLED TO MEET LOCAL CONDITIONS AND TO MEET REQUIREMENTS OF LOCAL LAWS



ALTERNATE ROD GUIDE
FOR USE WITH TWO RODS
(FORGED STEEL)



ALTERNATE ROD GUIDE.
FOR USE WITH ONE ROD.
(FORGED STEEL.)

DETAILS FOR

SPLIT SWITCH POINT DERAIL

NOVEMBER 1924.
REVISED - NOVEMBER 1925

PLAN Nº 213

TE OF ACCE
By A. R

es.. Adopted
... Adopted
... Adopted
... Adopted
... Adopted
... Adopted

... Adopted
... Adopted
... Adopted
... Adopted
... Adopted
... Adopted
aser
... Adopted
and
... Adopted
aser
.... Adopted
' to
... Adopted
y—
... Adopted
y—
... Adopted

° to
... Adopted
° to
... Adopted
10',
... Adopted
sive Adopted
sive Adopted
sive Adopted
sive Adopted
gles
... Adopted
°15' Adopted
gles
... Adopted
°15' Adopted
sive Adopted
sive Adopted
gles
.... Adopted
gles
.... Adopted
gles
.... Adopted
.... Adopted
.... Adopted

gn—
....*Inform.

Exhibit B-8

INDEX

March, 1925

Switches

Split Switches, Layouts

PLAN No.	PLAN Date	TITLE	DATE OF ACCEPTANCE By A. R. E. A.
101	Sep. 15, 1919	16′ 6″ Split Switch with Uniform Risers	Adopted Mar., 1920
102	Sep. 15, 1919	16′ 6″ Split Switch with Graduated Risers	Adopted Mar., 1920
103	Sep. 15, 1919	11′ 0″ Split Switch with Uniform Risers	Adopted Mar., 1920
104	Sep. 15, 1919	11′ 0″ Split Switch with Graduated Risers	Adopted Mar., 1920
105	Sep. 15, 1919	22′ 0″ Split Switch with Uniform Risers	Adopted Mar., 1920
106	Sep. 15, 1919	22′ 0″ Split Switch with Graduated Risers	Adopted Mar., 1920
107	Sep. 15, 1919	30′ 0″ Split Switch with Uniform Risers	Adopted Mar., 1920
108	Sep. 15, 1919	30′ 0″ Split Switch with Graduated Risers	Adopted Mar., 1920

Diagrams of Preferred Names of Parts

PLAN No.	PLAN Date	TITLE	DATE OF ACCEPTANCE By A. R. E. A.
190	Sep. 15, 1919	Diagram illustrating Preferred Names of Parts for Split Switches with Uniform Risers	Adopted Mar., 1921
191	Sep. 15, 1919	Diagram illustrating Preferred Names of Parts for Split Switches with Graduated Risers	Adopted Mar., 1921

Split Switch Fixtures

PLAN No.	PLAN Date	TITLE	DATE OF ACCEPTANCE By A. R. E. A.
201	Sep. 15, 1919	Details of Split Switch Fixtures (General)	Adopted Mar., 1920
202	Sep. 15, 1919	Details of Split Switch Fixtures (Special Features)	Adopted Mar., 1920
203	Sep. 15, 1919	Details of Split Switch Fixtures (Heel Plates and Turnout Plates)	Adopted Mar., 1920
204	Sep. 15, 1919	Details of Split Switch Fixtures (Heel Plates and Turnout Plates for 22′ 0″ and 30′ 0″ Switches)	Adopted Mar., 1920
205	Nov., 1923	Details of Split Switch Fixtures for Rails 6½″ High and Over (General)	Adopted Mar., 1924
206	Nov., 1923	Details of Split Switch Fixtures for Rails 6½″ High and Over (Special Features)	Adopted Mar., 1924
207	Nov., 1923	Details of Split Switch Fixtures for Rails 6½″ High and Over (Heel Plates and Turnout Plates for 11′ 0″ and 16′ 6″ Switches)	Adopted Mar., 1924
208	Nov., 1923	Details of Split Switch Fixtures for Rails 6½″ High and Over (Heel Plates and Turnout Plates for 22′ 0″ and 30′ 0″ Switches)	Adopted Mar., 1924

Illustration Bills of Material

PLAN No.	PLAN Date	TITLE	DATE OF ACCEPTANCE By A. R. E. A.
210	Sep. 15, 1919	Illustration Bills of Material for 11′ 0″ and 16′ 6″ Split Switches	Adopted Mar., 1920
211	Sep. 15, 1919	Illustration Bills of Material for 22′ 0″ and 30′ 0″ Split Switches	Adopted Mar., 1920
212	Nov., 1923	Illustration Bills of Material for Rails 6½″ High and Over for 11′ 0″ and 16′ 6″ Split Switches	Adopted Mar., 1924

Derail Switch Point

PLAN No.	PLAN Date	TITLE	DATE OF ACCEPTANCE By A. R. E. A.
213	Nov., 1924	Details for Split Switch Point Derail	*Inform. Mar., 1925

Switch Stands

PLAN No.	PLAN Date	TITLE	DATE OF ACCEPTANCE By A. R. E. A.
251	Nov.17, 1920	Switch Stand Connecting Rods *and* Requisites for Switch Stands, including Connecting Rods	Adopted Mar., 1921
252	Nov., 1921	Detail of Lamp Tips for Switch Stands	Adopted Mar., 1922
253	Nov., 1922	Detail of Switch Stand Target Shapes	Adopted Mar., 1923
254	Nov., 1921	Day Target Discs for Switch Lamps	Adopted Mar., 1922

Frogs

Bolted Rigid Frogs

PLAN No.	PLAN Date	TITLE	DATE OF ACCEPTANCE By A. R. E. A.
301	Sep. 15, 1919	No. 6 Bolted Rigid Frog	Adopted Mar., 1920
302	Sep. 15, 1919	No. 7 Bolted Rigid Frog	Adopted Mar., 1920
303	Sep. 15, 1919	No. 8 Bolted Rigid Frog	Adopted Mar., 1920
304	Sep. 15, 1919	No. 10 Bolted Rigid Frog	Adopted Mar., 1920
305	Sep. 15, 1919	Detail of Plates for No. 6, 7, 8 and 10 Bolted Rigid Frogs	Adopted Mar., 1920
306	Sep. 15, 1919	No. 11 Bolted Rigid Frog	Adopted Mar., 1920
307	Sep. 15, 1919	No. 16 Bolted Rigid Frog	Adopted Mar., 1920
308	Sep. 15, 1919	Detail of Plates for No. 11, 16 and 20 Bolted Rigid Frogs	Adopted Mar., 1920
309	Oct. 19, 1920	No. 4 and No. 5 Bolted Rigid Frogs	*Inform. Mar., 1921
320	Nov., 1920	Data for Laying Out Bolted Rigid Frogs	Adopted Mar., 1921

Clamp Frogs

PLAN No.	PLAN Date	TITLE	DATE OF ACCEPTANCE By A. R. E. A.
331	Sep. 15, 1919	No. 6 Clamp Frog	Adopted Mar., 1921
332	Sep. 15, 1919	No. 7 Clamp Frog	Adopted Mar., 1921
333	Sep. 15, 1919	No. 8 Clamp Frog	Adopted Mar., 1921
334	Sep. 15, 1919	No. 10 Clamp Frog	Adopted Mar., 1921
335	Sep. 15, 1919	Detail of Plates for No. 6, 7, 8 and 10 Clamp Frogs	Adopted Mar., 1921

Diagrams of Preferred Names of Parts

PLAN No.	PLAN Date	TITLE	DATE OF ACCEPTANCE By A. R. E. A.
390	Sep. 15, 1919	Diagram illustrating Preferred Names of Parts for Bolted Rigid Frogs	Adopted Mar., 1921
391	Sep. 15, 1919	Diagram illustrating Preferred Names of Parts for Clamp Frogs	Adopted Mar., 1921

Spring Rail Frogs

PLAN No.	PLAN Date	TITLE	DATE OF ACCEPTANCE By A. R. E. A.
401	Sep. 15, 1919	No. 10 Spring Rail Frog	Adopted Mar., 1920
402	Sep. 15, 1919	No. 8 Spring Rail Frog	Adopted Mar., 1920
403	Sep. 15, 1919	No. 11 Spring Rail Frog	Adopted Mar., 1920
404	Nov., 1923	No. 10 Spring Rail Frog for Rails 6½″ High and Over	Adopted Mar., 1924
420	Nov., 1922	Data for Laying Out Spring Rail Frogs	Adopted Mar., 1923
490	Sep. 15, 1919	Diagram illustrating Preferred Names of Parts for Spring Rail Frogs	Adopted Mar., 1921

Guard Rails

PLAN No.	PLAN Date	TITLE	DATE OF ACCEPTANCE By A. R. E. A.
501	Nov., 1920	Details of Guard Rails	Adopted Mar., 1921
502	Nov., 1920	Details of Guard Rail Fixtures	Adopted Mar., 1921
590	Sep. 15, 1919	Diagram illustrating Preferred Names of Parts for Guard Rails	Adopted Mar., 1921

Frogs, Manganese

Rail Bound Manganese Steel Frogs

PLAN No.	PLAN Date	TITLE	DATE OF ACCEPTANCE By A. R. E. A.
601	Sep. 15, 1919	No. 6 Rail Bound Manganese Steel Frog	Adopted Mar., 1920
602	Sep. 15, 1919	No. 7 Rail Bound Manganese Steel Frog	Adopted Mar., 1920
603	Sep. 15, 1919	No. 8 Rail Bound Manganese Steel Frog	Adopted Mar., 1920
604	Sep. 15, 1919	No. 10 Rail Bound Manganese Steel Frog	Adopted Mar., 1920
605	Sep. 15, 1919	No. 11 Rail Bound Manganese Steel Frog	Adopted Mar., 1920
606	Sep. 15, 1919	No. 16 Rail Bound Manganese Steel Frog	Adopted Mar., 1920
607	Sep. 15, 1919	No. 20 Rail Bound Manganese Steel Frog	Adopted Mar., 1920
608	Oct. 19, 1920	No. 4 and No. 5 Rail Bound Manganese Steel Frogs	*Inform. Mar., 1921

Solid Manganese Steel Frogs

PLAN No.	PLAN Date	TITLE	DATE OF ACCEPTANCE By A. R. E. A.
651	Sep. 15, 1919	No. 6 Solid Manganese Steel Frog	Adopted Mar., 1920
652	Sep. 15, 1919	No. 7 Solid Manganese Steel Frog	Adopted Mar., 1920
653	Sep. 15, 1919	No. 8 Solid Manganese Steel Frog	Adopted Mar., 1920
654	Sep. 15, 1919	No. 10 Solid Manganese Steel Frog	Adopted Mar., 1920
655	Sep. 15, 1919	No. 11 Solid Manganese Steel Frog	Adopted Mar., 1920
656	Oct. 19, 1920	No. 4 and No. 5 Solid Manganese Steel Frogs	*Inform. Mar., 1921
670	Nov., 1920	Standard Dimensions for Solid Manganese Steel Frogs	Adopted Mar., 1921

Diagrams of Preferred Names of Parts

PLAN No.	PLAN Date	TITLE	DATE OF ACCEPTANCE By A. R. E. A.
690	Sep. 15, 1919	Diagram illustrating Preferred Names of Parts for Rail Bound Manganese Steel Frogs	Adopted Mar., 1921
691	Sep. 15, 1919	Diagram illustrating Preferred Names of Parts for Solid Manganese Steel Frogs	Adopted Mar., 1921

The star (*) indicates the plan has been accepted as information only by the American Railway Engineering Association.

NDEX

tion or as i
1925 Inde

F

; Plan 213
on March,
.... Fo
One Piece
Joints... As i
.... As i
.... As i
90°..... As i
istruction,
.... As i
istruction,
.... As i
road over
e........ F

tion

higher rails s
tin 257, Page 2

m 4½ in. to 3

, correcting ty

(Supplement

1, to ⅞ in. (

ished when sc
1925.)

the two bolts
wing rails.)
(Supplement

ished when sc

r right hand co
Page 18; ado

Exhibit B-9

INDEX

March, 1925

Crossings

PLAN No.	PLAN Date	TITLE	DATE OF ACCEPTANCE By A. R. E. A.
700	Nov., 1921	Application of Crossing Designs and Recommended Practices	Adopted Mar., 1922
700-A		Data and Record Sheet for Ordering Crossings	Adopted Mar., 1923
700-A	Example No. 1	Data and Record Sheet for Ordering Crossings	Adopted Mar., 1923
700-A	Example No. 2	Data and Record Sheet for Ordering Crossings	Adopted Mar., 1923
700-B	Nov., 1924	Data and Record Sheet for Ordering Compromise Joints	Adopted Mar., 1925
700-C	Nov., 1924	Data and Record Sheet for Ordering Compromise Rails	Adopted Mar., 1925

Bolted Rail Crossings

PLAN No.	PLAN Date	TITLE	DATE OF ACCEPTANCE By A. R. E. A.
701	Oct., 1921	Three Rail Design—Angles 90° to 50°, inclusive	Adopted Mar., 1922
702	Oct., 1921	Two Rail Design—Angles 90° to 50°, inclusive	Adopted Mar., 1922
703	Oct., 1921	Three Rail Design—Angles below 50° to 35°, inclusive	Adopted Mar., 1922
704	Oct., 1921	Two Rail Design—Angles below 50° to 35°, inclusive	Adopted Mar., 1922
705	Oct., 1921	Three Rail Design—Angles below 35° to 25°, inclusive	Adopted Mar., 1922
706	Oct., 1921	Two Rail Design—Angles below 35° to 25°, inclusive	Adopted Mar., 1922
707	Oct., 1921	Single Rail Design and Two Rail Design with Short Easer Rails—Angles below 25° and above 14° 15′	Adopted Mar., 1922
708	Oct., 1921	Single Rail Design and Two Rail Design—Angles below 25° and above 14° 15′	Adopted Mar., 1922
709	Oct., 1921	Single Rail Design and Two Rail Design with Short Easer Rails—Angles 14° 15′ to 8° 10′, inclusive	Adopted Mar., 1922
710	Oct., 1921	Single Rail Design and Two Rail Design—Angles 14° 15′ to 8° 10′, inclusive	Adopted Mar., 1922
716	Nov., 1924	Bolted Rail Crossings, Steam Railroad over Electric Railway—Angles 90° to 50°, inclusive	Adopted Mar., 1925
717	Nov., 1924	Bolted Rail Crossings, Steam Railroad over Electric Railway—Angles below 50° to 30°, inclusive	Adopted Mar., 1925

Manganese Steel Insert Crossings

PLAN No.	PLAN Date	TITLE	DATE OF ACCEPTANCE By A. R. E. A.
751	Nov., 1920	Designs and Dimensions of Inserts, Detail A—Angles 45° to above 14° 15′	Adopted Mar., 1922
752	Nov., 1920	Designs and Dimensions of Inserts, Detail B—Angles 45° to above 14° 15′	Adopted Mar., 1922
753	Nov., 1920	Designs and Dimensions of Inserts—Angles 14° 15′ to 8° 10′, inclusive	Adopted Mar., 1922
754	Oct., 1921	Three Rail Design, Detail A—Angles below 45° to 35°, inclusive	Adopted Mar., 1922
755	Oct., 1921	Two Rail Design, Detail A—Angles below 45° to 35°, inclusive	Adopted Mar., 1922
756	Oct., 1921	Three Rail Design, Detail A—Angles below 35° to 25°, inclusive	Adopted Mar., 1922
757	Oct., 1921	Two Rail Design, Detail A—Angles below 35° to 25°, inclusive	Adopted Mar., 1922
758	Oct., 1921	Two Rail Design with Short Easer Rails, Detail A—Angles below 25° and above 14° 15′	Adopted Mar., 1922
759	Oct., 1921	Two Rail Design, Detail A—Angles below 25° and above 14° 15′	Adopted Mar., 1922
760	Oct., 1921	Single Rail Design with Short Easer Rails, Detail A—Angles below 25° and above 14° 15′	Adopted Mar., 1922
761	Oct., 1921	Single Rail Design, Detail A—Angles below 25° and above 14° 15′	Adopted Mar., 1922
762	Oct., 1921	Three Rail Design, Detail B—Angles below 45° to 35°, inclusive	Adopted Mar., 1922
763	Oct., 1921	Three Rail Design, Detail B—Angles below 35° to 25°, inclusive	Adopted Mar., 1922
764	Oct., 1921	Two Rail Design with Short Easer Rails, Detail B—Angles below 35° to 25°, inclusive	Adopted Mar., 1922
765	Oct., 1921	Two Rail Design with Short Easer Rails, Detail B—Angles below 25° and above 14° 15′	Adopted Mar., 1922
766	Oct., 1921	Single Rail Design with Short Easer Rails, Detail B—Angles below 25° and above 14° 15′	Adopted Mar., 1922
767	Oct., 1921	Two Rail Design—Angles 14° 15′ to 8° 10′, inclusive	Adopted Mar., 1922
768	Oct., 1921	Single Rail Design—Angles 14° 15′ to 8° 10′, inclusive	Adopted Mar., 1922

Insulated Internal Joints

PLAN No.	PLAN Date	TITLE	DATE OF ACCEPTANCE By A. R. E. A.
770	Nov., 1922	Insulated Internal Joint for Crossings, Three Rail Design—Angle below 45° to 25°, inclusive	*Inform. Mar., 1923

Solid Manganese Crossings

PLAN No.	PLAN Date	TITLE	DATE OF ACCEPTANCE By A. R. E. A.
771	Nov., 1923	Solid Manganese Steel Crossings—Angles 90° to 60°, inclusive.	Adopted Mar. 1924
771-B	Nov., 1924	Solid Manganese Steel Crossings—Angles 90° to 60°, inclusive, Design No. 2 and Design No. 3, Alternates for Design detailed on Plan 771	*Inform. Mar., 1925
772	Nov., 1923	Solid Manganese Steel Crossings—Angles below 60° to 40°, inclusive	Adopted Mar., 1924
773	Nov., 1924	Solid Manganese Steel Crossings—Angles below 40° to 30°, inclusive	Adopted Mar., 1925
776	Nov., 1923	Solid Manganese Steel Crossings, Steam Railroad over Electric Railway—Angles 90° to 60°, inclusive	Adopted Mar., 1924
777	Nov., 1923	Solid Manganese Steel Crossings, Steam Railroad over Electric Railway—Angles below 60° to 40°, inclusive	Adopted Mar., 1924

Tables for Gages and Flangeways

PLAN No.	PLAN Date	TITLE	DATE OF ACCEPTANCE By A. R. E. A.
791	Nov., 1921	*Table No.* 1—Gages and Flangeways in Curved Track	Adopted Mar., 1922
792	Nov., 1921	*Table No.* 2—Gages and Flangeways in Curved Track—Gage Diagrams for Rigid Wheel Base Locomotives	Adopted Mar., 1922

Double Slip Switches

Double Slip Switch Layouts

PLAN No.	PLAN Date	TITLE	DATE OF ACCEPTANCE By A. R. E. A.
801	Nov., 1922	No. 8 Double Slip Switch with Movable Center Points with Uniform Risers	Adopted Mar., 1923
802	Nov., 1922	No. 8 Double Slip Switch with Movable Center Points with Graduated Risers	Adopted Mar., 1923
803	Nov., 1923	No. 10 Double Slip Switch with Movable Center Points with Uniform Risers	Adopted Mar., 1924
804	Aug., 1923	No. 10 Double Slip Switch with Movable Center Points with Graduated Risers	Adopted Mar., 1924

Details of Double Slip Switches

PLAN No.	PLAN Date	TITLE	DATE OF ACCEPTANCE By A. R. E. A.
851	Nov., 1922	Details of No. 8 Double Slip Switch with Movable Center Points Uniform Risers	Adopted Mar., 1923
852	Nov., 1922	Details of No. 8 Double Slip Switch with Movable Center Points with Graduated Risers	Adopted Mar., 1923
853	Nov., 1923	Details of No. 10 Double Slip Switch with Movable Center Points with Uniform Risers	Adopted Mar., 1924
854	Aug., 1923	Details of No. 10 Double Slip Switch with Movable Center Points with Graduated Risers	Adopted Mar., 1924

Diagram of Preferred Names of Parts

PLAN No.	PLAN Date	TITLE	DATE OF ACCEPTANCE By A. R. E. A.
890	Nov., 1924	Diagram illustrating Preferred Names of Parts of Double Slip Switch with Movable Center Points	Adopted Mar., 1925

Turnouts and Crossovers

PLAN No.	PLAN Date	TITLE	DATE OF ACCEPTANCE By A. R. E. A.
900	Nov., 1920	Table of Practical Turnout Leads *and* Table of Theoretical Turnout Leads	Adopted Mar., 1921

Turnout and Crossover Layouts

PLAN No.	PLAN Date	TITLE	DATE OF ACCEPTANCE By A. R. E. A.
901	Sep. 20, 1920	Layout of No. 6 Turnout and Crossover	Adopted Mar., 1921
902	Sep. 20, 1920	Layout of No. 7 Turnout and Crossover	Adopted Mar., 1921
903	Sep. 20, 1920	Layout of No. 8 Turnout and Crossover with Rigid Frogs	Adopted Mar., 1921
904	Sep. 20, 1920	Layout of No. 8 Turnout and Crossover with Spring Frogs	Adopted Mar., 1921
905	Sep. 20, 1920	Layout of No. 10 Turnout and Crossover	Adopted Mar., 1921
906	Sep. 20, 1920	Layout of No. 11 Turnout and Crossover	Adopted Mar., 1921
907	Sep. 20, 1920	Layout of No. 16 Turnout and Crossover	Adopted Mar,, 1921
908	Sep. 20, 1920	Layout of No. 20 Turnout and Crossover	Adopted Mar., 1921
Index A		Specifications for the Design and Dimensions of Manganese Steel Pointed Switches	Adopted Mar., 1920
Index B		Specifications for Switches, Frogs, Crossings and Guard Rails.	Adopted Mar., 1921
Index B		Supplement to above—Manganese Steel Track Castings	Adopted Mar., 1922

The star (*) indicates the plan has been accepted as information only by the American Railway Engineering Association.

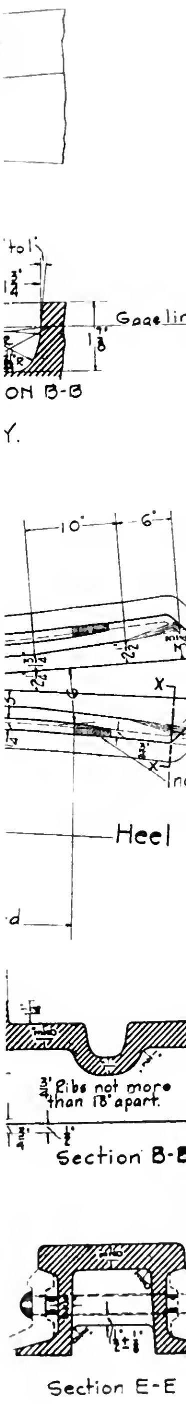

to 1
1 3/4
Gage line
1 7/8
ON B-B
Y.
10
6
2 1/2
X
In
Heel
d
3/4 Ribs not more than 18 apart.
Section B-B
Section E-E

Exhibit B-10

INDEX—SUPPLEMENT

March, 1926

Plans offered for adoption or as information March, 1926; also changes in Plans and Specifications listed in 1925 Index (Pages I and II) made since their last presentation

Plans Offered March, 1926

No. 213.	Dated Nov., 1925	Details for Split Switch Point Derail. (Replacing Plan 213 dated Nov. 1924, which was accepted as information March, 1925)	For adoption
No. 321.	Dated Nov., 1925	Tie Layouts for standard length Rigid Frogs for One Piece Guard Rail, 6 Ties, 19″ to 20″ spacing, Suspended Joints	As information
No. 325.	Dated Nov., 1925	Frog Fillers	As information
No. 643.	Dated Nov., 1925	No. 8 Solid Manganese Steel Self-Guarded Frog	As information
No. 720.	Dated Dec., 1925	Tie Layouts for Railroad Crossings, angles 50° to 90°	As information
No. 774.	Dated Dec., 1925	Solid Manganese Steel Crossing, Double Rail Construction, angles below 25° and above 14° 15′	As information
No. 775.	Dated Dec., 1925	Solid Manganese Steel Crossing, Single Rail Construction, angles 14° 15′ to 8° 10′ inclusive	As information
No. 778.	Dated Nov., 1925	Manganese Steel Insert Crossing, Steam Railroad over Electric Railway, angles below 45° to 30° inclusive	For adoption

Revisions to Plans Since Last Presentation

No. 101. Add the following note:
"All details apply only to rails under 6½ inches in height. For higher rails some of the details are subject to modification." (Supplement to Manual, Bulletin 257, Page 21; adopted March, 1923. See Plans 205 to 208 inclusive.)

Nos. 102, 103, 104, 105, 106, 107, 108, 201, 202 and **203.**
Same addition as Plan 101.

No. 204. Same addition as Plan 101.
Also change distance between spike holes on plate, Detail 2034, from 4½ in. to 3½ in. (Supplement to Manual, Bulletin 267, Page 23; adopted March, 1924.)

No. 210. Change third line under Section 8, first column, to read:
"Plate No. 1, 7 in. wide, Detail No. 2020," (instead of Plate No. 2, correcting typographical error.)

No. 251. Complete Section 11 so that it will read:
"Shapes and sizes of targets shall conform to plan No. 253." (Supplement to Manual, Bulletin 257, Page 21; adopted March, 1923.)

No. 252. Change two dimensions 9/32 in., given on diagram of lamp tip, type 61, to 7/32 in. (Supplement to Manual, Bulletin 267, Page 24; adopted March, 1924.)

No. 301. Change foot guard note under specifications to read:
"Additional foot guarding to that shown in plan view to be furnished when so specified." (Supplement to Manual, Bulletin 277, Page 18; adopted March, 1925.)

Nos. 302, 303, 304, 306, and **307.**
Same change as Plan 301.

No. 309. Same change as Plan 301.
Also, in plan view of No. 4 Frog omit the 5 in. dimension between the two bolts through the Heel Riser Block. (5 in. between bolts is not enough for beveled wing rails.)

No. 320. Change toe spread for No. 9 frog given in table from $8\frac{1}{16}$ in. to 8 in. (Supplement to Manual, Bulletin 267, Page 23; adopted March, 1924.)

Nos. 331, 332, 333 and **334.**
Same change as Plan 301.

Nos. 401, 402 and **403.**
Same addition as Plan 101; also same change as Plan 301.

No. 404. Same change as Plan 301.

No. 601. Same change as Plan 301.

No. 602. Change foot guard note under specifications to read:
"Additional foot guarding to that shown in plan view to be furnished when so specified."
Also change bolt spacing in heel extension to read:
5″, 5″, 6″, 5″ (instead of 5″, 5″, 5½″, 5½″).
Also change the 2½ in. dimension to 2 in. in partial plan view in lower right hand corner of plan just to the left of the title. (Supplement to Manual, Bulletin 277, Page 18; adopted March, 1925.)

No. 603. Same changes as Plan 602.

Nos. 604, 605, 606, 607 and **608.**
Same change as Plan 301.

No. 773. In title change to read:
"Angles below 40° to 25° inclusive," (instead of 40° to 30° inclusive.) (Submitted for adoption, March, 1926.)

No. 851. Change Plate Insulation Fibre, Detail 8016, to conform to Plans 202 and 206 (correcting error.)

No. 852. In lower left hand corner of plan (two places) change length of chamfer cut from 18 in. to 9 in. (Supplement to Manual, Bulletin 267, Page 23; adopted March, 1924.)

Revisions to Specifications

SPECIFICATIONS FOR SWITCHES, FROGS, CROSSINGS AND GUARD RAILS, AS PUBLISHED 1921 MANUAL, PAGES 214 TO 220, INCLUSIVE

Section 14 (Bolts), add the following paragraph:
"Bolts with countersunk heads, button heads or cone heads shall be provided with locking necks or other effective locking means to keep bolts from turning." (Submitted for adoption, March, 1926.)

Section 24 (Nut Locks), change to read as follows:
"Spring Washers. For heat treated or high tensile bolts, spring washers shown on trackwork plans shall conform to specifications of the American Railway Engineering Association for high spring pressure, and where nutlocks (N.L.) are specified on present trackwork plans the term "spring washers" shall be understood." (Submitted for adoption, March, 1926.)

Section 38 (Fit of Bolts), change first sentence to read:
"Main or body bolts in bolted rigid frogs and bolted rail crossings shall have a tight fit in straight, true holes." (Supplement to Manual, Bulletin 267, Page 24; adopted March, 1924.)

Section 39 (Rivets), change last sentence to read:
"Countersunk rivets shall be flush with the surface and fill the countersink, except that rivets through base plates and tie plates may have a crown of not more than ⅛ in. below the lower surface of the plate." (Supplement to Manual, Bulletin 277, Page 17; adopted March, 1925.)

SUPPLEMENT (Add Sections 48 and 49)

MANGANESE STEEL TRACK CASTINGS

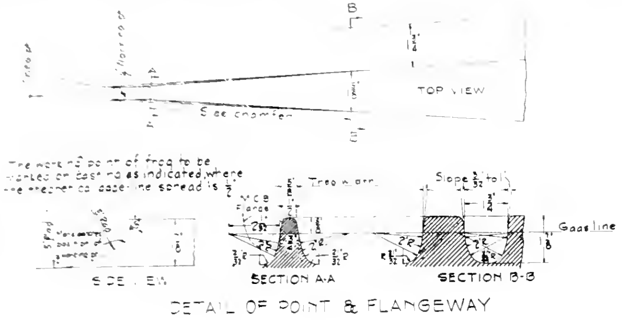
Section 48. General Conditions. Castings shall be reasonably smooth and true to pattern in accordance with good foundry practice. Large lumps, sharp fins, sand and chills on the outside of castings shall be removed. The castings shall be free from such blow holes, sand holes, cracks, cold shuts and other defects which would impair their serviceability and as further specified below. Castings must be out of twist and reasonably true, both as to general surface and alinement, and must not show any signs of straining or undue denting produced in the straightening process.

The bottom part of castings which rest on ties shall be reasonably straight and out of twist, and shall be free from lumps or such imperfections as would prevent a good bearing.

Section 49. Imperfections. Tread surfaces within 2½ in. of gage line and side of groove 1 in. down from tread shall be free from physical defects, such as shrinkage cracks, sand holes, blow holes, cold shuts or segregation of metal, unless such defects are so small that they have been practically removed by the finish grinding, and there must be no indication of unsoundness of the metal. Shrinkage cracks, cold shuts or segregation of metal will not be allowed in any part of the tread surfaces. Sand holes, blow holes and cold shuts in portions of the casting where they will not appreciably weaken the casting, or impair its wearing qualities, will be permitted. Castings must be free from shrinkage cracks running vertically in web members of solid work or horizontally at or near the ends or in corners of junction of projecting members or longitudinally in grooves. Other small shrinkage cracks which do not materially weaken the casting will be acceptable.

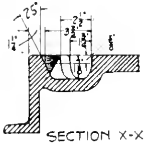
(Supplement to 1921 Manual, Bulletin No. 249, Part 1, dated Sept., 1922, Page 7, adopted March, 1922.)

Exhibit B-11

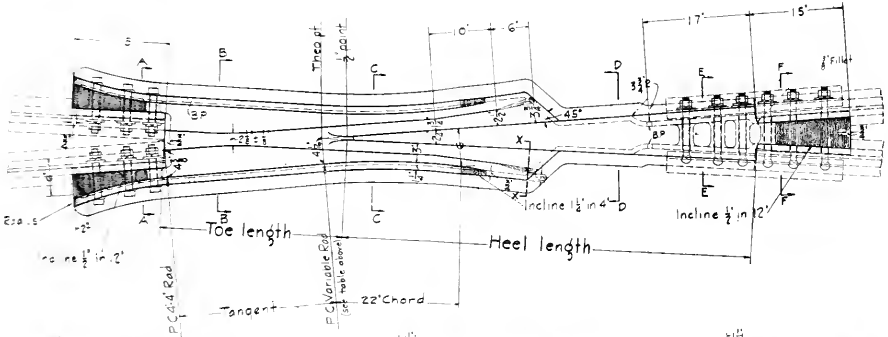


CASTING DATA

HEIGHT OF CONN RAILS	HEIGHT OF CASTING
4$\frac{1}{2}$" to 4$\frac{11}{16}$" incl	4$\frac{3}{4}$"
4$\frac{3}{4}$" to 5$\frac{1}{16}$" incl	5"
5$\frac{1}{8}$" to 5$\frac{7}{16}$" incl	5$\frac{1}{4}$"
5$\frac{1}{2}$" to 5$\frac{11}{16}$" incl	5$\frac{3}{4}$"
5$\frac{3}{4}$" to 6$\frac{1}{16}$" incl	6$\frac{1}{8}$"
6$\frac{1}{8}$" to 6$\frac{7}{16}$" incl	6$\frac{1}{2}$"



CLASS		HEEL LENGTH	TOE LENGTH	TOTAL LENGTH	VARIABLE RADIUS
A	Rail base 5$\frac{5}{8}$" down but not incl 5$\frac{3}{8}$" Rail head 2$\frac{1}{2}$" to 2$\frac{5}{8}$" incl, or rail head at or exceeding 2$\frac{3}{4}$" when head & base do not exceed 8$\frac{5}{8}$"	5'-5"	2'-5"	7'-10"	8'-11"
B	Rail base 5$\frac{3}{8}$" down but not incl 5$\frac{1}{8}$" Rail head 2$\frac{7}{16}$" to 2$\frac{5}{8}$" incl, or rail head at or exceeding 2$\frac{5}{8}$" when head & base do not exceed 8$\frac{5}{16}$"	5'-3"	2'-4"	7'-7"	8'-10"
C	Rail base 5$\frac{1}{8}$" down but not incl 5" Rail head 2$\frac{5}{16}$" to 2$\frac{1}{2}$" incl or rail head at or exceeding 2$\frac{1}{2}$" when head & base do not exceed 7$\frac{15}{16}$"	5'-0"	2'-3"	7'-3"	8'-9"
D	Rail base 5" down but not incl 4$\frac{5}{8}$" Rail head 2$\frac{11}{16}$" to 2$\frac{3}{8}$" incl, or rail head at or exceeding 2$\frac{11}{16}$" when head & base do not exceed 7$\frac{11}{16}$"	4'-10"	2'-1"	6'-11"	8'-7"



NOTES.

All special length splice-bar bolts for connecting adjoining rails to be furnished with frog. Bolts to have hexagon nuts, and nutlocks, - unless otherwise specified.

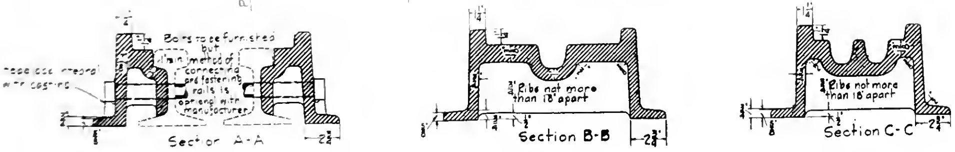
Splice bars not to be furnished with frog unless specified or when special bars are required. Maximum length of splice-bars to be used, 30 inches.

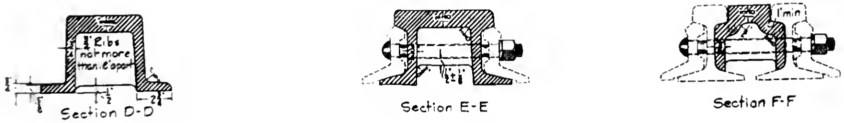
One or more plug inserts of iron or soft steel, to allow for drilling of electrical bond holes, to be cast in vertical walls, as indicated by 'BP' on drawing, when so specified.

Bolt holes through casting to be ⅛ inch larger than bolt diameter.

Heel and Toe extensions may be made 12 inches long for 4 hole splice bars.

Base flange of manganese casting may be extended at tie locations, of approved design, for additional tie supports when so specified, or tie plates may be used.





NO. 8 SELF GUARDED FROG
SOLID MANGANESE STEEL

ANGLE 7°09'10"

NOVEMBER 1925. PLAN NO. 643

plans and specifications on date of last printing; dates revisions were adopted and references as to plans and specifications affected, also listing plans to be offered March, 1926. This index should be found useful as a reference as to revisions, particularly as some of the plans have not been reprinted when revised.

A looseleaf book containing all the plans and specifications listed in these three index sheets, plans printed on good quality bond stock that will stand much handling and permit good blueprint copies will soon be available. These books are to be carried in stock by Secretary Fritch. The Committee recommends that all members of the Association interested make advance application for one or more copies of this book to Secretary Fritch at 431 South Dearborn Street, Chicago, so it can be determined how many copies to have printed. The cost will depend largely on number of books ordered from the printer at the same time and will be billed accordingly, probably at not over $5.00 each.

Revisions affecting the Manual are recommended in Appendix A.

"H"—SELF-GUARDED FROGS

The Committee offers as information to invite criticism and comment Plan No. 643 of No. 8 solid manganese self-guarded frog.

Since self-guarded frogs are extensively used and the basic patents having expired the Committee recommends completing plans of self-guarded solid manganese frogs of other frog numbers, also plans of self-guarded bolted rail frogs.

Conclusions

The Committee recommends that the following plans be adopted as recommended practice and printed in the Manual:

Plan No. 778, dated November, 1925, Manganese Steel Insert Crossings.

Plan No. 213, dated November, 1925, Details for Split Switch Point Derail.

The Committee also offers for information to invite criticism the following plans and index sheets:

Plan No. 774, dated December, 1925, Solid Manganese Steel Crossing.

Plan No. 775, dated December, 1925, Solid Manganese Steel Crossing.

Plan No. 720, dated December, 1925, Tie Layouts for Crossings.

Plan No. 321, dated November, 1925, Tie Layout Standard Length Rigid Frogs for One-Piece Guard Rail.

Plan No. 325, dated November, 1925, Frog Fillers.

Index, pages I and II, dated March, 1925, listing latest plans and specifications.

Index, page III, dated March, 1926, listing revisions not appearing on plans and specifications, also plans to be offered March, 1926.

Plan No. 643, dated November, 1925, No. 8 Solid Manganese Steel Self-Guarded Frog.

Appendix C

(3) SPECIFICATIONS AND DESIGN OF WOODEN HANDLES FOR TRACK TOOLS

T. T. Irving, Chairman, Sub-Committee; H. M. Brown, C. R. Harding, E. R. Lewis, F. H. Masters, S. B. McConnell, W. W. Morrison, J. V. Neubert, W. G. Nusz.

The specifications and plans submitted herewith have been prepared in collaboration with the various manufacturers and railroads.

SPECIFICATIONS FOR HICKORY HANDLES FOR TRACK TOOLS

MATERIAL

Handles shall be made of sound hickory. The wood shall be coarse grained and show not more than twenty rings of annual growth per inch, and after seasoning, shall weigh not less than 37½ lb. per cubic foot. It shall be straight grained, free from decay, knots, checks, worm holes, dip grain, bird peck or other injurious defects. The wood shall be thoroughly seasoned with a moisture content of not over fifteen per cent and not less than eight per cent.

PHYSICAL REQUIREMENTS

Handles shall be smooth, straight, and for each type of tool, uniform in size and shape. The grain of the wood must run parallel to the center line of handle, with an allowable variation of not over one in twenty. Handles which are warped or twisted will not be accepted.

DESIGN

Handles shall conform to the dimensions shown on the plan forming part of this specification, with an allowable variation of one-quarter inch in length, and one-sixteenth inch over or one-thirty-second inch under for all other dimensions.

MANUFACTURE

(a) Handles shall be smoothly finished and waxed. Handles finished with a coating of linseed oil instead of wax will be accepted when order so specifies.

(b) Each handle shall be plainly marked for identification as specified by the purchaser, with his initials or brand, burned or stamped with steel stencil, or when so ordered, marked with black paint. Marking unless otherwise specified by purchaser shall be placed near the hand grasp end of handles and letters must not be less than one-quarter inch in height.

INSPECTION

(a) Handles will be inspected at points of manufacture, shipment or destination in suitable and convenient places satisfactory to the purchaser.

(b) Inspectors representing the purchaser shall have free entry to the works of the manufacturer at all times while work on the contract of the purchaser is being performed, and shall have all reasonable facilities afforded them, free of cost, to satisfy them that the handles are being supplied in accordance with these specifications.

(c) Inspectors will make a reasonably close examination of each handle and the acceptance or rejection will be based on the inspector's knowledge of the appearance and weight of wood of the density required; rings of annual growth will not be counted nor handles weighed by scale unless the inspectors' decisions are questioned. Exactness of size and shape will be checked by accurate measurements of handles taken at random.

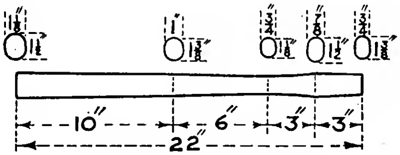
(d) Handles which show injurious defects subsequent to their acceptance at the place of manufacture or sale, shall be rejected and shall be replaced by the manufacturer at his own expense.

DELIVERY

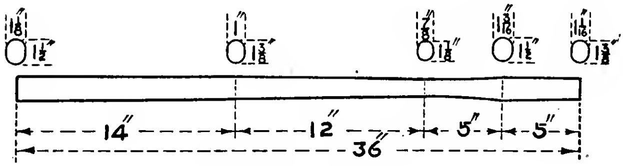
Accepted handles shall be shipped by the seller in accordance with the instructions in the order covering them; they shall be securely packed in standard packages, each of which shall be marked to show seller's or manufacturer's name and the number and type of the handles contained.

Conclusions

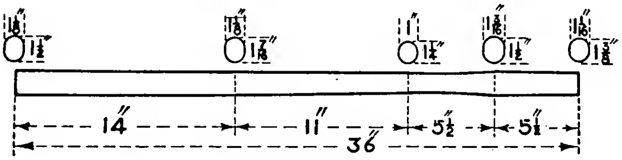
The Committee recommends that the plans and specifications offered herewith be adopted as recommended practice and printed in the Manual.



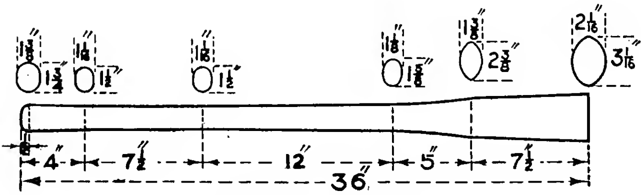
TRACK CHISEL



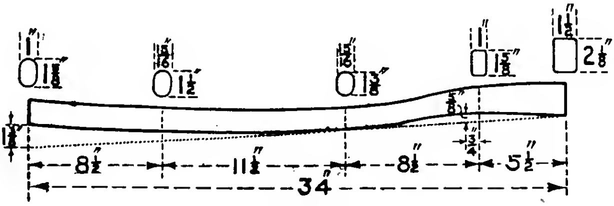
SPIKE MAUL



SLEDGE



CLAY PICK



ADZE

Track-Tool Handles

Appendix D

(4) EFFECT OF BRINE DRIPPINGS ON TRACK APPLIANCES AND TESTS OF TIE PLATES SUBJECT TO BRINE DRIPPINGS

E. D. Swift, Chairman, Sub-Committee; W. G. Brown, C. R. Harding, J. V. Neubert, W. G. Nusz, I. H. Schram, J. R. Watt.

The work of the Sub-Committee has consisted in the installation and observation of test tie plates in certain tracks of the Chicago Junction Railway at Union Stock Yards, Chicago.

Installation was made in the summer of 1921 and the test was terminated in June, 1925, when heavier rail was laid in the tracks.

There were twelve groups of these plates, totaling in all approximately 1300 plates. Some of the groups had received coatings or other protective treatment; others were untreated.

An inspection made six months after installation showed that all plates had collected some rust. Inspections of approximately every six months were made up to the time of the termination of the test.

Exhibit "A" shows graphically the percentages of loss in weight per ounce per inch of area of 10 plates from each group at the termination of the test. It also gives the important characteristics of the plates.

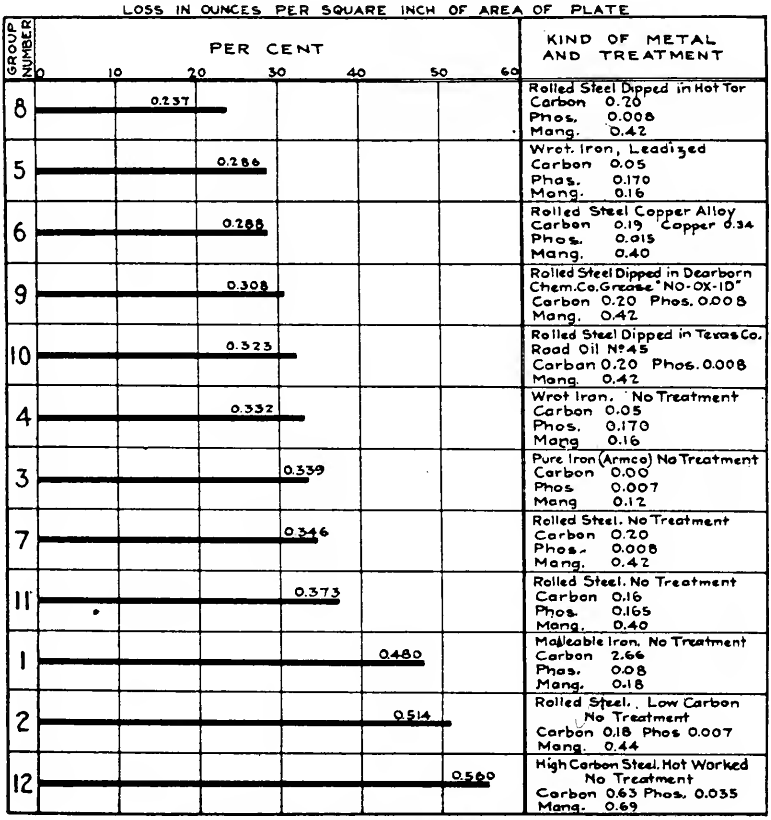
Exhibit "B" are photographs, one of the bottom and one of the top of specimen plates for each group. The plates shown are from the lots of 10 mentioned above and the views were taken before the plates were cleaned.

Conclusions

The Committee recommends that this report be received as information.

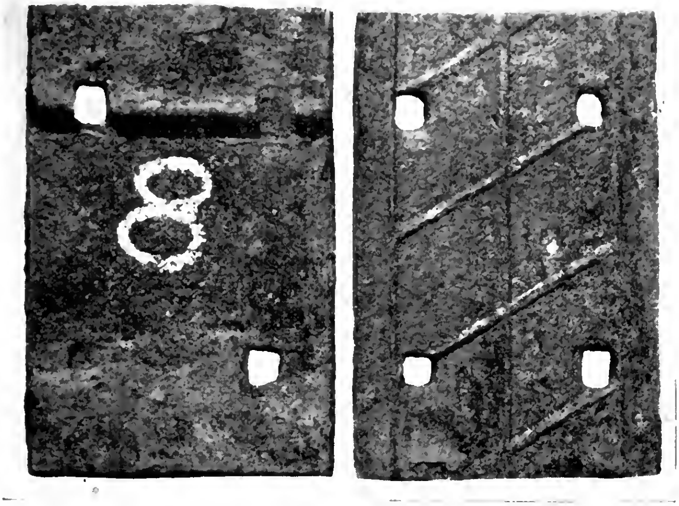
Exhibit A

RESULTS OF TESTS ON TIE PLATES SUBJECTED TO BRINE DRIPPINGS SHOWING LOSS OF WEIGHT BY CORROSION



Note: Plates in Groups 7, 8, 9 & 10 alike except for treatment.

Exhibit B



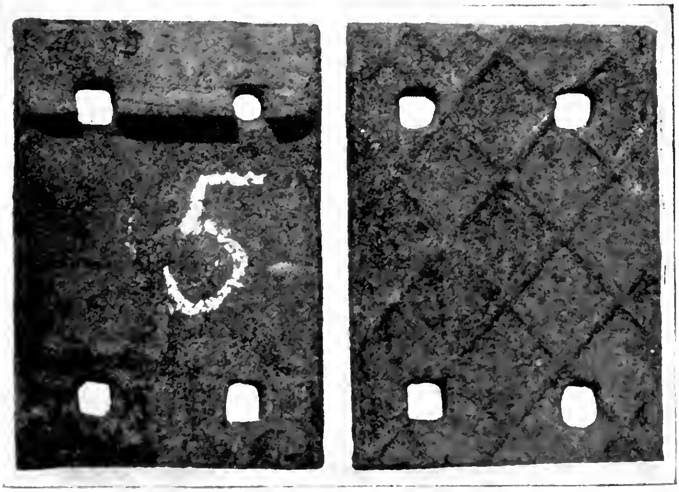
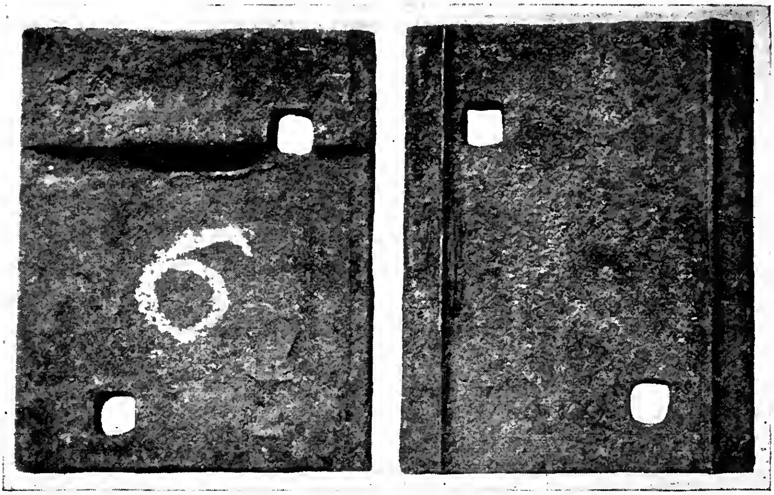


Exhibit B



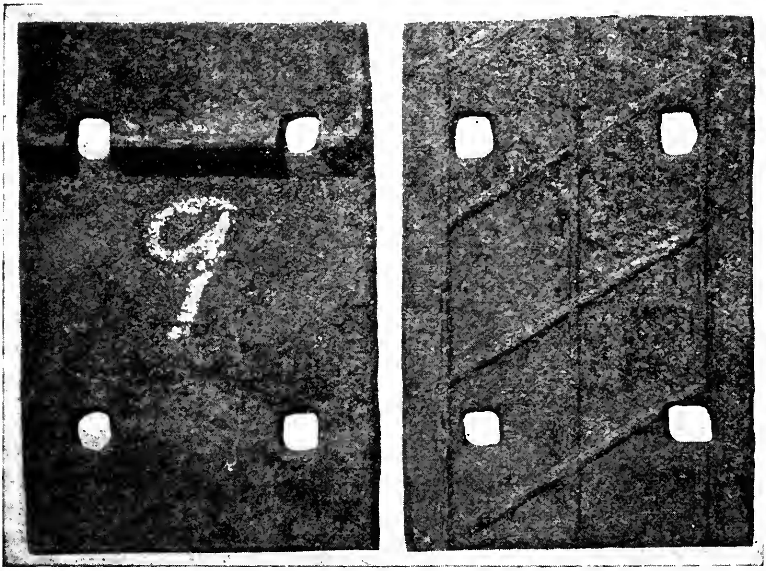
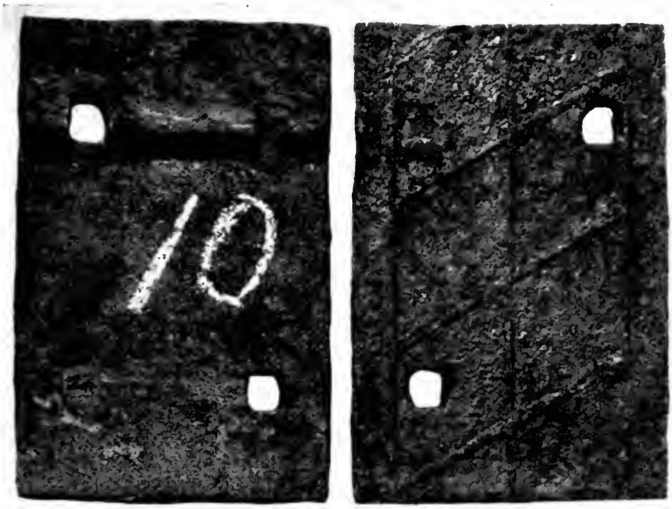
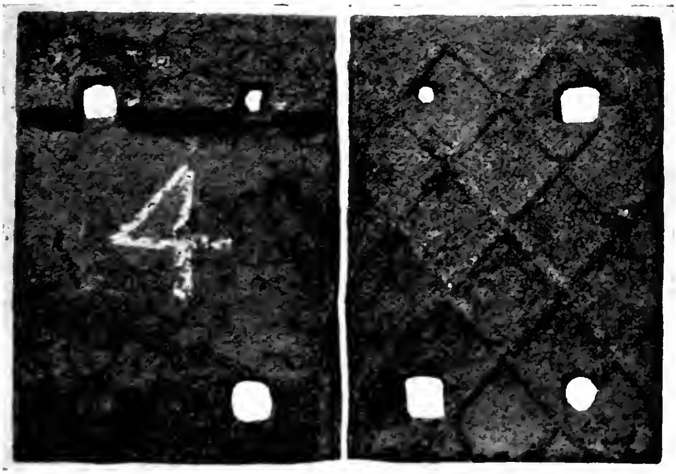
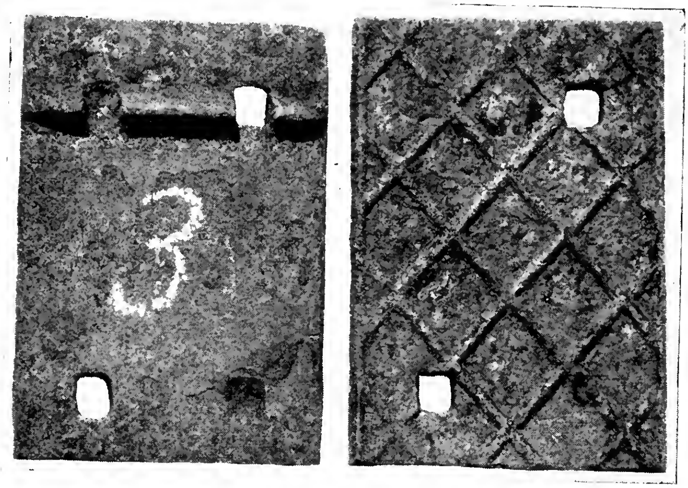


Exhibit B






3

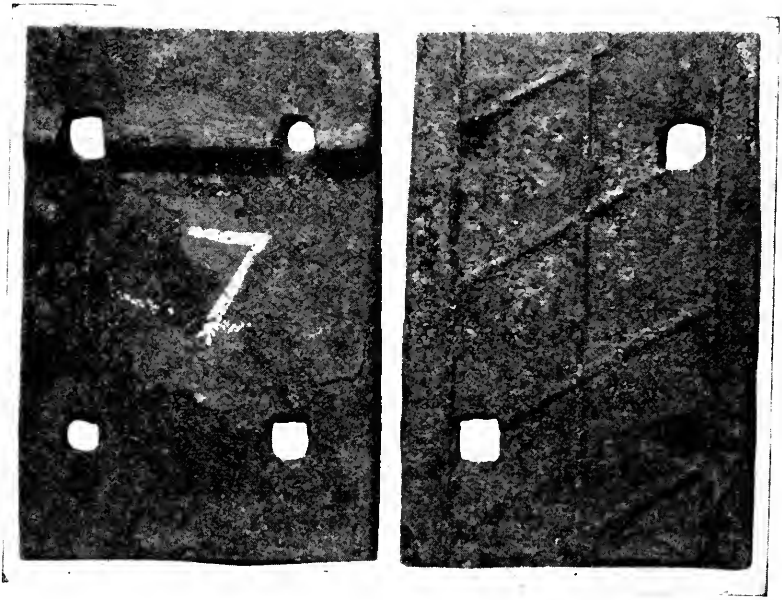
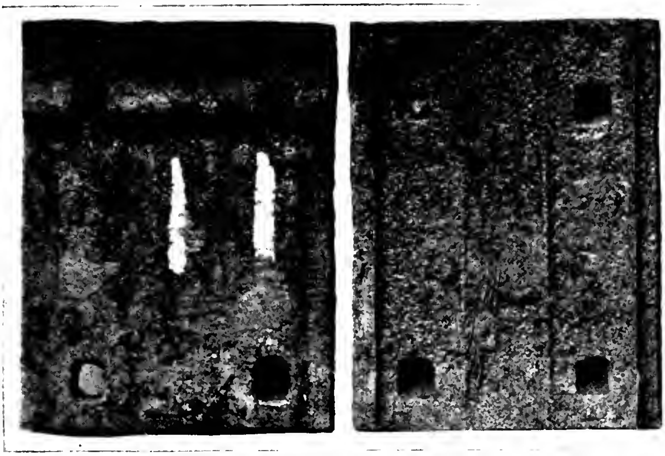

7

Exhibit B



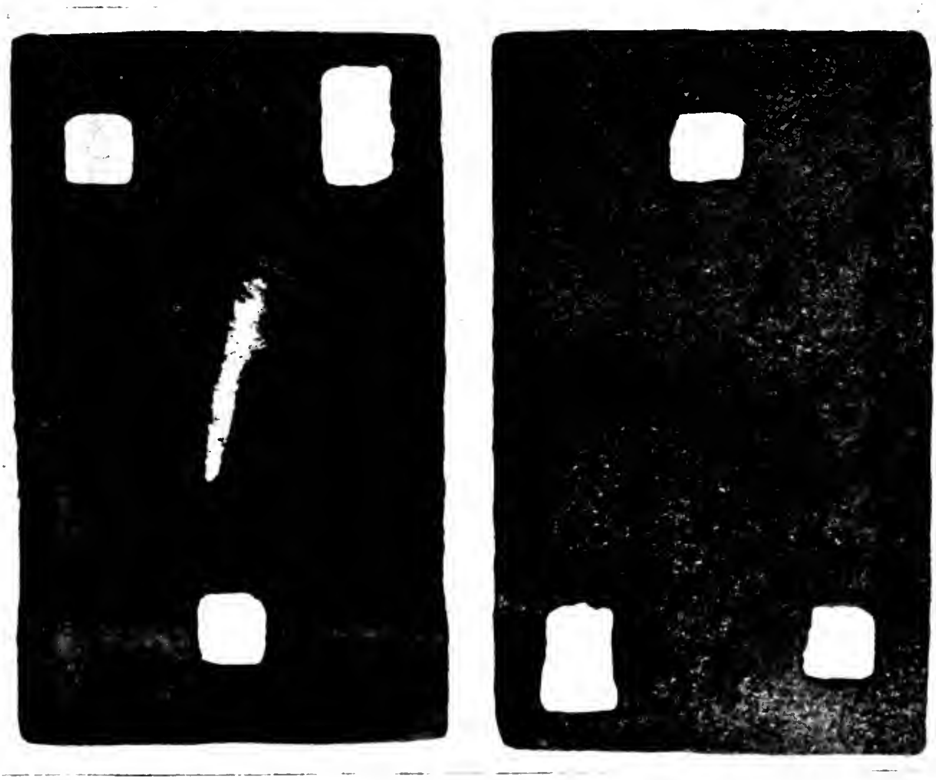
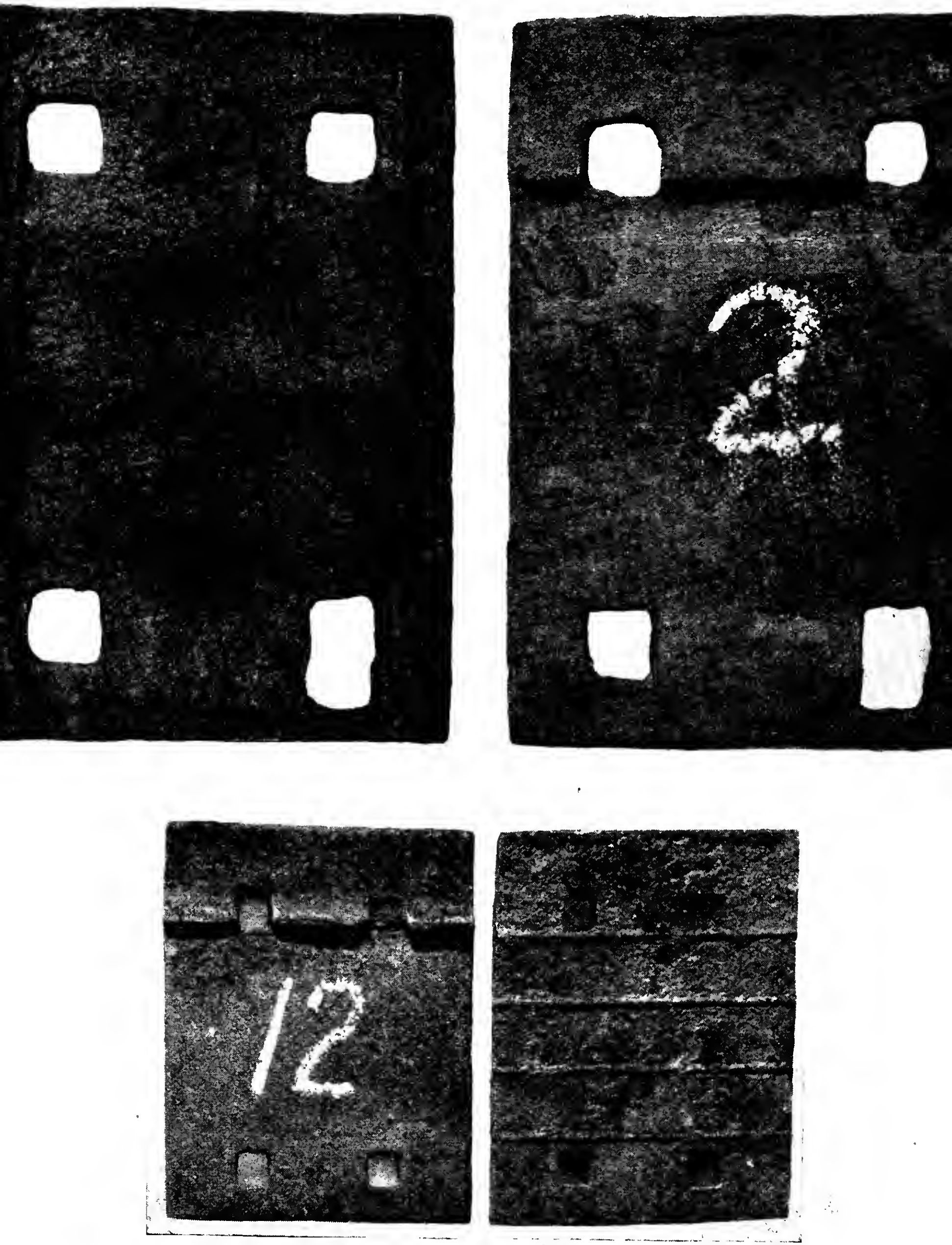


Exhibit B



Appendix E

(5) CANTING OF RAIL INWARD AND TAPER OF TREAD OF WHEEL

H. G. Clark, Chairman, Sub-Committee; C. R. Harding, H. D. Knecht, E. R. Lewis, S. B. McConnell, J. V. Neubert.

The Proceedings of the Association, Volume 26, pages 560 to 566 inclusive, contain a comprehensive discussion of the practices of 67 of the prominent railways relating to the canting of rail. To arrive at definite conclusions as to the desirability of this practice, reference was made to this report in a letter addressed to the Chief Engineers of the 47 largest railroads in the United States and Canada. They were asked to give their personal opinion as to whether or not canting of rail was favored, and if favorable, the reasons leading to that conclusion, and similarly if not favorable, the reasons therefor. The tabulation which follows was prepared for the purpose of defining the practice of the railroads or the personal comment of the Chief Engineers as to the desirability of canting rail.

Conclusions

1. The summary shows that 6 railroads, with a mileage of 37,664 or 16.7 per cent, are emphatically favorable to the canting of rail; 31 railroads, with a mileage of 129,151 or 57.3 per cent, are favorable; 7 railroads, with a mileage of 51,160 or 22.7 per cent, are unfavorable; and 3 railroads, with a mileage of 7,339 or 3.3 per cent, express an unformed opinion. Further summarized, 74.0 per cent of the mileage addressed favor the canting of rail; 22.7 per cent do not favor; and 3.3 per cent have an unformed opinion.

2. The practice of canting rail is gaining favor, and practically all railroads following this practice indicate that it reduces maintenance, provides a better bearing on the rail and a more uniform wear.

3. No special provisions through switches are necessary when canting rail except to bring rails gradually to a vertical position by adzing.

4. Practice differs as to the amount of cant, the preponderance of replies indicating either 1 in 20 or 1 in 40.

The recommendations of the Committee on Track are—

(1) That rail should be canted inwardly.
(2) That inclined tie plates should be used to produce the desired result.
(3) That the amount of cant should be left to the individual railroads.
(4) That these recommendations be printed in the Manual as its final report.

Appendix F

(6) METHODS OF DETERMINING RECOMMENDATIONS FOR RAIL RENEWALS

J. deN. Macomb, Chairman, Sub-Committee; W. J. Harris, C. R. Harding, R. L. Longshore, W. W. Morrison, J. V. Neubert, I. H. Schram.

This is a reassignment of the above subject reported to the annual convention of 1924 and published in Volume 25 of the Proceedings, pages 463 to 465 inclusive.

The additional material presented herewith covers consideration of the problem from the standpoint of track inspection, traffic density, etc.

Exhibit F

METHODS OF DETERMINING RECOMMENDATIONS FOR RAIL RENEWALS

Further study has been made, based on consideration of inspection, traffic density, etc., and it is recommended that the following items should be considered:

Track Inspection

Inspection of rail in track should be made, the track being gone over on a motor car at very moderate speed, and the following conditions noted:

(1) The amount of wear of rail should be determined preferably by the use of an instrument to take the contour of the rail.

On curves, this determines the degree to which the head has been worn away or has been distorted from its original section.

On tangent, this data is useful principally as information, as rail is usually retired from track for reasons other than the amount of wear on tangent.

(2) Wear spots along the gage edge of the head of the rail.

(3) Defective spots beginning to show in the rail.

(4) Driver burn spots of consequence.

(5) Chipped and battered rail ends.

(6) The amount which the rails which are not chipped are low at the ends.

(7) Kinks or any other bends in the rails.

(8) Condition of rail with respect to corrosion.

(9) Amount rails have worn under the head and on top of the base due to contact with the joint bars.

(10) Condition of the joint bars, particularly when there is not sufficient life left in the rails to justify renewal of the joints.

In addition to the preceding, the following conditions should be observed:

(11) Condition of ties (as, for instance, a mixture of soft and hardwood).

(12) Character and condition of ballast and roadbed.

The following notes may be made on the method of securing certain items listed above:

The counts of rails with wear spots and rails with driver burns should be made with tally registers while passing over the track slowly.

Also, notes should be made of the number of rails showing defective spots. Regarding these rails, the inspector should watch one side of track only; going over the track twice, if necessary, although where the rail on both sides of track was laid at the same time, the condition of the two rails will usually be found to be quite uniform.

Information in regard to chipped and battered rail ends, as well as amount which rails have worn down, also expansion in track, should be secured at convenient intervals by measurements at 10 or 20 joints by use of a straight edge provided at one end with a depth gage reading to one hundredths of an inch.

To eliminate, as far as possible, the effect of a low joint, the straight edge should be applied to each rail end separately.

In recording these rail end readings, notes should be made as to whether end was chipped or battered.

The amount of expansion should be determined by means of a taper gage (a steel wedge having graduations on one face showing each one hundredth of an inch increase in thickness of the wedge).

Temperatures of rail should be taken in connection with expansion measurements.

Where rail ends have been built up by welding, such fact should be noted.

As additional information, the gage of track should be recorded where other readings are being taken. (This is conveniently done by means of a two-piece extension rule.)

Office Statistics

The following statistics should be collected:

(1) Gross tons of traffic handled (both freight and passenger). (Railroads usually compile operating statistics from which this information may be taken direct, or estimated.)

(2) Characteristics of locomotives, especially total weight on drivers and weight of heaviest driver; also trailer; also weight of car loads, if excessive.

As the amount of traffic handled and unit loads are not the full measure of the life of rail, among others, the following items should also be taken into consideration:

(3) Gradients.

(4) Curvature.

(5) Record of rail failures.

Recommendation

Having available the above information, both from track inspection and office statistics, covering the stretch of track under investigation, the final recommendation as to whether the rail should be renewed at the particular time or not, will depend upon a combination of most or all of these items, bearing in mind the standard of maintenance in use by the company, as well as general conditions.

Under these circumstances, it is impossible to lay down any set of fixed rules which would be applicable to all railways generally, but it is believed that by carefully collecting this information in the field, and considering it in the office, considerable economies of maintenance may be effected and a much more uniform standard of maintenance attained than without such study.

Conclusions

It is recommended that this report be accepted as information and published in the Proceedings.

Appendix G

(7) DESIGN OF TIE PLATES

J. R. Watt, Chairman, Sub-Committee; L. B. Allen, H. W. Brown, H. G. Clark, J. W. DeMoyer, C. R. Harding, T. T. Irving, J. V. Neubert, E. D. Swift, W. P. Wiltsee.

The Committee submits herewith plan and table of dimensions for tie plates 9 to 12 inches long. These designs have been arrived at not only by analysis, as shown in Appendix "I," Bulletin 263, but also by careful study of the dimensions of tie plates in general use at the present time.

The tie plates of a given dimension are usually used under more than one section of rail and therefore any specific designs must necessarily be a compromise. It is thought that the dimensions proposed in this report are the best for general use and that their use will result in a substantial reduction in the number of rolls necessary for the manufacture of tie plates. At the present time there are a large number of rolls for tie plates which vary from each other only in unimportant dimensions.

No recommendation is made as to width of plates for softwood ties, as the character of ties and local conditions vary so much that it is thought best that the width be fixed to suit local conditions.

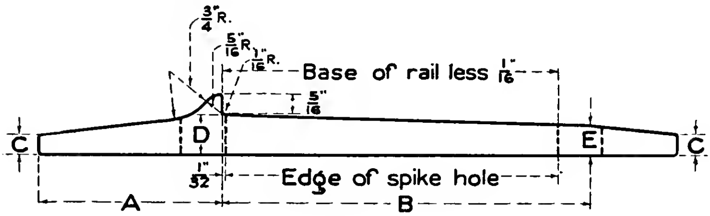
Conclusions

The Committee recommends that the plan and table of dimensions submitted herewith be adopted as recommended practice and printed in the Manual.

TABLE OF DIMENSIONS FOR TIE PLATES

LENGTH OF PLATES	RANGE OF RAIL BASES	SAME FOR FLAT AND CANTED PLATES			FLAT PLATES	CANTED 1 IN 40		CANTED 1 IN 20	
		A	B	C	D & E	D	E	D	E
9"	$4\frac{3}{4}$" TO 5"	$2\frac{3}{8}$"	$5\frac{3}{8}$"	$\frac{5}{16}$"	$\frac{9}{16}$"	$\frac{9}{16}$"	$\frac{7}{16}$"	$\frac{3}{4}$"	$\frac{15}{32}$"
$9\frac{1}{2}$	$4\frac{3}{4}$ TO $5\frac{1}{8}$	$2\frac{5}{8}$	$5\frac{9}{16}$	$\frac{5}{16}$	$\frac{5}{8}$	$\frac{5}{8}$	$\frac{1}{2}$	$\frac{3}{4}$	$\frac{15}{32}$
10	$4\frac{7}{8}$ TO $5\frac{1}{2}$	$2\frac{7}{8}$	$5\frac{3}{4}$	$\frac{5}{16}$	$\frac{5}{8}$	$\frac{5}{8}$	$\frac{15}{32}$	$\frac{3}{4}$	$\frac{15}{32}$
$10\frac{1}{2}$	$5\frac{1}{8}$ TO $5\frac{3}{4}$	3	$5\frac{15}{16}$	$\frac{3}{8}$	$\frac{11}{16}$	$\frac{11}{16}$	$\frac{17}{32}$	$\frac{13}{16}$	$\frac{17}{32}$
11	$5\frac{3}{8}$ TO 6	$3\frac{1}{4}$	$6\frac{1}{8}$	$\frac{3}{8}$	$\frac{11}{16}$	$\frac{11}{16}$	$\frac{17}{32}$	$\frac{13}{16}$	$\frac{1}{2}$
$11\frac{1}{2}$	$5\frac{3}{4}$ TO $6\frac{1}{4}$	$3\frac{1}{2}$	$6\frac{5}{16}$	$\frac{3}{8}$	$\frac{3}{4}$	$\frac{3}{4}$	$\frac{19}{32}$	$\frac{13}{16}$	$\frac{1}{2}$
12	6 TO $6\frac{1}{2}$	$3\frac{5}{8}$	$6\frac{1}{2}$	$\frac{3}{8}$	$\frac{3}{4}$	$\frac{3}{4}$	$\frac{19}{32}$	$\frac{13}{16}$	$\frac{1}{2}$

DATA FOR DESIGNING TIE PLATES



Ribs not exceeding ¼ inch deep are desirable on bottom of plate.

Thicknesses shown are exclusive of any ribs or corrugations on bottom.

On hardwood ties, widths of 7 inches or 7½ inches are recommended.

If splices are slotted for spiking, spike holes in tie plates shall be located accordingly.

Spike holes shall be made the size of the spike plus ⅛ inch, and in high carbon hot worked plates, spike holes shall have a fillet radius of $\frac{1}{16}$ inch.

Plates may be rolled with a camber or crown of $\frac{1}{16}$ inch if desired by the purchaser.

Where plate is cambered or crowned the shoulder height, $\frac{5}{16}$ inch, is measured at center of plate.

For extra heavy service add ⅛ inch to dimensions D and E.

Appendix H

(8) CAUSE AND PREVENTION OF RAIL BATTERING AND PRINCIPLES OF JOINT DESIGN

J. B. Myers, Chairman, Sub-Committee; L. B. Allen, C. W. Breed, J. W. DeMoyer, C. R. Harding, W. J. Harris, H. D. Knecht, R. L. Longshore, W. H. Petersen, J. V. Neubert.

A questionnaire was sent out to all railroads represented in the A.R.E.A., copy of which has been made a part of this report. The object of this questionnaire was to ascertain from the various railroads their opinions and experiences in regard to the subject, from which we hoped to determine means to eliminate the causes of rail chipping and battering, and to fix, in so far as we could, the principles of joint design.

Answers to the questionnaire were received from 49 railroads, and a summary of the answers is shown. There is also included in the report a brief of the answers received from each railroad.

Conclusions

The Committee has been unable to formulate definite rules on the subject, and it is recommended that the report be received as information.

AMERICAN RAILWAY ENGINEERING ASSOCIATION

TRACK COMMITTEE, SUB-COMMITTEE (8)

Questionnaire Covering Cause and Prevention of Rail Battering and Principles of Joint Design

1. State briefly the cause contributing to rail battering.................
2. State briefly measures to be taken to prevent rail battering...........
3. What type of joint are you using on heavy traffic lines?
    (a) Plain angle bars?....................................
    (b) Reinforced angle bars?..........Name.................
    (c) Base supported joints?............Name...............
    (d) Independent base supported joints?......Name..........
    (e) Are bars heat treated?...............................
    (f) Do you use suspended or supported type of joints?.......
4. Do you space and slot spike joint ties?.............................
5. Do rails laid with joint ties spaced and slot spiked, chip or batter more or less than rails laid "hit or miss"?.....................
6. State number of bolts used per joint....Diameter....Heat treated....
7. Does the use of spring washers improve joint conditions in relation to rail battering?.....Type used.....High or Low Pressure.....
8. Where tapered tie plates are used, do you have less battering of rail ends than where flat tie plates are used?.......................
9. What differences have been observed between the battering of rails on single track and on double track?..........................
10. Do high carbon rails chip or batter more or less than low carbon rails? ....
11. As compared with new rail and under the same traffic conditions, have you noticed any difference in the chipping, battering or flowing of rail ends that have been built up by the oxy-acetylene process?.....

12. As compared with new rail, and under same traffic conditions, have you noticed any difference at the rail ends in the chipping, battering or flowing of sawed end repair rail?....................
13. Have you noticed any rail battering due to the differences in heights of new rail, and have any methods been used to overcome this?....
14. What relations, if any, should exist between length of joint and rail section? ....
15. What relation, if any, should exist between number of bolts in joint and rail section?...
16. What proportion should the moment of inertia of joint (2 bars) bear to the rail?..
17. What relation should exist between the section modulus of the top of the bar and the section modulus of the bottom?...............
18. What clearance, if any, should be allowed for take up between joint and web of rail?..
19. What principle should determine the section design of bar as between Suspended and Supported Joints?.............................

....

......................Railroad

SUMMARY TO ANSWERS TO QUESTIONNAIRE

49 Railroads Replied

No. 1. Various causes listed are as follows:

40 roads state poor maintenance or some defect resulting from that feature, including loose bolts.
12 roads state some deficiency in the joint itself, such as poor design, weak joint, etc.
17 roads state improper expansion allowance.
13 roads state wear of bars.
5 roads state soft metal in rail.
7 roads state deflection under load and heavy traffic.
10 roads state ballast conditions.
7 roads state rail creeping.

No. 2. Remedies to overcome the causes listed under No. 1 are principally notations to "correct those causes." They include:

Good maintenance.
Design of strong joints.
Minimum expansion allowance.
Use heat treated high tension bolts.
Anchor rail thoroughly.
Use of harder rails and building up by welding.
Use of good ballast with good drainage.
Good maintenance includes solid joint ties and tight bolts.

No. 3. 21 roads use 100 per cent joints.
6 roads use their own standard.
36 roads use Heat Treated joints.
6 roads use Non-Heat Treated joints.
6 roads did not report.
32 roads use Suspended joints.
7 roads use Supported joints.
6 roads lay rail "hit or miss."

No. 4. 37 roads space and slot spike joints.
8 roads do not slot spike joints.
4 roads answer conditionally.

No. 5. 9 roads report less chipping and battering.
15 roads report no difference noted.
1 road reports batters less but chips more.
1 road reports wear is more when joint is supported.

No. 6. 39 roads report using 4 bolts.
9 roads report using 6 bolts.
46 roads report using Heat Treated bolts.
3 roads report using Non-Heat Treated bolts.

No. 7. 35 roads believe washers improve conditions.
6 roads believe washers do not improve conditions.
6 roads report washers not used.
21 roads use Hipower, High Pressure.
1 road uses Hy-Chrome, High Pressure.
12 roads use Verona, Low Pressure.
1 road uses Verona Spring, High Pressure.

No. 8. 20 roads note no difference with canted plates.
1 road reports the battering is less.
Other roads have "no data."

No. 9. Evidence is that:
Receiving end on double track wears more.
Both ends on single track crush equally bad.
12 roads say it is greater on double track.
3 roads say it is greater on single track.

No. 10. 4 roads state the chipping and battering is more.
8 roads state the chipping and battering is less.
5 roads state the chipping is more; battering less.
1 road states the chipping is less; battering more.

No. 11. 3 roads state welded rail unsatisfactory.
5 roads state welded rail will flow less.
3 roads state welded rail will chip and flow more.
6 roads state they note no difference.

No. 12. 12 roads note no difference with sawed rail.
5 roads state chipping is worse.
5 roads state chipping and flowing is less.

No. 13. 7 roads report noting difference in rail heights causing battering. No remedy suggested.
1 road suggests welding as a remedy.
33 roads have noticed no difference.

No. 14. 22 roads state "No relation between length of joint and rail section."
Other roads report "No Conclusion."

No. 15. 21 roads report "no relation" between number of bolts and rail section.
1 road reports cross-sectional area is criterion.
1 road reports tensile strength should be same.
8 roads report 4 bolts are sufficient.
3 roads report 6 bolts are sufficient.

No. 16. Varies from 50 per cent to 106 per cent. Most roads seem to think the moment of inertia should be equal.

No. 17. General opinion is that Section Modulus should be equal or the bottom slightly greater.

No. 18. Varies from 1/8 inch to 1/4 inch, but practically every road prefers 3/16 inch.

No. 19. General opinion seems to be that both should be designed for maximum strength obtainable, equal to rail strength if possible. Same principle to govern bolt designs.

ANSWERS TO QUESTIONNAIRE—TRACK COMMITTEE
CAUSE AND PREVENTION OF RAIL BATTERING AND PRINCIPLE OF JOINT DESIGN

Railroad Reporting	No. 1	No. 2	No. 3
Ann Arbor	Loose bolts, poor joints, poor track	Keep track in good condition.	Bonzano
Atlantic Coast Line	Depression of joint under load.	Increased strength of rail support	100 per cent and continuous, suspended
Bangor & Aroostook	Weak joint, loose bolts, joint ties not tamped	Heavy rail, strong joints, tight bolts, good tamping	Plain bars, H. T., Weber and Abbott, suspended
Baltimore & Ohio	Excessive expansion, rail creeping, inferior joint design and fixtures, poor maintenance of track structure	Correct conditions mentioned in Question No. 1	100 per cent reinforced, H.T., oil quenched, suspended
Boston & Albany	Poor maintenance	Deeper rail and good maintenance	N. Y. C. standard, H. T., 3 tie supported
Buffalo, Rochester & Pittsburgh	Poor maintenance, improper design of joint and rail, joint ties not plated	Good maintenance, properly designed joints, tie plates and heavy rail	Heavy reinforced angle bars, suspended
Canadian Pacific	Springy joints, loose bolts, unequal expansion allowance.	Stiff joints, tight bolts and proper expansion	100 per cent H. T. rail, laid "hit or miss"
Chicago & Northwestern	Loose bolts, expansion low, low joints, heavy traffic	Proper expansion, tight bolts, heavy angle bars	Reinforced bars, H. T., suspended
Chicago, Rock Island & Pacific	Unequal expansion allowance, loose bolts and wear of bars.	Minimum expansion allowance, hold rail with anchors, use H.T. bolts and keep tight	100 per cent H. T
Chicago, Burlington & Quincy	Weak joints, loose bolts, worn angle bars and poor maintenance	Apply bars properly, tight bolts, use good washers and replace worn bars	Plain H. T., suspended
Chicago, St. Paul, Minneapolis & Omaha	Poor ballast, soft metal, loose bolts, plain angle bars, improper expansion	Good ballast, good rail, tight bolts, reinforced bars, proper expansion	Plain and continuous H. T, suspended
Chicago, Milwaukee & St. Paul	Wear of fishing angle and joint	Keep good tight joints, renew joints when worn loose	Plain, 100 per cent H. T., both joint ties not spaced
Chicago & Eastern Illinois	Poor design, poor maintenance and unequal expansion	Good design, good maintenance, proper expansion and heavy ballast	Plain H. T., suspended
C. C. C. & St. L.	Too much expansion allowance, loose joint ties, loose bolts and chipped rails	Careful expansion allowance, solid joint ties, tight bolts, smooth cut rails	Plain, continuous and Bonzano, 3 tie supported
Chicago Great Western	Soft rails and poor ballast	Harder rails and good ballast.	Plain and R. J. Co.'s joint, 100 per cent Weber and Abbott, H. T., suspended
Clinchfield	Loose bolts, loose joints, poor maintenance, heavy maintenance	High maintenance, built up by welding	Continuous, H. T., supported.
Delaware & Hudson	Joints loose and not properly surfaced	Keep joints tight and well surfaced	100 per cent, continuous (130 lb. only), both H.T., supported.
Delaware, Lackawanna & Western	High carbon rails, poorly fitting angle bars, poor maintenance, improper expansion opening	Better rail specifications, good maintenance and proper expansion allowance	Neafie plain bars, H. T., supported and suspended
Denver & Rio Grande Western	Deflection of joints, improper expansion and irregular temperature movements	Use stiff joint and limit temperature movement	Plain and 100 per cent, H. T., suspended
D. W. & P.	Soft track and low joints	Keep joints up	Plain, 100 per cent, not H. T., suspended
Elgin, Joliet & Eastern	Soft material, soft road bed, loose bolts, heavy tonnage	Use hard and tough rail, H. T. joints and bolts with strong nutlocks and minimum expansion allowance	24 inch H. T. bars, suspended.
Erie	Poor maintenance, loose bolts, unsupported joints, improper expansion opening	Joint ties properly spaced, good spring washer, bolts tight, anchors properly applied	100 per cent H. T., suspended.
Great Northern	Excessive expansion, low joints, high speed	Good maintenance and proper expansion	H. T. angle bars, suspended
G. M. & N.	Loose joints and bad joint ties	Tight joints, tie plates and solid ties	Plain H. T., suspended
Hocking Valley	Loose joint ties, soft rail, loose bolts, poor ballast, swinging joints, creeping rail, contraction and expansion	Proper maintenance, good ballast, tight joints, ties and bolts, better quality rails, proper expansion	Continuous, 100 per cent H.T., suspended

ANSWERS TO QUESTIONNAIRE—TRACK COMMITTEE
CAUSE AND PREVENTION OF RAIL BATTERING AND PRINCIPLE OF JOINT DESIGN

No. 4	No. 5	No. 6	No. 7	No. 8	No. 9
Yes		$\frac{15}{16}$ inch, H. T.	Yes, high chrome, high pressure	Do not know	No difference.
Yes	Less	$\frac{7}{8}$ inch to 1 inch, H. T.	No, low pressure	Use flat plates	None.
Yes	None, laid "hit or miss"	4 bolts, $\frac{7}{8}$ inch, H. T.	Do not use	No difference	No data.
Yes	No difference	6, $1\frac{1}{16}$ inch, H. T., 100 lb., 4, $1\frac{1}{8}$ inch, H. T., 130 lb.	Yes, improved high power	No noticeable difference	Both ends on single track, receiving end on double track.
Yes	Less	6 bolts, $\frac{7}{8}$ inch, H. T.	Yes, high power, high pressure	No data	None.
Yes	Batter is less, chips the same	4 bolts, 1 inch, H.T.	Yes, low pressure, considering use of high pressure	No data	Both ends on single track, receiving ends on double track.
No	No difference	4 bolts, 1 inch, H.T.	Yes, high power, high pressure	Not perceptibly	Both ends on single track, receiving end on double track.
Yes	No difference	4 bolts, $\frac{7}{8}$ inch, H. T.	Yes, various types, high pressure	Not sufficient data.	Both ends on single track, receiving end on double track.
No	No data	4 bolts, 1 inch, H.T.	Yes, National Spring Washer, test use of high power	Use Cambered tie plate; it reduces rail creeping	None.
Yes	No difference	4 bolts, 1 inch, H.T.	Very much, Verona, high pressure springs	No difference	Greater on double track.
Yes	None, laid "hit or miss"	4 bolts, 1 inch, H.T., $\frac{3}{4}$ inch and $\frac{7}{8}$ inch, not H. T.	Yes, Verona, high pressure, trying out high power	Not used	Both ends on single track, receiving end on double track.
Only on single track	Do not know	4 bolts, 1 inch, H.T.	Yes, high pressure.	No difference noted	Greater on double track with movement one way.
Spaced, but not slot spiked	No	4 bolts, 1 inch, H.T.	Yes, Verona, tail-less type	Not used	Greater on double track.
Yes	Judge it is less	6 bolts, $\frac{7}{8}$ inch, H. T.	No, coil spring, high and low pressure	No	None.
Yes	Less	4 bolts, $\frac{7}{8}$ inch and 1 inch, H. T.	Not used	Not used	Greater on single track.
Yes	Less	4 bolts, 1 inch, H.T.	Yes, Verona, low pressure	No experience	No double track.
Yes		4 bolts, 1 inch and $1\frac{1}{8}$ inch, H. T.	Keep joints tight, Verona rail springs, Verona high pressure, high power, all high	No apparent difference	No.
No	Less	6 bolts, 1 inch, H.T.	Yes	Not used	Greater on double track.
Yes	No	4 bolts, 1 inch, H.T.	Yes, high pressure.	No difference	None.
Yes		4 bolts, $\frac{7}{8}$ inch, H. T.	Yes, high power, high pressure		No double track.
Yes	No difference	4 bolts, $1\frac{1}{16}$ inch and $1\frac{3}{16}$ inch, H. T.	Yes, to a marked extent, Verona and high power	Not used	Both ends on single track, receiving end on double track
Yes	Less	4 bolts, $\frac{63}{64}$ inch, H. T.	Yes, high power, high pressure	Yes	Apparently more on double track.
Yes	No data	4 bolts, $1\frac{1}{16}$ inch to $1\frac{3}{16}$ inch, H. T.	Yes, to a limited extent, Verona and high power	No apparent difference	Greater on double track.
Yes		4 bolts, $\frac{7}{8}$ inch, H. T.	Yes, high pressure.	Not used	No double track.
Yes		4 bolts, 1 inch to $1\frac{1}{8}$ inch, H. T.	Yes, keeps joint tight, high power, high pressure	No difference noted.	Greater on single track.

ANSWERS TO QUESTIONNAIRE—TRACK COMMITTEE
CAUSE AND PREVENTION OF RAIL BATTERING AND PRINCIPLE OF JOINT DESIGN

Railroad Reporting	No. 10	No. 11	No. 12	No. 13
Ann Arbor				
Atlantic Coast Line	More	Little difference	None noted	
Bangor & Aroostook	No data	Welding not satisfactory	None noted	
Baltimore & Ohio	With expansion controlled should be less	Welded rail less	Sawed end less	No
Boston & Albany	No difference	Welding a failure with frogs	None used	
Buffalo, Rochester & Pittsburgh	More	No opinion	No information	No
Canadian Pacific	Not noticeable	No experience	No difference	No
Chicago & Northwestern	No data	No difference	Chipping is slightly worse	No
Chicago, Rock Island & Pacific	No data; opines low carbon will crush more	No data	No data	No
Chicago, Burlington & Quincy	Less	Welded rail will flow less	Sawed rail will flow and chip less	No, but keep rails of same heat together.
Chicago, St. Paul, Minneapolis & Omaha	No high carbon rail	No built up rail	No	No
Chicago, Milwaukee & St. Paul	No record	Have little built up rail	Sawed rail will split and batter faster	Very little noticed.
Chicago & Eastern Illinois	No data	Yes, more than new rail	Sawed rail will chip, less battering same	No
C. C. C. & St. L.	No data	No conclusion	No experience	No
Chicago Great Western	Less	No	No	No
Clinchfield	No data	Welded rails stand up better	Do not saw rail	No
Delaware & Hudson				No
Delaware, Lackawanna & Western	More	No data	No data	
Denver & Rio Grande Western	No data	Welded rail batters and flows more	No difference noted	No
D. W. & P.				Yes
Elgin, Joliet & Eastern	Chip more, but batter less	Welded rail not so good	Not used	No
Erie	Less	No	No experience	No
Great Northern	Chips more and batters less	No	No	Yes, but have not overcome this
G. M. & N.				
Hocking Valley	Less	No experience	No experience	Very slight, grind it down smooth

ANSWERS TO QUESTIONNAIRE—TRACK COMMITTEE
CAUSE AND PREVENTION OF RAIL BATTERING AND PRINCIPLE OF JOINT DESIGN

No. 14	No. 15	No. 16	No. 17	No. 18	No. 19
No relation	No relation	Same	Do not know	3/16 inch	Do not know.
None	None	....	....	....	....
....	Should be determ	ined by laboratory	test	1/8 inch	No difference in design needed.
None	None	Equal or little more than rail	About equal	1/8 inch to 3/16 inch	If joint design is heavy enough there would seem to be no difference.
None	Sufficient to equal tensile strength of joint	Equal	....	3/16 inch	In both cases to be as near strength of rail as possible.
No relation	No relation	No opinion	No opinion	1/4 inch	No difference in design needed.
None	None	About 1 to 3	About equal	1/8 inch	Laid "hit or miss."
....	....	....	....	3/16 inch	....
None	None	....	Equal	3/8 inch	No difference; lay rail "hit or miss."
No conclusions	4 sufficient for all weight of rail	Equal	No conclusions	Top 3/16 inch, bottom 5/16 inch	Do not know.
....	4 bolts are satisfactory	....	....	3/16 inch	....
Do not know	4 sufficient for all weight rail	....	....	....	Do not know.
None	None	....	....	3/16 inch	....
None	None	About 1 to 2½	About 1 to 1¼	3/16 inch	Design suspended joint on principle of a bridge.
24 inch joints used on all rail	4 bolts of various sizes used on all rails	106 per cent	Bottom about 10 per cent greater	3/16 inch	Suspended joint with Sec. Mod. about 5 per cent greater than rail Sec. Mod.
Cannot say	Cannot say	Cannot say	Cannot say	Cannot say	Cannot say.
None	4 bolts are adequate	Equal as near as possible	Base should be greater	3/16 inch	No conclusions.
....	6 bolts give better results	....	....	....	....
None	None	As near equal as possible	Equal	1/8 inch	Greater tensile strength in top fibre of supported joint.
....	....	....	....	1/16 inch	....
Longer angle bars for larger rail sections	6 bolts for larger rail sections	Make as high as possible for convenient size joint	Equal	3/16 inch	Prefer 6 hole bar with suspended joint.
None	None	About 50 per cent	As near equal as possible; present bar is 87.4 per cent.	3/16 inch	....
Undecided	Undecided	Undecided	Undecided	Undecided	Undecided
....	....	....	....	3/16 inch	....
Same for all sections	None	Top 40 per cent, bottom 60 per cent	....	1/8 inch	The fishing distance.

ANSWERS TO QUESTIONNAIRE—TRACK COMMITTEE
CAUSE AND PREVENTION OF RAIL BATTERING AND PRINCIPLE OF JOINT DESIGN

Railroad Reporting	No. 1	No. 2	No. 3
Kansas City Southern	Loose bolts, worn angle bars, improper size bolt holes	Maintain tight bolts, proper expansion, replace worn angle bars	Special, H. T., suspended
Lehigh Valley	Soft rail, too wide expansion, loose joint bolts	Avoid conditions noted in No. 1	
Louisville & Nashville	Flow of metal, low carbon, rails more subject to this	No preventive measures	Plain, 100 per cent, R. J. Co., Weber, H. T., suspended
Lake Superior & Ishpeming	Soft roadbed, muck embankment	Keep tight joints, place 18 inch sub-ballast over muck embankment	Plain and Abbott base plates, not H. T., suspended
Missouri Pacific	Open joints, soft metal in rail, loose joints, rail creeping	Proper expansion, use H. T. bars, high tension bolts, spring washers, proper anchorage	Plain and 100 per cent, R. J. Co., H. T., suspended
N. Y. N. H. & H.	Loose joints or too light bars.	Keep joints tight	Plain and Thompson, H. T., supported and suspended
Nickel Plate	Deflection of joint, loose bolts, loose joint ties	Good maintenance, H. T. angle bars	M.-K.-T. section H. T., Bonzano, reinforced, continuous, suspended
Northern Pacific	Expansion gaps, flow of metal, unequal rail heights, low tension bolts	Proper expansion, high tension bolts, proper anchoring, high carbon rail	Plain H. T., supported
Nashville, Chattanooga & St. Louis	Expansion gaps, flow of metal, improperly tightened joints, unequal rail heights, loose joint ties	Proper expansion, high carbon rail, joints tightened properly, good maintenance	100 per cent and Weber, H. T., suspended
New York Central	Short rail joints, improper expansion and degree of maintenance	Use long, stiff 3 tie joint, proper expansion and high degree of maintenance	Plain, H. T., supported
New York Central West of Buffalo	Poor drainage, poor ballast, light rail, lack of joint support, loose bolts	Good drainage and ballast, solid joint ties, tight bolts	Dudley plain bars, H.T., supported
Norfolk & Western	Poor maintenance, improper expansion allowance, heavy traffic, rail creeping	Maintain joints and joint ties properly, proper expansion allowance and build up by oxy-acetylene process	24 inch continuous ribbed bars, not H. T., suspended
O. W. R. R. & N.	Poor ties, poor ballast, poor maintenance	Good ties, good ballast, good maintenance	Continuous, not H. T., supported and suspended
Pennsylvania	Loose bolts, badly worn and poorly maintained bars, joints of poor design	Good joint bars, tight bolts and well tamped ties	P. R. R. reinforced, H. T., suspended
Pittsburgh & West Virginia	Unable to state definitely; possibly due to bolts stretching or bars wearing	No remedy until cause is known; renewing bolts may help	Plain, Bonzano and continuous, not H. T., suspended
Seaboard Air Line	Loose joints	Tight joints and anticreepers.	100 per cent and continuous, H.T.
Southern (Western District)	Lack of proper tamping, too large expansion gap	Proper tamping, tight bolts, 100 per cent maintenance at joints	Weber, H. T., suspended
Southern Pacific	Loose or decayed joint ties, poor drainage, loose bolts, slewed ties, worn splice bars, unequal rail heights	Good maintenance, eliminate unequal height of rails	100 per cent, H. T., suspended or "hit and miss"
St. Louis Southwestern	Impact of wheel loads due to conditions at joint	Proper design and maintenance of joint	Reinforced, I. S. Co., H. T., suspended
Union Pacific	Rail creeping, joint churning, loose bolts, surface flow	Sufficient anchors, adequate ballast, tight joint ties, tight bolts	100 per cent base supported angle bars, H. T., continuous joints, not H. T., suspended
Western Pacific	Improper design or loose joint ties	Properly designed bar and well tamped ties	100 per cent, R. J. Co., not H. T., suspended
Washington Terminal	Worn splice bars and loose joint ties	Keep tight joint ties and renew worn bars	Plain, 100 per cent, B. & O. std.; yes; suspended
Western Maryland	Wide spacing, loose bolts, poor ballast	Proper spacing of rails, tight bolts, good ballast, solid joint ties	100 per cent, R. J. Co., H. T., suspended
Chesapeake & Ohio	Soft rail, improper joint maintenance, creeping rail	Use higher carbon rail, good joints, tight bolts and joint ties, anchor well	100 per cent, H.T., continuous, not H. T., suspended

ANSWERS TO QUESTIONNAIRE—TRACK COMMITTEE
CAUSE AND PREVENTION OF RAIL BATTERING AND PRINCIPLE OF JOINT DESIGN

No. 4	No. 5	No. 6	No. 7	No. 8	No. 9
Yes	No difference if anchored well and has strong joint	4 bolts, 1 inch, H.T.	Questionable, National Lock Washer, Harvey Grip-Bolts, low pressure	No difference	Greater on double track.
No	No difference	6 bolts, $1\frac{1}{8}$ inch, H. T.	Yes, Verona Rail Springs, high power, high pressure	No difference	Have little heavy traffic, single track.
Yes	Opines no difference if well anchored	4 bolts, $\frac{15}{16}$ inch, H. T.	Unable to say. Verona Tool Works	None used	Rails batter on both tracks
Yes		4 bolts, $\frac{7}{8}$ inch, not H. T.	No, low pressure	Not used	
Yes	No difference	4 bolts, 1 inch, H. T.	Yes, improved high power, high pressure	Not sufficient data	None, depends on amount of traffic.
No		4 bolts, 1 inch, H.T.	Yes, high power	Tappered plates used only	Double track, more on receiving end.
Yes	No record	4 bolts, 1 inch, H.T.	Not used	Cannot say	Not investigated.
Yes, light rail, not slot spiked	No difference noted	4 bolts, $1\frac{1}{16}$ inch to $1\frac{1}{8}$ inch	Yes, improved high power, Palmer Rail Spring high pressure	None noted, but improvement is expected	Greater on receiving end of double track.
No	No data	4 bolts, 1 inch, H. T.	Slightly, high power	Probable	Greater on receiving end of double track.
Yes	Less	6 bolts, $\frac{7}{8}$ inch, H. T.	None used	None used, considering adoption of 1:44	Greater on receiving end in direction of greater tonnage.
Yes	Very much less	6 bolts, $\frac{7}{8}$ inch, H. T.	Not used	No difference	Greater on receiving end of double track.
No, ties spaced later	No difference noted	4 bolts, $\frac{15}{16}$ inch to $1\frac{1}{16}$ inch, H. T.	Yes, Verona springs and high power with 130 lb. rail	No difference noted	Both ends on single track, receiving end on double track.
No		4 bolts, 1 inch, H. T.	No, high power, high pressure		Less on double track.
Yes	Less	4 bolts, 1 inch and $1\frac{1}{8}$ inch, H. T.	No, coil spring, both	No difference	No record.
Yes	No difference noted	4 bolts, 1 inch, H.T.	Low pressure	No difference	None.
Yes	No information	4 bolts, 1 inch, H. T.	Yes, spring, both	No	
Yes	All ties are spaced.	4 bolts, $\frac{7}{8}$ inch, H. T.	Yes		
No	No data yet	4 bolts, $\frac{7}{8}$ inch, H. T.	Yes, high power	No conclusion	Greater on double track.
Yes	Little difference	4 bolts, 1 inch, H.T.	Yes, high power		
Yes	No difference	4 bolts, $\frac{15}{16}$ inch to $1\frac{1}{16}$ inch, H. T.	Yes, both	No data	Receiving end on double track, both ends on single track.
Yes		4 bolts, $\frac{7}{8}$ inch, not H. T.	Yes, Verona, low pressure, high power is better	No difference	No difference.
Yes	Wears more when supported	6 bolts, 1 inch, H.T.	No, Verona, low pressure	None used	Greater on receiving end of double track.
Yes	No	6 bolts, 1 inch, H T	Yes, none used	Not noticeable.	Receiving end on double track, both ends on double track.
Yes	No apparent difference	4 bolts, 1 inch, H.T.	Yes, high power, high pressure	Not noticeable	Practically none.

ANSWERS TO QUESTIONNAIRE—TRACK COMMITTEE
CAUSE AND PREVENTION OF RAIL BATTERING AND PRINCIPLE OF JOINT DESIGN

Railroad Reporting	No. 10	No. 11	No. 12	No. 13
Kansas City Southern......	Chips more and batters less............	No experience........	Sawed rail chips and batters more........	No..................
Lehigh Valley.............	Less.................	No..................	Not used............	No..................
Louisville & Nashville......	No difference........	No experience........	Sawed rail flows less, due to cold rolling..	Unable to say.......
Lake Superior & Ishpeming	....	....	....	No..................
Missouri Pacific............	Batters more and chips less...........	Batters less and chips more...............	No difference........	Yes, no methods tried yet..........
N. Y. N. H. & H..........	....	....	....	No..................
Nickel Plate...............	Chips more and batters less...........	No record...........	No difference........	No..................
Northern Pacific...........	Assume it is less....	No experience........	No comparison.....	Yes, but have no remedy............
Nashville, Chattanooga & St. Louis.................	No data.............	No data.............	"Clipped" rail flows more easily.........	No..................
New York Central.........	No data.............	None used...........	No difference........	Yes.................
New York Central West of Buffalo....................	Less.................	Not used............	No difference........	No..................
Norfolk & Western.........	No difference noted..	Data not complete...	Sawed rail will chip and batter quicker..	No..................
O. W. R. R. & N...........	....	....	....	No..................
Pennsylvania..............	Opinions equally divided...............	No distinct difference apparent............	Probably chips and batters less.........	No..................
Pittsburgh & West Virginia	Opinion not expressed	No experience........	Rep. rail does not batter..............	No..................
Seaboard Air Line..........	No difference noted..	Not used............	Experience too limited	No..................
Southern (Western District)	No observation......	No experience........	Not used............	No..................
Southern Pacific...........	No opinion..........	Welded rail chips and batters less.........	Little difference.....	....
St. Louis Southwestern.....	Chips more, but batters less............	No experience........	No experience.......	....
Union Pacific..............	High carbon rails not used...............	Welded rails chip and batter less..........	Had little experience.	No..................
Western Pacific............	....	....	....	Yes, but have no remedy............
Washington Terminal.......	They chip more.....	None used...........	None used...........	....
Western Maryland.........	High carbon rails not used...............	Welded rail does not hold up as well......	Not used............	Yes, by welding.....
Chesapeake & Ohio........	No observations....	Welded rail holds up as well.............	No experience........	No observations.....

ANSWERS TO QUESTIONNAIRE—TRACK COMMITTEE
CAUSE AND PREVENTION OF RAIL BATTERING AND PRINCIPLE OF JOINT DESIGN

No. 14	No. 15	No. 16	No. 17	No. 18	No. 19
None, wheel load should govern ..	4 bolts are sufficient..........	½ inch..........	Equal..........	⅛ inch to 3/16 inch..	Principle for both is to get strength equal to continuous rail.
No definite relation known of...	No relation known of.......	Make bars as strong as you can........	Upper and lower cords should be as strong as clearance will permit.......	¼ inch plus to clearance allowances.	None.
....	....	....	....	....	....
....	....	....	....	....	....
....	....	30 per cent to 45 per cent..........	Bottom 10 per cent to 20 per cent greater than top..	3/16 inch..........	....
None..........	None..........	....	....	3/16 inch..........	....
No relation......	No relation......	Equal for non H. T. bars, ½ for H. T. bars..........	Equal for plain angle bars........	½ inch recessed nut is good, too.......	....
Nothing definite.	No relation......	Equal or greater...	Equal..........	3/16 inch..........	No data
Not determined..	None..........	Equal..........	Equal..........	3/16 inch..........	Determine by laboratory experiments.
No relation......	6 bolts are necessary for 3 tie joint..........	1 to 2½ for heavy sections..........	No definite relation, but bottom is higher..........	3/16 inch..........	Maximum obtainable stiffness.
Uniform joint for all sections is desirable.........	Same for all sections..........	40 per cent........	Equal..........	⅛ inch to 3/16 inch..	Suspended joint should be stronger.
Depends on type of bar and fishing height......	....	Not less than 50 per cent; prefer 75 per cent..........	Equal..........	⅛ inch to ¼ inch; prefer 3/16 inch.....	Design joint equal strength of rail.
....	....	....	....	....	....
No recommendation..........	Area of cross section is essential factor.........	Equal..........	Equal..........	3/16 inch..........	Position of ties should not affect design.
....	....	....	....	....	....
None..........	None..........	....	....	....	....
....	....	....	....	....	....
No data	4 bolts are sufficient up to 110 lb. rail.........	No data..........	No data..........	3/16 inch..........	Obtain same beam strength as in rail for both types of joint.
No relation......	No relation......	35 per cent........	Equal..........	3/16 inch..........	Same principle should govern both.
No relation......	No relation......	Approximately 1 to 2½..........	Equal..........	3/16 inch..........	Same design for both.
None..........	None..........	Equal..........	Equal..........	3/16 inch..........	Governed by individual standards.
None..........	4 bolts are sufficient; depends on size of bolt...	....	6 above to 7 below.	¼ inch..........	Supported joint should be stiffer.
Depends on condition of road...	Depends on condition of road...	....	....	....	....
No relation......	No relation......	No data..........	Bottom slightly greater..........	⅛ inch..........	No difference.

Appendix I

(9) TRACK CONSTRUCTION IN PAVED STREETS, COLLABORATING WITH COMMITTEE ON RAIL ON SPECIFICATIONS FOR GIRDER RAIL

J. B. Baker, Chairman, Sub-Committee; J. V. Neubert, C. R. Harding, V. Angerer, O. F. Harting, J. deN. Macomb, C. E. Merwin, J. B. Myers, G. A. Peabody, G. J. Slibeck, J. B. Strong, J. B. Latimer.

This subject is being considered under the following sub-divisions:

(a) Tangent track and Curves for Steam Railroad use, laid with Girder Rails and Girder Guard Rails.

(b) Tangent track and Curves for Steam Railroad use, in paved streets laid with standard "T" Rail, where nature and depth of the paving will allow the use of "T" Rail with special provisions for flangeways.

(c) Specifications for Girder Rails, collaborating with Committee on Rail.

(d) Switches, particularly tongue switches, mates, frogs and crossings used in track as referred to under (a) and (b) and of such designs and construction as may be recommended for the purpose.

(e) Crossings of Steam Railroad Tracks over Electric Railway Tracks where Girder Rail is used in the Steam Railroad Track.

SUBJECT "A"—GIRDER RAIL CONSTRUCTION

A summary of replies to questionnaires from fifteen roads, with a total Girder Rail track mileage of 68.06, follows:

1. The mileage of the different sections used on the reporting roads is, for the

9 in.—141-lb. Girder Rail	46.78 miles	
9 in.—159-lb. Girder Rail	13.83 miles	
9 in.—154-lb. Girder Rail	.13 miles	60.74 miles
7 in.—127-lb. Girder Rail	7.32 miles	7.32 miles
Grand Total		68.06 miles

2. Girder Guard Rail is used to a very limited extent, and then only opposite frogs and on inner rail of curves.

3. Twelve reporting railroads express a preference in the use of available Girder Rail sections, as follows:

4 Roads having 26.83 miles of various Sections	159-lb.
5 Roads having 22.26 miles of various Sections	141-lb.
3 Roads having 11.39 miles of various Sections	127-lb.

4. Girder Rails are used in lengths of 30-ft., 33-ft., 44-ft., 50-ft., 60-ft., 62-ft., and 66-ft., the greatest tonnage however being furnished in 33-ft. lengths.

5. The length of Splice Bars varies from 22-in. to 36-in. and the size and number of Joint Bolts from 12 1-in. Bolts to 4 1¼-in. Bolts, with varied spacing arrangements.

6. (a) Ties are generally 7-in.×9-in., with about equal use of lengths 8-ft. and 8½-ft.

(b) The spacing of ties generally favored is approximately 22½-in. center to center, the equivalent of 18 ties to 33-ft. rail.

(c) The use of treated and yellow pine ties predominates.

(d) Tie rods of various sizes spaced approximately 5 feet center to center are generally used.

(e) Tie plates are in general use and are standard for most railroads reporting.

(f) Almost without exception crushed stone or concrete is used under the ties.

(g) Stone blocks are generally used as a street paving. Asphalt and cement concrete, brick, wood block, and sheet asphalt are used to a limited extent.

SUBJECT "B"—"T" RAIL CONSTRUCTION

A summary of replies received from fifteen of the twenty railroads circularized with questionnaire is as follows:

1. "T" Rail should be used in streets only when the street construction is not of permanent character and the rail traffic exceedingly light, otherwise the cost of maintenance would be excessive.

Girder Rail should be used in the construction of all permanent low speed tracks in streets and highways where the vehicular traffic or local specifications require paving.

Vertical stiffness is the most important factor in determining the height of Girder Rail to be used.

2. The mileage of "T" Rail Track in paved streets for the reporting roads, divided according to various sections, is as follows:

A.S.C.E. 60-lb. and 70-lb.	10.25	Miles	
A.S.C.E. 75-lb.	0.75	"	
A.S.C.E. 80-lb.	0.25	"	
A.S.C.E. 85-lb.	4.99	"	
A.R.A. 90-lb.	2.00	"	
Various sections	100.70	"	118.94 Miles

3. The majority of reporting roads use "T" rails of 33-ft. lengths, one road using 60-ft. and another making arrangements for use of 39-ft. lengths.

4. (a) For track constructed with "T" Rail, the standard guard rails used to protect frogs at other locations, are used in paved streets.

(b) Guard Rails are used to a very limited extent on curved track constructed with "T" Rails, and then only on the inner rail.

5. The replies indicate a variance of opinion as to the minimum degree of curve for which "T" Rails should be pre-curved, the answers ranging from 2 to 30 degree curves.

6. (a) The size of ties vary; 6-in. x 8-in., 7-in. x 8-in., 7-in. x 9-in., and 8-ft. 0-in. in length, are used. The use of 7-in. x 9-in. ties is quite general. Spacing varies from 14 ties (approximately 29-in. center to center) to 20 ties (approximately 20-in. center to center) in 33-ft. length.

(b) The use of treated Oak and Pine ties predominates.

(c) Tie Rods are not generally used in "T" Rail Construction, one of the roads reports the use on curves only, spaced 10-ft. center to center.

(d) Plain flat Tie Plates are generally used. Two roads report the use of chairs for "T" Rail where the local paving specifications required additional depth.

(e) Broken stone varying in size from ¾-in. to 3-in. or concrete is used for foundation, from 6-in. to 12-in. under the ties depending on the nature of the sub-soil.

(f) Broken stone is generally used as ballast.

(g) Various types of paving are used with "T" Rail Construction, as follows:

Concrete: The flangeway provided by templet when paving is laid.

Asphaltum or similar wearing surface material: The flangeway made by a hot iron or in some cases wheel flanges provide their own flangeway.

Stone Blocks: The flangeway is provided by wood block fillers along the rail.

Numerous other methods of providing flangeway are used.

SUBJECT "C"—SPECIFICATIONS FOR GIRDER RAILS, COLLABORATING WITH COMMITTEE ON RAIL

In cooperation with the Rail Committee of the A.R.E.A., the Way Committee of the A.E.R.E.A., and a Special Committee of the A.S.T.M., a

"Standard Specification for the Manufacture of Open-Hearth Steel Girder Rails of Plain, Grooved and Guard Types,"

has been prepared.

This specification, as given in full in the report of the Committee on Rail, was adopted by the American Electric Railway Engineering Association at their convention in October, 1925, and if acceptable to the A.R.E.A., will, in all probability, be presented to the A.S.T.M., for action during their convention in June, 1926.

This specification has been the subject of considerable discussion by the above associations and as now presented is considered to adequately meet the requirements of all interested parties.

SUBJECTS "D" AND "E"—SPECIAL TRACK CONSTRUCTION

Plans and data pertaining to these subjects have been collected, but additional time will be necessary to prepare details that will illustrate the recommended practice.

Conclusions

1. Satisfactory results have been obtained from the use of both "T" Rails and Girder Rails in Steam Railroad Track in paved city streets, but a very considerable expense is involved in the construction and maintenance of the paving as vibration and movement of the rails under the traffic loads accelerate the disintegration of the paving. In order to minimize this detrimental effect it is of importance that the designs of rail sections and joints for this service should embody strength and rigidity. To most economically meet these requirements the following sections of Girder Rails, Splice Bars and accessories are recommended:

2. **Plan of the 159-lb. Girder Rail Section,** to be designated as the "159-lb. G-9 Section."

3. **Plan of the 174-lb. Girder Guard Rail Section,** to be designated as the "174-lb. GG-9 Section."

4. **Plan of the 159-lb. G-9 Joint Bars** to be used with the 159-lb. G-9 Section and 174-lb. GG-9 Section, the same to be designated as "159-lb. G-9 Splice Bars."

5. **Plan of the 128-lb. Girder Rail Section,** to be designated as the "128-lb. G-7 Section."

6. For Girder Rail construction the use of the 159-lb. G-9 Section, except under light rail traffic where the use of 128-lb. G-7 Section may be found more economical.

7. In 9-in. Girder Rail construction the use of the 174-lb. GG-9 Section Girder Guard Rail, which fishes with the 159-lb. G-9 Section, for guarding frogs and on the inner rail of curves where the life of the outer rail is limited by flange wear rather than by top wear.

8. **Bolt Holes** 1⅜-in. diameter drilled in both ends of the 159-lb. G-9 Section and the 174-lb. GG-9 Section, with their center line 3¾-in. up from the base of the rail and spaced from the ends as follows: 2¾-in.-7½-in.

9. **Bolt Holes** 1⅛-in. in diameter drilled in both ends of the 128-lb. G-7 Section with their center line 2¾-in. up from the base of the rail and spaced from the ends as follows: 2½-in.-4-in.-4-in.

10. **Splice Bars** of the Sections shown as the 159-lb. G-9 Joint Bars to be used with the 159-lb. G-9 Section and 174-lb. GG-9 Section, 26-in. long, with bolt holes punched 2¾-in.-7½-in. 5½-in.-7½-in.-2¾-in.

11. **High Tensile Bolts** 1¼-in. in diameter for use with the 159-lb. G-9 Section Rail.

12. **High Tensile Bolts** 1-in. in diameter for use with the 128-lb. G-7 Section Rail.

13. **Ties** of the best grade and class, preferably treated.

14. **Tie Plates** of sufficient size to prevent cutting of the Ties.

(Note.—See report of Committee on Rail for Standard Specification for the Manufacture of Open-Hearth Steel Girder Rails of Plain, Grooved and Guard Types—pp. 621 to 627.)

GENERAL REMARKS

(For Information Only)

1. The Committee, after investigation, decided on the elimination of the 9-in.-141-lb. Girder Rail from further consideration, because of the inferiority of section.

2. A Girder Guard Rail Section with the same joint fishing section as the 128-lb. G-7 Section is not available at this time but a section as shown on accompanying plan of 149-lb. GG-7 Section is desirable.

3. Splice Bars as furnished by the manufacturers for the 128-lb. G-7 Section may be used, but while not obtainable at present, a section as shown on accompanying Plan of Joint Bar for use with the 128-lb. G-7 Section and 149-lb. GG-7 Section and designated 128-lb. G-7 Joint Bar is desirable.

4. Tie Rods are generally but not uniformly used in Girder Rail Construction, in some instances special Brace Plates are used in lieu of the Tie Rods.

5. Ties are generally spaced 22½-in., the equivalent of 18 ties to a 33-ft. length.

Action Recommended

1. That the **Conclusions** above be approved for publication in the Manual.

2. That the **General Remarks** above be received as information.

3. That Subjects "D" and "E" above be re-assigned to the Committee for future work.

(See pp. 626 to 629 for Sections of Girder Rail.)

Appendix J

(10) THE VALUE OF NUTLOCKS FOR RAIL JOINTS WITH SPECIAL REFERENCE TO HEAT-TREATED BOLTS OF LARGE DIAMETER

L. W. Deslauriers, Chairman, Sub-Committee; S. Balkwill, C. R. Harding, F. H. Masters, J. V. Neubert, W. H. Petersen.

A questionnaire was sent out to all railroads represented in the A.R.E.A., which has been incorporated with the brief of answers.

The object of this questionnaire was to ascertain from the various railroads, their opinions and experiences in regard to the subject.

Answers to the questionnaire were received from 43 railroads and a summary of the answers is given. There is also included in the report a brief of the answers received from each railroad.

Conclusions

It is recommended that this report be received as information.

SUMMARY OF ANSWERS

(1) Of the 43 replies received 14 state that the true function of a nutlock should be to lock the nut and 24 state that it should have sufficient spring to keep bolts tight.

(2) Nutlocks of the spring washer type are considered satisfactory by 27 railroads; two roads report none are satisfactory, 2 are conducting tests to determine relative merits, others report as having no choice, no experience or as not being prepared to name, etc.

(3) Replies to this question indicate that 38 roads are in favor of using a nutlock on every bolt, 2 roads are not in favor and others have not replied to this question, or are not prepared to say.

(4) Spring washer type of nutlocks are being used by 39 roads, 1 road is not using them, others have not answered or are not prepared to say.

(5) Hipower, Plain Spiral, Positive, Ideal, Verona Spring Plates, Hychrome, Eaton High and Low Coil Spring Washers, are among types stated by various roads as being in use.

(6) Nutlocks of the spring washer type are reported as improving joint conditions by 36 roads, 3 report no improvement, others report no information or conducting tests.

(7) In reply to this question 28 roads have stated "yes" and 5 "no", others report as being undecided, unable to say, conducting tests, etc.

(8) Reduction of labor is reported by 32 roads, 2 roads report no reduction, others report as being undecided, or having no information.

Answers to Questionnaire—Track Committee
Sub-Committee No. 10

Name of Railroad	1 What is, in your opinion, the true function of a nutlock?	2 State in their order of merit the name of nutlocks which you consider satisfactory for use on track	3 On a rail joint do you consider it advisable to use a nutlock on every bolt?
Atchison, Topeka & Santa Fe Ry. Co. (Chief Engineer)	To retain high pressure within the joint	Hipower	Yes
Atlantic Coast Line R. R. Co.	To act as washer between the nut and joint bar	Positive	Yes
Baltimore & Ohio R. R. Co. Mtce. of Way Dept. (Mr. Myers)	Device to lock the nut and keep it from turning back on the threads due to vibration	Improved Hipower and Hipower	Yes
Baltimore & Ohio R. R. Co. (Mr. Lane)	To keep nut from turning off	None known to meet requirements	Ideal Std. Union Lock Nut found unsatisfactory
Bangor & Aroostook R. R. Co.	Prevent nut from unscrewing and have sufficient spring to keep bolt tight under any tendency to stretch	No experience	Yes
Baltimore & Ohio Chicago Terminal R. R. Co.		Improved Hipower	Yes
Boston & Albany			
Canadian Pacific Railway (Engineering Dept.)	To keep the nut from backing off the bolt	No information on nutlocks. Tests now conducted on spring and round washers to determine relative merits	Spring washer should be used on every bolt
Chesapeake & Ohio Ry. Co.	To keep tight bolts	Hipower Verona Spring Plates, Hychrome all about the same in service	Yes
Chicago, Burlington & Quincy R. R. Co.	To compensate for looseness that may develop from various causes in the rail joint	Verona Rail Joint Spring and ordinary coil nutlock	Yes
Chicago, Milwaukee & St. Paul Ry	To help keep tight joints	Must be a spring lock between bar and nut	Yes
Chicago & Northwestern Ry. Co.	To maintain bolts at the allowable working tension	Several makes of equal average merit	Yes, or other devices.
Chicago, Rock Island & Pacific Ry. Co. (Engineering Dept.)		Verona heavy spring washer	Yes
Chicago, Rock Island & Pacific Ry. Co. (Operating Dept.)	Nuts tight		Yes
Cleveland, Cincinnati, Chicago & St. Louis Ry. Co.	Keep bolts tight	No choice	No
Delaware, Lackawanna & Western R. R. Co.	Sufficient spring to take care of bolt stretch and joint wear	Improved Hipower and Verona Springs.	Yes
Elgin, Joliet & Eastern Ry. Co.	Keep all parts of joint tight	Cannot say	Yes
Gulf Coast Lines	To take up any bolt stretch	Improved Hipower (1), Hipower Nutlock (2), Reliance Nutlock, National Lock Washer Co.'s plain spiral Verona Nutlock (3)	Yes
Hocking Valley Ry. Co.	Keep nuts from turning off bolt and take up stretch	Hipower and Hychrome.	Yes
Illinois Central R. R. Co. (Chicago Terminals Improvement)	To maintain spring pressure, remove chatter and keep nut from backing off	Hipower	Yes

ANSWERS TO QUESTIONNAIRE—TRACK COMMITTEE
SUB-COMMITTEE NO. 10

4 Do you use nutlocks?	5 If so, state type used	6 Do you find that the use of nutlocks improves joint conditions?	7 Under similar conditions do you think that bolts equipped with nutlocks will last longer than those that are not?	8 Does the use of nutlocks reduce the amount of labor necessary to keep bolts tight?
Yes	Hipower and Plain Spiral	No definite information	Yes	No definite information.
Yes	Positive	Yes	Undecided	Undecided.
Yes (spring washer)	Improved Hipower	Yes	Yes	Yes.
Test of Ideal in progress	Ideal Std. Nutlock	No	No	No information.
			Yes	Yes.
Yes	Improved Hipower	Yes	Yes	Yes.
	Have used Hipower with untreated bolts	Yes		Found that Hipower washers gave uniform tightening of all bolts. Harvey Grip-Bolts now used.
No nutlocks used	Same as 2 and 4	Nutlocks do not improve conditions. Spring washers do improve joint conditions	Unable to say	Use of nutlocks or spring washers has a negligible effect upon the amount which a nut may be tightened in a given period of time.
Yes	Hipower Verona Spring Plates and Hychrome	Yes	Would not last longer, but joints are kept in better condition	Yes.
Yes	Verona Rail Joint Springs and ordinary coil nutlocks	Yes	Probably	Questionable.
Yes	Spring washers and Verona springs	Yes	Will keep joints tight together	Think it does.
Yes	Various	Yes	Yes	Yes.
Yes	Verona heavy spring washer. Improved Hipower washer, Verona springs	Yes	Yes	Yes.
Yes	Verona	Yes	Yes	Yes, after once tight.
No		No	No	No.
Yes	Improved Hipower, Hipower, Verona nutlocks and Verona springs	Yes	Yes	Yes.
Yes	Hipower lock washers, Hychrome nutlocks	Yes, very much	Yes	Yes.
Yes	Hipower nutlocks used at present	Yes	Yes	Yes.
Yes	Hipower and Hychrome	Yes, with small diameter bolts, but questionable with 1 inch or 1⅛ inch bolts	Yes	Yes, with small bolts. No difference with large bolts.
Yes	Hipower	Yes	Yes	Yes.

ANSWERS TO QUESTIONNAIRE—TRACK COMMITTEE
SUB-COMMITTEE No. 10

Name of Railroad	9 If so, to what extent?	10 State briefly your objections to the use of nutlocks, if any	11 When no nutlocks are used do you find it necessary to use other means or devices to keep bolts tight?
Atchison, Topeka & Santa Fe Ry. Co. (Chief Engineer)	To considerable extent	No objection	Spring washers used on all angle bar joints
Atlantic Coast Line R. R. Co.		None	
Baltimore & Ohio R. R. Co. Mtce. of Way Dept. (Mr. Myers)	50 per cent	None	Have always used spring washers
Baltimore & Ohio R. R. Co. (Mr. Lane)		None used that were satisfactory	Spring washers used
Bangor & Aroostook R. R. Co	Impossible to say to what extent	No objection to spring nutlocks with heavy capacity	Yes, screwing up the nuts
Baltimore & Ohio Chicago Terminal R. R. Co.	50 per cent	None	Have always used spring washers
Boston & Albany			
Canadian Pacific Railway (Engineering Dept)	(Same as 8)	Nutlocks are of no practical benefit. No objection to use of spring washers except cost	With or without nutlocks or spring washers, tightening of nuts is necessary.
Chesapeake & Ohio Ry. Co	Cannot say	None	Nutlocks used in all cases
Chicago, Burlington & Quincy R. R. Co.	To a very slight extent, if any	No objection	With or without nutlocks, use of wrench is necessary
Chicago, Milwaukee & St. Paul Ry		None	Must be tightened oftener
Chicago & Northwestern Ry. Co	Bolts cannot be kept tight without them	Better devices procurable for heavy traffic	Yes
Chicago, Rock Island & Pacific Ry. Co. (Engineering Dept.)	Hard to say	None	All main tracks equipped with spring washers.
Chicago, Rock Island & Pacific Ry. Co. (Operating Dept.)	Approximately 15 per cent	None	Usually nut is kept tight
Cleveland, Cincinnati, Chicago & St. Louis Ry. Co.		They do not fulfil function for which designed	No
Delaware, Lackawanna & Western R. R. Co.			
Elgin, Joliet & Eastern Ry. Co.	Probably 50 per cent.	None	Nutlocks used on all bolts
Gulf Coast Lines	May vary from 50 per cent to 90 per cent.	None	Yes
Hocking Valley Ry. Co.	No definite figure	In view of strength of modern bolts, use and cost of nutlocks is not justified	No
Illinois Central R. R. Co. (Chicago Terminals Improvement)	50 per cent	None	Nutlocks used throughout

ANSWERS TO QUESTIONNAIRE—TRACK COMMITTEE
SUB-COMMITTEE No. 10

12 What would you recommend using with heat-treated bolts? Why?	13 Do you find nutlocks are of greater value when used with heat-treated than with untreated bolts?	14 What principle should determine the design of a nutlock?	15 What principle should determine the design of a spring washer?
High tension spring washer.	No information	Sufficient pressure exerted through a maximum range. Continued pressure to be secured at minimum expense. This applies to spring washers and is beyond the range of nutlocks	See reply to previous question (14).
Yes, because length of bar may be shortened and number of bolts reduced to four	No	Inasmuch as washer is desired do not regard design of nutlock as controlling	...
Best spring washers obtainable	No	...	Provide adequate spring pressure between nut and face of joint to reduce vibration all possible with consequent reduction in wear of surfaces of rail and joint, and preserve sufficient threads on bolts to permit future tightening.
Spring washers. Keeps bolt even tension	No information	...	High quality steel offset to give spring.
...	Cannot say. Would expect nutlocks to be equally beneficial.	Would prefer a nutlock of the spring washer type, the spring being heavy enough to compensate the tendency which would otherwise stretch the bolt	See reply to previous question (14).
Best spring washers obtainable	No	...	...
...	...	...	...
Spring washers, but opinion subject to revision as result of tests	Same as No. 12	Same as No. 12	Tests to determine the advantage or otherwise of spring washers will enable us to determine the principle that should govern the design of spring washer, if required.
Same as untreated bolts	Cannot say	Sufficient spring to take up wear of angle bar and hold bolt tight	See reply to previous question (14).
Nutlocks necessary to compensate for wear in joint	More necessary with untreated bolts, on account of greater stretch	A device which would maintain a tension between the minimum and maximum tightness of the rail joint	See reply to previous question (14).
...	Should be. No information.	...	...
Joint spring for heavy traffic; nutlocks on sidings. Maintain bolts tension	...	Maximum spring pressure	Maximum spring pressure.
Verona heavy spring washers	No difference	The resistance to compression of the spring	Same as 14.
Nutlocks	No	...	...
...	No.	...	...
High class nutlocks that properly function in service	...	...	...
Nutlocks necessary to maintain joint tight	Practically no difference	Compression of nutlock should equal strength of bolt	Same as 14.
Improved Hipower or Hipower	Yes, because elongation of heat-treated bolts is less, so that nutlock will take up stretch for a longer period.	...	...
Hipower or Hychrome	No, of greater value with untreated bolts on account of heat-treated bolts not stretching after third tightening	Prevent nut from backing off bolt	Take up stretch in bolt.
...	No	To take up portion of the wear and stretch of bolt and provide resistance to nuts backing off.	To take up portion of the wear and stretch of bolt and depends only on pressure to keep nut from backing off.

ANSWERS TO QUESTIONNAIRE—TRACK COMMITTEE
SUB-COMMITTEE No. 10

Name of Railroad	1 What is, in your opinion, the true function of a nutlock?	2 State in their order of merit the name of nutlocks which you consider satisfactory for use on track	3 On a rail joint do you consider it advisable to use a nutlock on every bolt?
Indiana Harbor Belt R. R. Co	Prevent nut getting loose and maintain joint tight	Verona	Yes
Kansas City Southern Ry. Co	Prevent nut getting loose and minimize mechanical wear	Improved Hipower, Hipower and Improved Verona	Yes
Kansas City Terminal Ry. Co	To prevent loosening of nut	Eaton Lock Washer, Hipower Nutlock	Yes
Louisville & Nashville Ry. Co	To maintain contact between joint parts, and take up wear	Hipower, Verona, Reliance	Yes
Michigan Central Railroad Co. (Mr. Harris)	To take up wear and stretching of bolt	Flat spring, double curve, plain spiral	Yes
Michigan Central R. R. Co. (Mr. Lewis)	To keep joint tight	Hipower, Grip Nut, Verona, Boss	Yes
Nashville, Chattanooga & St. Louis Ry	To prevent nut from turning backward	Not prepared to name	Yes
New Jersey, Indiana & Illinois R. R. Co	To keep bolts from rattling	None	No
New York Central R. R. Co. (Ohio Central Lines)	To keep the nut from loosening.	Hipower	Yes
New York, New Haven & Hartford R. R. Co	To take up stretch in bolt and absorb shock of wheel load passing over joint	Improved Hipower, Hipower, Verona	Yes
New York, Ontario & Western R. R. Co	To keep nut from turning off	Any nutlock which will not break is satisfactory	Yes
Northern Pacific Ry. Co	To prevent nut from turning backward and take up slack	Improved Hipower from 85 lb.-130 lb. rails	Yes
Pennsylvania R. R. System (Central Region)	A nutlock should prevent nut backing off of bolt and a coil spring washer should take up wear of parts	Tests now being conducted to determine relative merits	See reply to No. 2.
Pere Marquette Ry. Co	To aid in keeping bolts tight	Do not care to go on record as to merits of different kinds	Yes
San Francisco-Sacramento R. R. Co	To prevent nuts becoming loose	Hipower, Positive, Plain coil, Tail nutlocks	Yes
Seaboard Air Line Ry. Co	Answers to questionnaire are personal and not for publication.		
Southern Pacific Lines (Chief Engineer)	To prevent nut becoming loose and take up slack	Contrary to Company's policy to answer this question	Yes
Southern Pacific Co. (Pacific System)	To hold the nut from back turning on the bolt	No opinion on the matter	Yes
Southern Railway System	Maintaining tension on bolts	Improved Hipower, Verona low pressure	Yes
St. Louis Southwestern Ry. Co	Protect bolt threads and retard loosening of nuts	Spring washer type, Hipower or equal	Yes
Union Pacific	Keep nuts from loosening	Hipower	Yes
Waterloo, Cedar Falls and Northern Ry. Co	To keep nut tight	Chrome steel with ends bent for positive action	Yes, or Harvey Grip-Bolts
Western Pacific R. R. Co	To keep bolts tight	Improved Hipower, Verona and all other types of nutlocks	Yes

ANSWERS TO QUESTIONNAIRE—TRACK COMMITTEE
SUB-COMMITTEE NO. 10

4 Do you use nutlocks?	5 If so, state type used	6 Do you find that the use of nutlocks improves joint conditions?	7 Under similar conditions do you think that bolts equipped with nutlocks will last longer than those that are not?	8 Does the use of nutlocks reduce the amount of labor necessary to keep bolts tight?
Yes, on all except 105 lb. rail	Verona	Yes	Yes	Yes.
Yes, on 100 lb. rail	Improved Hipower, Hipower and Improved Verona	Yes	If bolts are kept tight, nutlocks will not lengthen life of bolts	Yes.
Yes	Mostly high carbon Verona, a few Eaton lock washers and Hipower nutlocks	Yes	Yes	Yes.
Yes	Verona, Reliance, etc.	Yes	Yes	Yes.
Yes	Plain spiral	Yes	Yes	Yes.
Yes, where U. S. thread bolts are used	National and Verona, mostly	Yes	Yes	Yes.
No nutlocks used. Spring washers instead	Hipower, Hychrome and experimenting with Improved Hipower, Hychrome and Verona springs.	Yes	Yes	Yes.
Yes	Spring	No	No	No
Nutlocks with common steel bolts, none with heat-treated bolts	Spring washer type	With ordinary bolts nutlocks will improve joint conditions	Bolts will stay tight longer	Yes.
Yes	Hipower	Yes	Yes	Yes.
Yes	National lock washers, Hipower	Yes	Questionable	Yes
Yes	Improved Hipower and test installations of Palmer springs	Yes	Yes	Yes.
Yes, coil spring nutlocks which function as nutlocks	High and low coil spring washer	See reply to No. 2	See reply to No. 2	See reply to No
Yes	National Lock Washer	Yes	Yes, if bolts are kept tight	Probably.
Yes	Hipower with heat-treated bolts and ordinary plain coil with standard bolt.	Yes	Not prepared to say	Yes.
Yes	Hipower	Yes	Yes	Yes.
Spring washers	Hipower, experimenting with Verona rail springs	Yes	Yes	Yes.
Yes	Improved Hipower, Verona, plain low pressure	Yes	Yes	Yes.
Yes	Hipower of equal spring washer type.	Yes	Yes	Yes.
Yes	Hipower and others	Yes	Yes	Yes
Yes	Same as No. 2	Yes	Yes	Yes.
Yes	Generally Verona and some Improved Hipower washers	Yes	Yes	Yes

Answers to Questionnaire—Track Committee
Sub-Committee No. 10

Name of Railroad	9 If so, to what extent?	10 State briefly your objections to the use of nutlocks, if any	11 When no nutlocks are used do you find it necessary to use other means or devices to keep bolts tight?
Indiana Harbor Belt R. R. Co.	50 per cent	None	
Kansas City Southern Ry. Co.	About 10 per cent		Nuts must be tightened more frequently
Kansas City Terminal Ry. Co.	No exact information.	Cost only objection.	Yes
Louisville & Nashville Ry. Co.	Cannot state		
Michigan Central Railroad Co. (Mr. Harris)	No data	None	No other means used.
Michigan Central R. R. Co. (Mr. Lewis)	Probably 20 per cent, but bolts should be kept tight all the time		Yes, dip in tar and oil before applying, inspect daily and keep tight
Nashville, Chattanooga & St. Louis Ry	No data	They do not take up wear and permit bolts to become loose	Bolts can be kept tight by constant wrenching
New Jersey, Indiana & Illinois R. R. Co.			
New York Central R. R. Co. (Ohio Central Lines).	At least 50 per cent.	None, outside of cost.	No
New York, New Haven & Hartford R. R. Co.			
New York, Ontario & Western R. R. Co.		Longer bolt required, extra cost and breakage. Without nutlock a loose nut will show up more easily	Yes, thread tight bolts
Northern Pacific Ry. Co.	No information	None	No
Pennsylvania R. R. System (Central Region)	See reply to No. 2	Cost	See reply to No. 2
Pere Marquette Ry. Co.	Impossible to answer.	None	No
San Francisco-Sacramento R. R. Co.	50 per cent less	None	Fully equip with nutlocks
Seaboard Air Line Ry. Co.			
Southern Pacific Lines (Chief Engineer)	No record	None	No
Southern Pacific Co. (Pacific System)	Labor reduced from daily to occasional tightening	None	Always used nutlocks (spring washers)
Southern Railway System	80 per cent	None	More labor required.
St. Louis Southwestern Ry. Co.	No figures available.	None	Increased wrenching and bolt renewals.
Union Pacific	Cannot be answered in man hours or money	None	Nutlocks used in all cases
Waterloo, Cedar Falls and Northern Ry. Co.	Considerably	None	Wrench-works
Western Pacific R. R. Co.	Would judge that saving in labor with Hipower lock washer would run from 3 cents to 5 cents per bolt per year	None	Nutlocks used on all bolts

ANSWERS TO QUESTIONNAIRE—TRACK COMMITTEE
SUB-COMMITTEE NO. 10

12 What would you recommend using with heat-treated bolts? Why?	13 Do you find nutlocks are of greater value when used with heat-treated than with untreated bolts?	14 What principle should determine the design of a nutlock?	15 What principle should determine the design of a spring washer?
Nutlocks; easier to keep bolts tight	Untreated bolts	Resistance to compression with necessary spring	
Improved Hipower; proved best by use and observation	Probably more valuable with untreated bolts	Prevent nut from turning backward	Sufficient elasticity and at least $\frac{1}{16}$ inch deflection. Points of contact located so that tension of bolt will act parallel to axis of bolts.
Same as No. 2. To prevent nuts loosening up	Cannot say	Prevent nut from turning back	Same as No. 14.
Spring nutlocks used with heat-treated bolts	No		
Double curve. High tension afforded	No, on account of less stretching		
Nutlocks, because nuts will need tightening with any bolt	Too short experience to judge.	Lock	Spring.
Properly designed spring washers. To prevent bolts getting loose	Same with each		Resiliency.
Nothing	No		
Harvey Grip thread	No	Prevent nut from turning back, permit nut to be removed or tightened and be low in cost	Should be designed to take full stress of bolt without permanent set, prevent nut from turning and permit tightening of bolt.
	No	Lock the nut	Should develop tension in bolt up to elastic limit through a considerable range.
Spring washers	Yes	No interest in a nutlock as such	Should have greatest possible reaction within limits of bolt tension required for effective service.
See reply to No. 2	See reply to No. 2	Should prevent nut from backing off of bolt	Should develop through an appreciable distance a pressure sufficient to overcome the full effect of traffic load to which it is subjected.
Nutlocks	No difference	Performance in service	Same as No. 14.
Hipower or similar on account of necessity of having more strength than found in ordinary Veronas	No	Not prepared to say	Not prepared to say.
Nutlocks, spring washers or rail springs	Of greater value with untreated bolts on account of greater stretch of bolts	Should exert sufficient pressure to hold parts tightly together throughout full range of reaction as would be accomplished by wrench tightening	Spring washers should be able to take all pressure applied on bolts up to the strength of threads without damage.
Improved Hipower, Verona rail springs or similar type	Of greater value with treated bolts on account of the greater strength of same	To lock the nut relative to its position on the bolt	
Improved Hipower	With untreated	Reduction of lever arm to lowest practicable length	Sufficient spring to take up wear and cause tension strains to exist in bolt.
Improved Hipower. Saving in maintenance		Protect bolt and lock nut	Protect bolt and lock nut.
Same as No. 11	Advantages principally in stronger and more durable bolts	Adequate resistance to pressure so as to distribute tension amongst all bolts in a joint, prevent nuts loosening and take up slack	Same as No. 14.
Hipower washers because there is a balance as to strength	Yes	Prevent the nut from turning.	Sufficient spring pressure to hold bolt tight at all times.

(9) Extent of labor reduction, varying between 10 and 90% reported by 19 roads, 10 roads report having no data on the subject, 9 roads have not answered this question and others are conducting tests on the subject or claim no reduction.

(10) Replies to this question are as follows:

No objection	25 replies
Cost as an objection	4 replies
Not satisfactory	6 replies

Other roads have not replied to this question.

(11) Other means used by railroads for keeping bolts tight are as follows: Constant wrenching, dipping in tar and oil before applying, threadtight bolts, some roads report that with or without nutlocks the use of wrench is necessary.

(12) Nutlocks of the spring washer type are recommended for use with heat-treated bolt by 30 roads, 9 have not answered this question and others nothing being used or are conducting tests and are unable to report.

(13) Nutlocks (spring washer type) are found to be of greater value with heat-treated bolts by 4 roads, 18 roads claim no greater value, and 7 replies state no information on the subject, 4 report no difference, 7 have not answered this question and others are conducting tests.

(14) Eleven replies state that a nutlock should prevent the nut from backing off of the bolt, 16 have given a joint answer to questions 14 and 15 and others have not answered this question.

(15) A maximum pressure exerted through a maximum reactive range is given as the principle that should determine the design of a spring washer by 21 roads, 16 have not answered this question and others are not prepared to say.

REPORT OF COMMITTEE III—TIES

W. J. BURTON, *Chairman;*	JOHN FOLEY, *Vice-Chairman;*
F. T. BECKETT,	C. S. KIRKPATRICK,
R. S. BELCHER,	R. M. LEEDS,
E. BETTS,	R. S. MCCORMICK,
M. S. BLAIKLOCK,	A. J. NEAFIE,
BERNARD BLUM,	G. P. PALMER,
W. A. CLARK,	F. W. PFLEGING,
R. L. COOK,	L. J. RIEGLER,
E. L. CRUGAR,	J. H. ROACH,
J. F. DEIMLING,	S. E. SIMS,
A. R. DEWEES,	C. U. SMITH,
F. H. ELLSWORTH,	J. W. WILLIAMS,
S. B. FISHER,	W. W. WYSOR,
H. C. HAYES,	R. C. YOUNG,

Committee.

To the American Railway Engineering Association:

Your Committee respectfully presents herewith report covering the following subjects:

(1) Revision of Manual (Appendix A).
(2) Report on Use of Dating Nails; Specifications for Dating Nails, and Marking Ties for Service Records (Appendix B).
(3) Service Records (Appendix C).
(4) Extent to which A.R.E.A. Specifications are being adhered to (Appendix D).
(5) Report on Substitute Ties (Appendix E).

The following subjects, assigned this year, are not being reported on:

(6) Anti-splitting devices.
(7) Proper size hole for pre-boring.

Action Recommended

1. That the revised Specification for Cross-ties and the revised Specification for Switch-Ties (Appendix A) be approved and the revised text be substituted for the text now in the Manual.

2. That the conclusions in Appendix B, relating to the use of dating nails and the specifications therefor, be approved for printing in the Manual.

3. That the material in Appendix C, relating to Service Records, be received as information.

4. That Appendix D be received as information.

5. That Appendix E be received as information.

Bulletin 283, January, 1926.

Recommendations for Future Work

1. Revision of Manual.
2. Prepare recommendations for use of anti-splitting devices and specifications for same.
3. Report on proper size hole for pre-boring.
4. Continue report on Service Records.
5. Continue report on extent to which A.R.E.A. specifications are being adhered to.
6. Renewal of switch ties out of face by sets as against renewal of individual ties.
7. Report on Substitute Ties.

Respectfully submitted,

THE COMMITTEE ON TIES,
W. J. BURTON, *Chairman.*

Appendix A

(1) REVISION OF THE MANUAL

W. J. Burton, Chairman, Sub-Committee; R. S. Belcher, Bernard Blum, John Foley, H. C. Hayes, L. J. Riegler.

On December 7, 1921, the American Railway Engineering Association accepted with the United States Forest Service the sponsorship of an American Engineering Standards Committee project for the standardization of Specifications for Ties. In the organization of the Sectional Committee to develop the desired standard, the American Railway Engineering Association representative was chosen Chairman, and the United States Forest Service representative was elected Secretary. The 14 other members of the Sectional Committee represented tie producers, lumber manufacturers, wood preservers, testing engineers, miners, electric railways, short-line railroads and the public. Meetings were held in Washington and Philadelphia, and drafts of specifications based on the discussions at these meetings were circulated and revised in accordance with the balloting for each section of the proposed standards. The specifications of the American Railway Engineering Association and the National Association of Railway Tie Producers, adopted in 1921, and alike in nearly all respects, were the bases of the American Engineering Standards Committee consideration.

The agreement required for the transmission of a recommended standard to the American Engineering Standards Committee has been reached, and the approval of the American Railway Engineering Association as a sponsor is necessary for the reception of the recommended specifications by the Main Committee of the American Engineering Standards Committee.

The Committee on Ties recommends the approval by the American Railway Engineering Association of the following proposed Specification for Cross-Ties and Specification for Switch-Ties, and their transmission to the American Engineering Standards Committee as recommended American Engineering Standards. The Committee on Ties also recommends that these specifications be adopted as revisions of existing American Railway Engineering Association standards for inclusion in the Manual of Recommended Practice.

For ready comparison the proposed additions to the existing specifications are indicated by underscoring, and the text of portions of the old specifications omitted from the revised version is also given, between heavy lines. The changes are those which might be expected after five years' experience with a standard in daily use for a hundred million ties annually.

The soundness of the existing American Railway Engineering Association standards is proved by the slight revisions proposed after a critical consideration of these specifications by all interests concerned over a period of more than three years.

Nearly all the recommended changes are self-explanatory. Where they may not be, the following explanations may be enlightening:

SECTION 3. Since the majority of the railroads using needleleaved woods make no distinction between compact and coarse wood, it seems advisable that the standard stipulate compact wood only when it is ordered by the few railroads which believe they require it.

Since the proportion of summerwood is not a criterion of strength in all needleleaved woods used for ties, it seems inadvisable to include the existing requirements in an American Engineering Standard.

SECTION 8.—Since forest products are generally graded on the basis of quality, while ties are of one quality and sorted by sizes, it seems advisable and logical to refer to sizes instead of grades.

The adoption of standard dimensions for small ties now referred to as Grade "O," or usable rejects, or serviceable culls, will provide a legitimate tie for those who can use such a small one, and will tend to stop the practice of calling usable or serviceable ties smaller than Size "O."

SECTIONS 9 AND 22.—The few railroads which attempt to restrict the period during which trees for ties shall be felled can make such a restriction part of their buying arrangements, since those most familiar with tie production regard it as impracticable to determine, after a tree is felled or a tie is cut, whether or not the tree has been down or the tie made more or less than one month.

Exhibit 1

PROPOSED

SPECIFICATION FOR CROSS-TIES

MATERIAL

Kinds of Wood (1)

1. Before manufacturing ties, producers shall ascertain which of the following kinds of wood suitable for cross-ties will be accepted:

Ashes
Beech
Birches
Catalapas
Cedars
Cherries
Chestnut
Cypresses
Douglas fir
Elms
Firs (True)
Gums
Hackberries
Hemlocks
Hickories
Larches
Locusts
Maples
Mulberries
Oaks
Pines
Poplars
Redwoods
Sassafras
Spruces
Sycamores
Walnuts

Others will not be accepted unless specially ordered.

PHYSICAL REQUIREMENTS

General Quality

2. Except as hereinafter provided, all ties shall be free from any defects that may impair their strength or durability as cross-ties, such as decay, large splits, large shakes, large or numerous holes or knots, grain with slant greater than one in fifteen.

Resistance to Wear.

3. When so ordered, ties from needleleaved trees shall be of compact wood throughout the top fourth of the tie, where any inch of any radius from the pith shall have six or more rings of annual growth.

> **Resistance to Wear**
>
> 3. Ties from needleleaved woods shall be of compact wood throughout the top fourth of the tie, where any inch of any radius from the pith shall have not less than one-third summerwood in six or more rings of annual growth, or not less than one-half summerwood in fewer rings. Ties of coarse wood having fewer rings or less summerwood will not be accepted unless specially ordered.

Resistance to Decay

4. Ties for use without preservative treatment shall not have sapwood wider than one-fourth the width of the top between (a) inches and (b) inches from the middle of the tie, and will be designated as "heart" ties. Those with more sapwood will be designated as "sap" ties.

---

[1] Each railway will specify only the kind or kinds of wood it desires to use.

[a] 20 inches for standard-gage railway ties;
15 inches for narrow-gage railway ties.

[b] 40 inches for standard-gage railway ties;
25 inches for narrow-gage railway ties.

DESIGN

Dimensions (2)

5. Before manufacturing ties, producers shall ascertain which of the following lengths, shapes, or sizes will be accepted, and whether ties are to be hewed or sawed, and in either case whether on the sides as well as on the top and the bottom.

6. Except as hereinafter provided, standard-gage railway ties shall be 8 feet, 8 feet 6 inches, or 9 feet long; narrow-gage railway ties shall be 5 feet, 5 feet 6 inches, 6 feet, 6 feet 6 inches, or 7 feet long.

7. Except as hereinafter provided, ties shall measure as follows throughout both sections between (a) inches and (b) inches from the middle of the tie:

8.

Size	Sawed or Hewed Top, Bottom and Sides	Sawed or Hewed Top and Bottom
0	5 inches thick by 5 inches wide on top[3]	5 inches thick by 5 inches wide on top
1	6 inches thick by 6 inches wide on top[3]	6 inches thick by 6 inches wide on top
2	6 inches thick by 7 inches wide on top	6 inches thick by 7 inches wide on top
3	6 inches thick by 8 inches wide on top	6 inches thick by 8 inches wide on top 7 inches thick by 7 inches wide on top[4]
4	7 inches thick by 8 inches wide on top	7 inches thick by 8 inches wide on top
5	7 inches thick by 9 inches wide on top	7 inches thick by 9 inches wide on top
6	7 inches thick by 10 inches wide on top	7 inches thick by 10 inches wide on top

MANUFACTURE

9. All ties, except those of ....
(Insert kind or kinds of wood)
shall be made from trees which have been felled not longer than one month.

9. Except as hereinafter provided, all ties shall be straight, well hewed or sawed, cut square at the ends, have bottom and top parallel, and have bark entirely removed.

INSPECTION

Place

10. Ties will be inspected at suitable and convenient places satisfactory to the railway, at points of shipment or at destination. Ties will be inspected at points other than the railway's property whenever in the judgment of the railway there is sufficient number to warrant it; but the shipper shall provide accommodations for the inspector, at the expense of the railway, while away from rail or steamer lines, and transport him from and to a railway station or steamer landing.

---

[2] Each railway will specify only the length or lengths, shape or shapes, and size or sizes it desires to use; but each railway will use the standard designation for whatever size of tie it specifies. For example, a railway desiring 6 inch x 8 inch ties only will designate them as Size 3; a railway desiring 7 inch x 9 inch ties only will designate them as Size 5. A railway shall not, for instance, designate 6 inch x 8 inch ties as Size 1 and 6 inch x 6 inch as Size 2 or 7 inch x 9 inch as Size 1 and 7 inch x 8 inch as Size 2.

[3] None accepted in standard-gage railway ties.

[4] Railways which specify both 6 inch x 8 inch and 7 inch x 7 inch ties manufactured on top and bottom only and which desire to separate the 6 inch from the 7 inch ties will designate the 7 inch x 7 inch as Size 3A.

Manner

11. Inspectors will make a reasonably close examination of the top, bottom, sides and ends of each tie. Each tie will be judged independently, without regard for the decisions on others in the same lot. Rafted or boomed ties too muddied for ready examination will be rejected. Ties handled by hoists will be turned over as inspected, at the expense of the producer.

Decay

12. The following decay will be allowed: In cedar and in cypress, "pipe or stump rot" and "peck," respectively, up to the limitations as to holes; in chestnut, "bark disease" up to ¼ inch deep. "Blue stain" is not decay and is permissible in any wood.

> 12. Ties will be rejected when decayed in the slightest degree, except that the following will be allowed: In cedar, "pipe or stump rot" up to 1½ inches in diameter and 15 inches deep; in cypress, "peck" up to the limitations as to holes; and, in pine, "blue sap stain."

Holes

13. A large hole, other than one caused by "pipe or stump rot" in cedar, is one more than ½ inch in diameter and 3 inches deep within, or more than one-fourth the width of the surface on which it appears and 3 inches deep outside, the sections of the tie between (a) inches and (b) inches from its middle. A cedar tie with a pipe or stump rot hole more than 1½ inch in diameter and 15 inches deep will be rejected. Numerous holes are any number equaling a large hole in damaging effect. Such holes may be caused in manufacture or otherwise.

Knots

14. A large knot is one whose average diameter exceeds one-fourth the width of the surface on which it appears; but such a knot may be allowed if it occurs outside the sections of the tie between (a) inches and (b) inches from its middle. Numerous knots are any number equaling a large knot in damaging effect.

Shake

15. One which is not more than one-third the width of the tie will be allowed.

Split

16. One which is not over 10 inches long will be allowed, provided a satisfactory anti-splitting device has been properly applied.

Manufacture

17. A tie will be considered straight: (1) When a straight line along the top from the middle of one end to the middle of the other end is entirely within the tie; and (2) when a straight line along a side from the middle of one end to the middle of the other end is everywhere more than 2 inches from the top and the bottom of the tie.

18. A tie is not well hewed or sawed when its surfaces are cut into with scoremarks more than ½ inch deep or when its surfaces are not even.

19. The top and bottom of a tie will be considered parallel if any difference in the thicknesses at the sides or ends does not exceed ½ inch.

> 19. The top and bottom of a tie will be considered parallel if the difference in the thicknesses at the two sides or ends does not exceed one-half (½) inch; that is, one side may be seven and one-quarter (7¼) inches, while the other is six and three-quarters (6¾) inches wide; or one end may be six and three-quarters (6¾) inches, while the other is seven and one-quarter (7¼) inches thick.

Dimensions

20. The lengths, thicknesses and widths specified will be considered met by ties 1 inch shorter, and ¼ inch thinner and narrower than the standard sizes. Ties over 1 inch, but not over 2 inches, more in thickness than the maximum ordered will be accepted as one size below the largest tie ordered. Those over 2 inches more in thickness; those over 3 inches more in width; or those over 2 inches more in length than the maximum ordered will be rejected. Ties will be sized up by their smaller ends and sized down by their larger ends. The dimensions of the tie will not be averaged.

> 20. The lengths, thicknesses and widths specified are minimum dimensions. Ties over 1 inch and under 2 inches more in thickness than the maximum specified will be accepted as one grade below the largest tie specified. Those 2 inches to 3 inches more in thickness than the maximum specified will be accepted as two grades below the largest tie specified. Those over 3 inches more in thickness or width or over 2 inches more in length than the maximum specified will be rejected. Ties will be graded up by their smaller ends and graded down by their larger ends. The dimensions of the tie will not be averaged.

21. All thicknesses and widths apply to the sections of the tie between .... (a) inches and .... (b) inches from the middle of the tie. All determinations of width will be made on the top of the tie, which is the narrower of the horizontal surfaces, or the one with narrower or no heartwood if both horizontal surfaces are of the same width.

DELIVERY

> 22. All ties, except those ...., shall
> (Insert kind or kinds of wood)
> be delivered to the railway within one month after being made.

22. Ties delivered on the premises of a railway for inspection shall be stacked not less than 10 feet from the nearest rail of any track at suitable and convenient places; but not at public crossings, nor where they will interfere with the view of trainmen or of people approaching the railway. Standard-gage ties shall be stacked in alternate layers of 2 and 7, the bottom layer to consist of 2 ties kept at least 6 inches above the ground.

The next layer shall consist of 7 ties laid crosswise of the first layer. When the ties are rectangular, the two outside ties of the layers of seven and the layers of two shall be laid on their sides. The ties in layers of two shall be laid at the extreme ends of the ties in the layers of seven. No stack may be more than 12 layers high, and there shall be 5 feet between stacks to facilitate inspection. Ties which have stood on their ends on the ground will be rejected.

23. Each stack shall have fastened to it a tag on which is written the owner's name and address, the date when stacked, and the number of ties of each kind of wood in the stack.

24. All ties are at the owner's risk until accepted. All rejected ties shall be removed within one month after inspection.

25. Ties shall be stacked as grouped below. Only the kinds of wood named in a group may be stacked together.

26. Class U—Ties Which May Be Used Untreated

Group Ua

"Heart" black locust
"Heart" white oaks
"Heart" black walnut

Group Ub

"Heart" Douglas fir
"Heart" pines
"Heart" larches

Group Uc

"Heart" cedars
"Heart" cypresses
"Heart" redwood

Group Ud

"Heart" catalpas
"Heart" chestnut
"Heart" sassafras
"Heart" red mulberry

27. Class T—Ties Which Should Be Treated

Group Ta

Ashes
Hickories
"Sap" black locust
Honey locust
Red oaks
"Sap" white oaks
"Sap" black walnut

Group Tb

"Sap" cedars
"Sap" cypresses
"Sap" Douglas fir
Firs (True)
Hemlocks
"Sap" larches
"Sap" pines
"Sap" redwood
Spruces

Group Tc

Beech
Birches
Cherries
Gums
Hard maples

Group Td

"Sap" catalpas
"Sap" chestnut
Elms
Hackberries
Soft maples
"Sap" mulberries
Poplars
"Sap" sassafras
Sycamores
White walnut

SHIPMENT

28. Ties forwarded in cars or vessels shall be separated therein according to the above groups, and also according to the above sizes if inspected before loading, or as may be stipulated in the contract or order for them.

Exhibit 2

PROPOSED

SPECIFICATION FOR SWITCH-TIES

MATERIAL

Kinds of Wood (1)

1. Before manufacturing ties, producers shall ascertain which of the following kinds of wood suitable for switch-ties will be accepted:

Ashes
Beech
Birches
Cedars
Cherries
Chestnut
Cypresses
Douglas fir
Elms
Firs (True)
Gums
Hemlocks
Larches
Locusts
Maples
Oaks
Pines
Redwood
Spruces
Walnuts

Others will not be accepted unless specially ordered.

PHYSICAL REQUIREMENTS

General Quality

2. Except as hereinafter provided, all ties shall be free from any defects that may impair their strength or durability as switch-ties, such as decay, large splits, large shakes, large or numerous holes or knots, grain with slant greater than one in fifteen.

Resistance to Wear

3. When so ordered, ties from needleleaved trees shall be of compact wood throughout the top fourth of the tie, where any inch of any radius from the pith shall have six or more rings of annual growth.

> **Resistance to Wear**
>
> 3. Ties from needleleaved trees shall be of compact wood throughout the top fourth of the tie, where any inch of any radius from the pith shall have not less than one-third summerwood in six or more rings of annual growth, or not less than one-half summerwood in fewer rings. Ties of coarse wood having fewer rings or less summerwood will not be accepted unless specially ordered.

Resistance to Decay

4. Ties for use without preservative treatment shall not have sapwood wider than one-fourth the width of the top between 12 inches from each end of the tie, and will be designated as "heart" ties. Those with more sapwood will be designated as "sap" ties.

DESIGN

Dimensions (2)

5. Before manufacturing ties, producers shall ascertain what sizes will be accepted and whether ties are to be hewed or sawed, and in either case whether on the sides as well as on the top and the bottom.

---

(1) Each railway will specify only the kind or kinds of wood it desires to use.

(2) Each railway will specify only the shape or shapes and size or sizes it desires to use.

6. Except as hereinafter provided, all ties shall be either 5, 6 or 7 inches thick as ordered.

7. Except as hereinafter provided, ties sawed or hewed on top, bottom and sides shall be not less than either 6, 7, 8 or 9 inches wide on top throughout the section between 12 inches from each end of the tie, as ordered; ties sawed or hewed on top and bottom only shall be not less than either 5, 6 or 7 inches wide on top throughout the section between 12 inches from each end of the tie, as ordered.

8. Each tie shall be of a length specified below:

(Insert complete bill of material here.)

MANUFACTURE

9. All ties, except those of ....
(Insert kind or kinds or wood)
shall be made from trees which have been felled not longer than one month.

9. Except as hereinafter provided, all ties shall be straight, well hewed or sawed, cut square at the ends, have bottom and top parallel, and have bark entirely removed.

INSPECTION

Place

10. Ties will be inspected at suitable and convenient places satisfactory to the railway, at points of shipment or at destination. Ties will be inspected at points other than the railway's property whenever in the judgment of the railway there is sufficient number to warrant it; but the shipper shall provide accommodations for the inspector, at the expense of the railway, while away from rail or steamer lines and transport him from and to a railroad station or steamer landing.

Manner

11. Inspectors will make a reasonably close examination of the top, bottom, sides, and ends of each tie. Each tie will be judged independently, without regard for the decision on others in the same lot. Rafted or boomed ties too muddied for ready examination will be rejected. Ties handled by hoists will be turned over as inspected, at the expense of the producer.

Decay

12. The following decay will be allowed: in cedar and in cypress, "pipe or stump rot" and "peck," respectively, up to the limitations as to holes; in chestnut, "bark disease" up to ¼ inch deep. "Blue stain" is not decay and is permissible in any wood.

12. Ties will be rejected when decayed in the slightest degree, except that the following will be allowed: in cedar, "pipe or stump rot" up to one and one-half (1½) inches in diameter and fifteen (15) inches deep; in cypress, "peck" up to the limitations as to holes; and, in pine, "blue sap stain."

Holes

13. A large hole, other than one caused by "pipe or stump rot" in cedar, is one more than ½ inch in diameter and 3 inches deep within, or more than one-fourth the width of the surface on which it appears and 3 inches deep outside the sections of the tie between twelve inches from each end of the tie. A cedar tie with a pipe or stump rot hole more than 1½ inches in diameter and 15 inches deep will be rejected. Numerous holes are any number equaling a large hole in damaging effect. Such holes may be caused in manufacture or otherwise.

Knots

14. A large knot is one whose average diameter exceeds one-fourth the width of the surface on which it appears; but such a knot may be allowed if it occurs outside the section between 12 inches from each end of the tie. Numerous knots are any number equaling a large knot in damaging effect.

Shake

15. One which is not more than one-third the width of the tie will be allowed.

Split

16. One which is not over 10 inches long will be allowed, provided a satisfactory anti-splitting device has been properly applied.

Manufacture

17. A tie will be considered straight: (1) When a straight line along the top from the middle of one end to the middle of the other end is entirely within the tie; and (2) when a straight line along a side from the middle of one end to the middle of the other end is everywhere more than 2 inches from the top and the bottom of the tie.

18. A tie is not well hewed or sawed when its surfaces are cut into with scoremarks more than ½ inch deep or when its surfaces are not even.

19. The top and bottom of a tie will be considered parallel if any difference in the thicknesses at the two sides or ends does not exceed ½ inch.

20. The top and bottom of a tie will be considered parallel if the difference in the thicknesses at the two sides or ends does not exceed one-half (½) inch; that is, one side may be seven and one-quarter (7¼) inches while the other is six and three-quarters (6¾) inches wide; or one end may be six and three-quarters (6¾) inches while the other is seven and one-quarter (7¼) inches thick.

Dimensions

20. The lengths, thicknesses, and widths specified will be considered met by ties 1 inch shorter and ¼ inch thinner and narrower than the standard sizes. Ties over 1 inch more in thickness, over 3 inches more in width, or over 2 inches more in length than the maximum ordered will be rejected. The dimensions of the tie will not be averaged.

19. The lengths, thicknesses, and widths specified are minimum dimensions. Ties over one (1) inch more in thickness, over three (3) inches more in width, or over two (2) inches more in length will be rejected.

21. All thicknesses and widths apply to the section of the tie between 12 inches from each end of the tie. All determinations of width will be made on the top of the tie, which is the narrower of the horizontal surfaces, or the one with narrower or no heartwood if both horizontal surfaces are of the same width.

DELIVERY

22. All ties, except those of ...., shall
(Insert kind or kinds of wood)
be delivered to the railway within one month after being made.

22. Ties delivered on the premises of a railway while awaiting inspection shall be stacked not less than 10 feet from the nearest rail of any track at suitable and convenient places; but not at public crossings, nor where they will interfere with the view of trainmen or of people approaching the railway. Ties shall be stacked at least 6 inches above the ground. No tie shall be unsupported for more than 10 feet of its length. Each layer of ties and the ties in each layer shall be not less than one inch apart. Any stacking strips used shall not be over four inches wide. If rectangular ties are used to separate the layers, such strip ties shall be laid on their sides and the two outside ties as near as possible to the extreme ends of the ties. No ties shall be permitted to overhang more than 2 feet. No stack of ties shall be wider than 10 feet.

23. Each stack shall have fastened to it a tag on which is written the owner's name and address, the date when stacked, and the number of ties of each kind of wood in the stack.

24. All ties are at the owner's risk until accepted. All rejected ties shall be removed within one month after inspection.

25. Ties shall be stacked as grouped below. Only the kinds of wood named in a group may be stacked together.

26. CLASS U—TIES WHICH MAY BE USED UNTREATED

Group Ua	*Group Ub*
"Heart" black locust	"Heart" Douglas fir
"Heart" white oaks	"Heart" pines
"Heart" black walnut	"Heart" larches

Group Uc

"Heart" cedars
"Heart" cypresses
"Heart" redwood

Group Ud

"Heart" chestnut

27. Class T—Ties Which Should Be Treated

Group Ta

Ashes
"Sap" black locust
Honey locust
Red oaks
"Sap" white oaks
"Sap" black walnut

Group Tb

"Sap" cedars
"Sap" cypresses
"Sap" Douglas fir
Firs (True)
Hemlocks
"Sap" larches
"Sap" pines
"Sap" redwood
Spruces

Group Tc

Beech
Birches
Cherries
Gums
Hard maples

Group Td

"Sap" chestnut
Elms
Soft maples
White walnut

SHIPMENT

28. Ties forwarded in cars or vessels shall be separated therein according to the above groups, and also according to the above sets or lengths if inspected before loading, or as may be stipulated in the contract or order for them.

A

Appendix B

(2) SPECIFICATION FOR DATING NAILS—MARKING TIES FOR SERVICE RECORDS

R. S. Belcher, Chairman, Sub-Committee; F. T. Beckett, W. A. Clark, S. B. Fisher.

Your Committee first undertook to ascertain from manufacturers of dating nails the types, kind of material, and comparative prices of dating nails manufactured in the past. Information obtained is given in Exhibit 1 and shows a large variety of shapes and sizes of nails have been used. Comparative cost of the various kinds of nails is given and it will be noted that the cost at the factory for the nail now described in the Manual is approximately one-quarter of a cent per nail.

Also, a questionnaire was sent to sixty railroads of the United States and Canada (Exhibit 2). Forty-five replies were received, and many of these replies are extremely interesting and much valuable information on this subject is given.

Thirty-two of the roads reporting use dating nails to some extent; the first of these to use dating nails began their use in 1899.

Most of these use a galvanized iron or steel nail, a few use galvanized malleable iron. Some use is being made of copper dating nails and, while good results are expected, the price is considerably higher than galvanized nails, as indicated by Exhibit 1, and copper nails are not in general use.

Half of the roads reporting use nails with raised figures and half use depressed. A few use both raised and depressed figures to indicate treated and untreated, or two different treatments.

Twenty-two of the roads use nails with shank approximately 2½ inches long, the remainder use a shorter shank down to a minimum of $1\frac{3}{16}$ inches. A shank ¼ inch thick is most commonly used. The maximum is $\frac{5}{16}$ inch, the minimum $\frac{5}{32}$ inch.

Dating nails with heads ⅝ inch in diameter are most commonly used. A few use ¾ inch and a few more use ½ inch. Roundhead nails are most frequently used, but a few roads use square head nails. Four roads use both round and square head nails in treated and untreated ties, respectively, or the reverse.

There has been little cause for complaint due to corrosion of nails, although five roads do report some trouble on this account, and one notes that corrosion is more frequent in depressed figures than raised figure nails.

In general, galvanized nails have given satisfaction. Galvanized dating nails, with raised figures, placed in ties in 1892 and 1893 in Belguim are reported in good condition and it is thought can be plainly read for many years to come. In England and other parts of Europe, where dating nails are quite generally used, little trouble was experienced in determining the date on nails placed in ties twenty to thirty years ago.

Seven roads report a little trouble from nails coming out of ties due to checking of the wood. This more particularly when short shank nails are used.

Of thirty-one roads reporting as to the extent dating nails are applied to cross-ties, nine apply to all cross-ties, one to all main line cross-ties, twelve to all treated ties, and nine to test ties only.

In answer to question 7 of the questionnaire (Exhibit 2) as to the influence of dating nails, considerably more than half of those reporting are of the opinion that dating nails do have some influence on foremen and others responsible for removing ties, and most of these feel that this influence is favorable to the ties. The remainder are of the opinion that dating nails have no influence and that date is not considered when decision is made as to whether or not a tie should be removed. All answers to this question are quoted in Exhibit 3.

About sixty per cent of those answering question 11 of the questionnaire are of the opinion that the cost of dating nails is justified. Many of these feel that dating nails are of great assistance to those whose duty it is to carefully follow the life of ties and that awakened interest in the ties is worth many times the cost of the nail. The remainder are of the opinion that the cost of dating nails it not justified outside of test and check sections. All answers to question 11 are quoted in Exhibit 4.

Two of the roads reporting insert dating nails at treating plants and two or three treating companies have adopted the practice of inserting dating nails in all their ties prior to leaving the plant. This practice has the advantage that since nails are inserted at a single point work can be done for less money and with perhaps greater surety of their being driven into all ties than if driven into tie after tie is inserted in track. Some of the treating companies monogram these nails, in addition to showing the year, and this is an advantage to the railroad in that the origin of the tie is given. On the other hand, the tie is not always inserted in track the same year treated. The common practice of the railroads is to insert dating nails after ties are placed in track.

Some of the roads stamp date on end of ties. A few do this by hand hammer, but most of this branding is done by boring and adzing machines as the ties pass through these machines. This branding can be done at little or no expense additional to the boring and adzing. The ties passing through the boring and adzing machines are frequently branded, in addition to figures representing the date, with letters representing kind of wood and kind of treatment and with figures representing the weight of rail for which bored. For instance, on one end "P-90" representing pine, bored for 90-lb. rail, and on the other end "C-25" indicating creosote treatment, and the year treated. In some ties these figures and letters become illegible after the tie has been in service some years. This usually occurs when ties check or broom, and where ties have been pounded on end with track maul. Instances are noted of figures stamped on end of ties representing the year, legible after 25 years' of service in track. Some of the roads reporting branding of ties on end also use dating nails.

For use in test or check sections one road reports use of metal tags bearing symbol letters and figures showing kind of wood, kind of treatment, etc., in addition to dating nails showing date inserted. One road uses lettered nails showing year inserted and kind of treatment. Two roads use copper tags. One road uses copper numbering nails in addition to dating nails. One road uses lettered tags as well as lettered nails in test ties, and one road numbers every tenth tie with paint on test sections.

Conclusions

As a result of information contained in the answers to questionnaire and after careful study of this subject, your Committee has reached the following conclusions:

1. A dating nail should be applied to each tie.

2. Dating nails should be driven into the tops of the ties, six inches inside the inner flange of the rail and upon the line side of the track.

3. Dating nails may be applied at the treating plants or after ties are inserted in track. If the latter, dating nails should be driven the same day tie is inserted.

4. It is recommended that ties which are passed through boring and adzing machine be branded on end in addition to the boring and adzing. These brands to include, in addition to two figures representing the year, letters or figures indicating kind of rail for which bored, and letters may be used to indicate kind of wood, or group of woods, and treatment. For example, on one end of the tie "F-90," indicating Fir, bored for 90-lb. rail, and on the other end "A-25," indicating a certain kind of treatment, and the year.

5. In check sections or in any test ties desired, ties may be marked by copper or zinc tags bearing symbol letters and numbers indicating kind of wood, kind of treatment, and, if desired, individual tie numbers.

It is recommended that the conclusions be included in the Manual.

(6) SPECIFICATIONS FOR DATING NAILS

MATERIAL

The nails shall be made of iron or steel, galvanized with a coating of zinc (Prime Western, or equal), evenly and uniformly applied, by hot dip process, so that it will adhere firmly to the surface of the iron or steel.

CHEMICAL REQUIREMENTS

The following test shall be made to determine the integrity and adequacy of the zinc coating, and any specimen shall be capable of withstanding this test:

> (a) The sample shall be immersed in a standard solution of copper sulphat for one minute and then immediately washed in water thoroughly and wiped dry. This process shall be repeated. If after the fourth immersion there is a copper colored deposit on the sample, or the zinc has been removed, the lot from which the sample was taken shall be rejected.
>
> (b) The standard solution of copper sulphate is prepared by dissolving 36 parts of crystallized copper sulphate in 100 parts of water, then adding enough cupric oxide to neutralize any free acid. The solution is filtered or allowed to settle and decanted, then diluted with water until its specific gravity is 1.186 at 65 deg. Fahr. While nails are being tested, the temperature shall be at no time less than 60 deg. Fahr. nor more than 70 deg. Fahr.

DESIGN

The shank of nail shall be ¼ inch in diameter, and 2½ inches long; the head of nail shall be ⅝ inch in diameter, and $\frac{1}{16}$ inch thick, and shall bear two raised figures designating the year, the figures to be ⅜ inch long and raised $\frac{1}{16}$ inch.

INSPECTION

(a) Specimens for testing shall be selected by inspector from the finished nails.

(b) As many specimens will be tested as are considered necessary for determining whether or not the requirements of the specifications have been met.

(c) All tests and inspection shall be made at the place of manufacture or sale prior to shipment, and shall be so conducted as not to interfere unnecessarily with the operation of the mill.

(d) Inspectors representing the railroad shall have free entry to works of the manufacturer at all times during process of manufacture of nails for purchaser, and shall have all reasonable facilities afforded them by the manufacturer to satisfy them that the dating nails are in accordance with the specifications.

Exhibit 1

VARIOUS TYPES OF DATING NAILS MANUFACTURED IN THE PAST AND THEIR COMPARATIVE COST

Kind of Material	Galvanized or Not Galvanized	Raised or Depressed Figures in Head	Round or Square Head	Size of Head	Length of Shank	Thickness of Shank	Approximate Number per Pound	Approximate Cost per 100 Pounds at Factory	Approximate Cost per Nail at Factory
Steel	Galvanized	Raised	Round	½ inch	1¼ inch	1/6 inch	124	6.80	.00055
Steel	Galvanized	Raised	Round	....	2¼ inch	⅛ inch	104	7.00	.00067
Steel	Galvanized	Raised	Round	⅜ inch	2½ inch	⅛ inch	95	6.30	.00066
Steel	Galvanized	Raised	Round	½ inch	1 inch	1/6 inch	88	6.80	.00077
Steel	Galvanized	Raised	Round	⅝ inch	1¼ inch	¼ inch	43	6.80	.00158
Steel	Galvanized	Raised	Round	⅝ inch	1½ inch	¼ inch	41	6.80	.00166
Steel	Galvanized	Raised	Round	½ inch	2 inch	¼ inch	32	6.55	.00205
Steel	Galvanized	Either	Round	⅝ inch	2½ inch	¼ inch	27	7.00	.00259
Steel	Galvanized	Raised	Round	⅝ inch	2½ inch	¼ inch	26	6.30	.00242
Steel	Galvanized	Depressed	Round	9/16 inch	2½ inch	¼ inch	26	6.30	.00242
Steel	Galvanized	Depressed	Round	¾ inch	1¼ inch	⅜ inch	25	6.80	.00272
Steel	Galvanized	Raised	Square	⅝ inch	2 inch	9/32 inch	23	7.30	.00317
Steel	Galvanized	Depressed	Round	11/16 inch	2 inch	5/16 inch	21	6.30	.00300
Steel	Galvanized	Raised	Square	½ inch	2½ inch	¼ inch	20	7.30	.00365
Steel	Galvanized	Either	Square	⅝ inch	2 7/16 inch	9/32 inch	19	7.30	.00384
Copper	....	Depressed	Round	½ inch	1¼ inch	1/5 inch	82	20.00	.00244
Copper	....	Depressed	Round	½ inch	1¼ inch	3/16 inch	75	23.50	.00313
Copper	....	Depressed	Round	¾ inch	1¼ inch	¼ inch	....	24.50	....
Copper	....	Depressed	Round	1 inch	1¼ inch	¼ inch	....	24.50	....

NOTE.—Polished steel nails are priced approximately $2.00 less per 100 pounds than price shown for galvanized nails.

Exhibit 2

QUESTIONNAIRE COVERING THE USE OF DATING NAILS, SPECIFICATIONS FOR DATING NAILS, AND MARKING TIES FOR RECORDING THEIR SERVICE. SENT TO 60 RAILROADS OF THE UNITED STATES AND CANADA

The Tie Committee has been instructed to report on "Use of Dating Nails," "Specifications for Dating Nails," and "Marking of Ties for Recording Service."

With a view to securing data to enable the report to be prepared, your reply to the following questionnaire is requested not later than October 15, 1925.

1. Please state if you use dating nails or other methods of marking ties and, if so, how many years have dating nails or other systems of marking ties been in use.

2. State kinds of dating nails used covering the following variations:

(a) Copper, malleable iron, or steel.
(b) Galvanized or not galvanized.
(c) Are figures raised or depressed?
(d) Length of shank.
(e) Thickness of shank.
(f) Size of head.
(g) Shape of head.
(h) Any method of marking other than nails, giving details.

3. To what ties are nails applied, i. e., all ties, all treated ties, or otherwise?

4. Is a different nail used to indicate different kinds of ties? Please explain your practice.

5. When are nails applied to ties, that is, at treating plant or when tie is inserted in track, and by whom?

6. Please advise as to causes of any nail failures:

(a) Due to corrosion.
(b) Due to coming out of tie from any cause.
(c) Due to illegibility, giving causes, such as corrosion, mashing down of raised letters, filling up of depressed letters, etc.

7. Is it your opinion, based on your experience, that the presence of dating nails in ties influences the judgment of section foremen or others as to whether a tie should be removed or left in track? Please explain **fully.**

8. If any method of marking ties, other than nails, is used, please describe fully.

9. Do you favor a nail, or other mark, indicating more than merely the year inserted, such, for instance, as kind of wood, treatment, or plant

at which treated (some of the treating plants apply nails which carry trade mark, by means of which the treating company can be identified).

10. Do you consider your present practice as regards marking ties and your present type of nail the best possible, or do you suggest an improvement and, if so, in what particulars?

11. Do you consider that the information obtainable from the use of dating nails, or other means of marking, is not worth the cost of the nail, or other means of marking? Please explain fully.

Exhibit 3

IN ANSWER TO QUESTION 7 OF THE QUESTIONNAIRE, REPRESENTATIVES OF TWENTY-SEVEN RAILROADS EXPRESSED THEIR OPINIONS AS TO WHETHER OR NOT DATING NAILS IN TIES INFLUENCE THE JUDGMENT OF SECTION FOREMEN OR OTHERS AS TO WHETHER A TIE SHOULD BE REMOVED OR LEFT IN TRACK. THESE OPINIONS ARE GIVEN BELOW

Question 7. Is it your opinion, based on your experience, that the presence of dating nails in ties influences the judgment of section foremen or others as to whether a tie should be removed or left in track? Please explain fully.

Baltimore & Ohio Railroad

EARL STIMSON, Chief Engineer Maintenance, Baltimore, Md.

The presence of dating nails in ties would cause foremen to give more consideration to ties before removing them. In the majority of renewals the condition of tie is so evident that the presence or absence of nail would be immaterial. The advantage to be found in their use would come from the greater consideration given to the tie with superficial defects but having further service value; this would apply to the minor portion of the ties marked for renewal.

In my opinion, best results in avoiding removal of ties having further service value can be secured. First, by determination of annual requirements for a district based on analysis of records of kinds of ties in track. Second, by educating foremen to appreciate the increased life they can secure from treated ties. Third, by close supervision of ties removed.

If these or similar means equally effective are adopted, the use of dating nails in all ties is unwarranted.

Boston & Maine Railroad

F. C. SHEPHERD, Assistant Chief Engineer, Boston, Mass.

While we cannot definitely state, it is our opinion that the dating nails in the ties are going to have a marked psychological effect on the foremen. We believe that unless the tie has served fully its expected term of life, as shown by the dating nail, it is going to be looked over very carefully before it is taken out for renewal, which has not always been the case in the past.

Chesapeake & Ohio Railway

R. N. BEGIEN, Vice-President, Richmond, Va.

In some instances dating nails may influence judgment as to removal of ties but think these cases will be rare.

Chicago, Burlington & Quincy Railroad

A. W. Newton, Chief Engineer, Chicago, Ill.

No.

Chicago, Burlington & Quincy Railroad

J. H. Waterman, Superintendent Timber Preservation, Galesburg, Ill.

No.

Chicago & Eastern Illinois Railway

L. C. Hartley, Chief Engineer, Chicago, Ill.

I think the presence of dating nails has no influence on judgment of section foremen or others as to whether a tie should be removed.

Chicago, Milwaukee & St. Paul Railway

W. H. Penfield, Engineer Maintenance of Way, Chicago, Ill.

Do not believe that it would make any difference on our railroad. All ties renewed are marked early in the spring, as soon as the frost is out of the ground, by the section foreman. His inspection is then checked by Roadmaster and Division Engineer. The plan works out very well and, for some time past, there has been very little changing required of the foreman's markings.

Chicago, Milwaukee & St. Paul Railway

F. S. Pooler, Tie Agent, Chicago, Illinois.

It should not. If a tie is in such condition and so located it must be removed, its length of service should not influence trackmen.

Chicago & Northwestern Railway

C. T. Dike, Engineer Maintenance, Chicago, Ill.

Yes. It is our opinion that the use of tie dating nails will result in securing greater life from ties by preventing removal before tie should come out of track.

Cleveland, Cincinnati, Chicago & St. Louis Railway

Hadley Baldwin, Chief Engineer, Cincinnati, O.

Date does not seem to have much influence.

Delaware, Lackawanna & Western Railroad

G. J. Ray, Chief Engineer, Hoboken, N. J.

In my opinion the use of dating nails is valuable. They do have some influence upon the foremen and others responsible for removing ties. They are also of great assistance to those whose duty it is to carefully follow the life of treated ties and assist in maintaining a valuable record.

Duluth & Iron Range Railroad

W. A. Clark, Chief Engineer, Duluth, Minn.

Believe dating nail does have some influence in preventing premature removal of ties.

Elgin, Joliet & Eastern Railway

F. H. Masters, Assistant Chief Engineer, Joliet, Ill.

I do not believe that the presence of dating nails influences the judgment of the section foremen. Ties are removed from track when decayed or worn out regardless of dating nails.

Erie Railroad

R. S. Parsons, Vice-President, Youngstown, Ohio.

Believe the dating nail has a decided influence on tie inspector and foreman.

Great Northern Railway

J. R. W. Davis, Chief Engineer, St. Paul, Minn.

From my experience walking over the track inspecting ties with the section foremen, that the year on the dating nail had no influence on their judgment as to when the tie should be removed from track. The section foremen, I believe, on the Great Northern are getting all the life possible out of the ties regardless of what year is shown on the dating nail.

Gulf Coast Lines—International-Great Northern

H. R. Safford, Executive Vice-President, Houston, Texas.

It is our opinion that the presence of dating nails in ties does influence section foremen and others as to whether a tie should be removed, especially if the tie has not been in what would be normally the assumed life of such tie.

Illinois Central Railroad

A. F. Blaess, Chief Engineer, Chicago, Ill.

It has a deterring effect on foremen and tends to reduce waste of ties.

Kansas City Southern Railway

C. E. Johnston, Vice-President and General Manager, Kansas City, Mo.

The presence of dating nails does influence the judgment of section foremen and others in removing ties. A tie might appear bad, but when the age is definitely known it is a decided factor as to whether the tie shall be removed this year or allowed to remain in another year.

Lehigh Valley Railroad

G. L. Moore, Engineer Maintenance of Way, Bethlehem, Pa.

Does not influence removal of ties.

Louisville & Nashville Railroad

James F. Burns, Assistant Engineer Maintenance of Way, Louisville, Ky.

The presence of the nail undoubtedly influences the judgment of section foreman as to whether a tie should be removed from or left in the track. The presence of the nail has a psychological effect on the foreman.

Minneapolis, St. Paul & Sault Ste. Marie Railway

E. A. Whitman, Chief Engineer, Minneapolis, Minn.

In my opinion the presence of dating nails in ties will influence the judgment of section foreman or roadmaster as to whether a tie should be removed or left in the track, as I think that regardless of the rough appearance of the tie, if there is a dating nail present it will indicate that the tie is treated and lead to a more careful examination of the tie with a fixed purpose of making the tie serve a certain period of years if it is possible to do so.

New York Central Lines

Dr. Hermann von Schrenk, Consulting Timber Engineer, St. Louis.

I am very much of the opinion that the presence of dating nails is a vital factor in the manner in which section foremen and others deal with ties. I consider this the most important function of the dating nail. I have had any number of experiences with the section men who feel that the dated ties will last for so many years that they will not remove them. The increase of interest of the men in dated ties brings about a method of handling which undated ties would hardly receive.

New York Central Railroad

J. V. Neubert, Engineer Maintenance of Way, New York.

It has been our experience that tie dating has a good influence as to the removal of cross-ties and the psychological effect on the section foremen is marked. Our foremen follow the tie markings closely, taking an interest in the tie's life. Also such markings give us reliable data as to the average life of cross-ties.

New York, New Haven & Hartford Railroad

R. L. Pearson, Engineer Maintenance of Way, New Haven, Conn.

Believe the use of dating nail has an influence in determining whether or not a tie should be removed or left in track.

Norfolk & Western Railway

W. P. Wiltsee, Chief Engineer, Roanoke, Va.

I think the actual condition of the tie at the time of inspection by roadmaster or section foreman would govern rather than the presence of dating nail; however, the presence of dating nail, if visible, would of course assist the inspector should there be a doubt as to the advisability of renewing the tie.

Northern Pacific Railway

Bernard Blum, Engineer Maintenance of Way, St. Paul, Minn.

We found a number of foremen who not only were influenced but apparently used as a basis the age of a tie as shown by the nail to remove ties.

Pennsylvania Railroad System

A. C. Shand, Chief Engineer, Philadelphia, Pa.

No evidence that presence of dating nail influences judgment in deciding that ties should or should not be removed. The physical condition of each tie determines its serviceability and it is only replaced when it is no longer in a condition that will provide satisfactory service.

Pennsylvania Railroad System, Central Region

W. D. Wiggins, Chief Engineer Maintenance of Way, Pittsburgh, Pa.

In test track, ties are likely to be left in for their full life. If nails were used in all ties it is reasonable to assume that they would deter the premature removal of ties.

Pennsylvania Railroad System, Eastern Region

W. J. Coughlin, Chief Engineer Maintenance of Way, Philadelphia.

We can see little or no difference.

Rock Island Lines

C. F. Ford, Supervisor Tie and Timber Department, Chicago, Ill.

To some extent. Particularly where all the ties in the track are not treated.

St. Louis Southwestern Railway

W. S. Hanley, Chief Engineer, St. Louis.

Section men will give a tie closer inspection when dating nail indicates that it has not been in service the average number of years for ties of similar quality.

Southern Pacific Lines

H. M. Lull, Chief Engineer, Houston, Texas.

We are of the opinion that dating nails do have some effect on section foremen in selecting ties to be removed. They will naturally select the oldest ties where there is not a great deal of difference in superficial appearance of the ties.

Texas & Pacific Railway

E. F. Mitchell, Chief Engineer, Dallas, Texas.

Yes. The trackmen are inclined to be slow about removing ties that do not appear to have given the length of service that they should give.

Union Pacific System

R. L. Huntley, Chief Engineer System, Omaha, Neb.

Dating nail influences section foremen to some extent.

Exhibit 4

In answer to question 11 of the questionnaire, representatives of thirty-four railroads expressed opinions as to whether or not dating nails or other means of marking ties was worth the cost. These replies are quoted below

Question 11. Do you consider that the information obtainable from the use of dating nails, or other means of marking, is not worth the cost of the nail, or other means of marking? Please explain fully.

Atlantic Coast Line Railroad

J. E. Willoughby, Chief Engineer, Wilmington, N. C.

I do not think the information obtainable from the use of dating nails is worth the cost.

Baltimore & Ohio Railroad

Earl Stimson, Chief Engineer Maintenance of Way, Baltimore, Md.

In my opinion, best results in avoiding removal of ties having further service value can be secured, first, by determination of annual requirements for a district based on analysis of records of kinds of ties in track. Second, by educating foremen to appreciate the increased life they can secure from treated ties. Third, by a close supervision of ties removed. If these or similar means equally effective are adopted, the use of dating nails in all ties is unwarranted.

The branding method of marking may be accomplished at but a small percentage of the cost of dating nails and gives a measure of information that is sufficient to warrant critical examination of any one or more ties that are in question as to their removal.

Boston & Maine Railroad

F. C. Shepherd, Assistant Chief Engineer, Boston, Mass.

Believe cost of using the dating nails is well worth the expenditure and do not know of any other means of marking that would be as satisfactory.

Central of Georgia Railway

L. A. Downs, President, Savannah, Ga.

On the Central of Georgia Railway we are limited almost entirely to one class of timber for tie purposes. We use sap pine, treated Rueping process, almost entirely. We have not considered that a system of dating these ties would give us any information which would change our practice. We, therefore, consider that it would not be worth the cost of purchasing and applying the nails and keeping the necessary records. This is probably not true of many other roads where it is considered an advantage to test out various classes of ties. We believe that a dating nail is the best means of marking a tie.

Chesapeake & Ohio Railway

R. N. Begien, Vice-President, Richmond, Va.

Think present method of marking (dating nails in treated ties) is worth the cost until service life of treated ties is fully established.

Chicago, Burlington & Quincy Railroad

J. H. Waterman, Superintendent Timber Preservation, Galesburg, Ill.

I certainly do not think that it costs more than it is worth.

Chicago, Burlington & Quincy Railroad

A. W. Newton, Chief Engineer, Chicago, Ill.

I believe that dating nails justify the expense for the general information they give.

Chicago & Eastern Illinois Railway

L. C. Hartley, Chief Engineer, Chicago, Ill.

No, except in test sections.

Chicago, Milwaukee & St. Paul Railway

W. H. Penfield, Engineer Maintenance of Way, Chicago, Ill.

We did use dating nails quite extensively for marking treated cross-ties, years 1900 to about 1910. The practice was discontinued because we had no well-defined plan for keeping record of the ties in which dating nails had been driven, and felt that it would be more satisfactory to depend upon records of our test track installations for information. I think that with our present organization, we could use dating nails to very good advantage, and keep up record of the information that would be obtained from them, and believe that it would well justify the cost.

Chicago, Milwaukee & St. Paul Railway

F. S. Pooler, Tie Agent, Chicago, Ill.

I do not favor dating nails. The advantages obtained do not justify the expense.

Chicago & Northwestern Railway

C. T. Dike, Engineer Maintenance, Chicago, Ill.

Use of tie dating nails fully justifies the cost.

Cleveland, Cincinnati, Chicago & St. Louis Railway

Hadley Baldwin, Chief Engineer, Cincinnati, O.

No.

Delaware, Lackawanna & Western Railroad

G. J. Ray, Chief Engineer, Hoboken, N. J.

Yes. I think the use of dating nails is worth more than it costs. This past summer I had the opportunity of examining ties in tracks on various roads in England and other parts of Europe where dating nails are quite generally used. I had but little trouble in determining the date on nails placed in ties from twenty to thirty years ago. Galvanized dating nails with raised letters placed in ties in 1892 and 1893 in Belgium seemed to be in good condition and no doubt can be plainly read for many years to come.

Duluth & Iron Range Railroad

W. A. Clark, Chief Engineer, Duluth, Minn.

Believe the information obtained, together with influence of dating nail in preventing premature removal, justifies their use in treated ties.

Elgin, Joliet & Eastern Railway

F. H. Masters, Assistant Chief Engineer, Joliet, Ill.

We consider records given by the use of dating nails as well worth the cost of the nails and the application.

Erie Railroad

R. S. Parsons, Vice-President, Youngstown, Ohio.

Believe it advisable to mark tie in such a manner that both the kind of wood, character of treatment and treating plant can be identified in cases of failure.

Gulf Coast Lines—International-Great Northern

H. R. Safford, Executive Vice-President, Houston, Texas.

It is thought that the information obtainable from the use of dating nails on selected stretches of track is worth what it costs.

Illinois Central Railroad

A. F. Blaess, Chief Engineer, Chicago, Ill.

Information worth while.

Kansas City Southern Railway

C. E. Johnston, Vice-President and General Manager, Kansas City.

The advantage in marking ties by the use of nails will fully justify the expense.

Louisville & Nashville Railroad

J. F. Burns, Assistant Engineer Maintenance of Way, Louisville, Ky.

Information obtained from the practice is worth far more than the cost of the nail. The foreman is much more careful in removing ties and in examining them more closely than he would otherwise do.

Lehigh Valley Railroad

G. L. Moore, Engineer Maintenance of Way, Bethlehem, Pa.

Use of dating nails has served its purpose on the Lehigh Valley. We discontinued using them two years ago.

Missouri Pacific Railroad

E. M. Durham, Jr., Assistant to President, St. Louis, Mo.

Our experience with dating nails is limited, but the information we expect to obtain from marking of ties in test sections will be well worth the comparatively small expense involved.

Minneapolis, St. Paul & Sault Ste. Marie Railway

E. A. Whitman, Chief Engineer, Minneapolis, Minn.

I believe the investment in nails is warranted.

Nashville, Chattanooga & St. Louis Railway

Hunter McDonald, Chief Engineer, Nashville, Tenn.

No.

New York Central Lines

Dr. H. von Schrenk, Consulting Timber Engineer, St. Louis, Mo.

I believe that dating nails should be used on every tie inserted, that the awakened interest of everyone who deals with track is worth many times the cost of the nail.

New York Central Railroad

J. V. Neubert, Engineer Maintenance of Way, New York.

We thoroughly believe the information obtainable from the use of dating nails is worth far more than the cost of the nails and installation. Through cross-tie installation data, with nail or notch, we have kept records of cross-tie renewals from 20 to 25 years and we consider this data very valuable, having used it extensively in cross-tie statistics and kind of wood.

New York, New Haven & Hartford Railroad

R. L. Pearson, Engineer Maintenance of Way, New Haven, Conn.

No.

Norfolk & Western Railway

W. P. Wiltsee, Chief Engineer, Roanoke, Va.

I think the information secured through use of dating nails fully justifies the cost thereof.

Northern Pacific Railway

Bernard Blum, Engineer Maintenance of Way, St. Paul, Minn.

We found that practical use was not being made of the dating nails, and tabulating nearly two million ties annually renewed is out of the question. We also found that ties were being removed account of age, whether they were ripe or not.

Pennsylvania Railroad System

A. C. Shand, Chief Engineer, Philadelphia, Pa.

The identification of every tie placed in service not considered of sufficient value to justify the cost. The cost of identification justifiable in test sections of track designated for study.

Pennsylvania Railroad System, Central Region

W. D. Wiggins, Chief Engineer Maintenance of Way, Pittsburgh, Pa.

The cost of the nail and inserting are small, compared with other costs of keeping records, either in test sections or of all ties. We consider the cost of test sections justified by the information secured.

Pennsylvania Railroad System, Eastern Region

W. G. Coughlin, Chief Engineer Maintenance of Way, Philadelphia.

We do not think the nails worth while.

Rock Island Lines

C. F. Ford, Supervisor Tie and Timber Department, Chicago, Ill.

Our experience in attempting to have all ties marked with dating nails in the field proved unsatisfactory, due to the failure on the part of the trackmen to apply dating nails. If the use of dating nail is desired to check up the removal of tie before it should be removed, think that same results can be accomplished by branding on end of tie.

St. Louis Southwestern Railway

W. S. Hanley, Chief Engineer, St. Louis, Mo.

I consider the expense of dating nails worth their cost.

Seaboard Air Line Railway

E. A. Frink, Principal Assistant Engineer, Savannah, Ga.

Recommend the use of dating nails.

Southern Pacific Lines

H. M. Lull, Chief Engineer, Houston, Texas.

We believe that the use of dating nails has a good influence on section foremen in selecting the oldest ties in making their renewals and is also of considerable value to supervisory officers in checking up on the life of ties taken out of the track when going over the line on inspection trips. A year additional life for only a few ties will pay for all of the nails used annually in a mile of track, and we are convinced that the value of the nails is well worth their cost.

Texas & Pacific Railway

E. F. Mitchell, Chief Engineer, Dallas, Texas.

We consider the information obtained from the use of dating nails well worth the cost of the nail and the cost of its application.

Union Pacific System

R. L. Huntley, Chief Engineer System, Omaha, Nebraska.

Consider the information obtainable worth the cost of the nail.

Appendix C

(3) THE EXTENSION OF SERVICE TEST RECORDS FOR THE PURPOSE OF FURNISHING INFORMATION FOR THE STUDY OF ECONOMICS OF TIES

Bernard Blum, Chairman, Sub-Committee; E. L. Crugar, R. S. McCormick, C. U. Smith, R. C. Young.

In the preparation of service tests it is necessary to first determine the object of the test, and then the test practice can be devised. A consideration of the elements affecting tie life or service has led to selecting the following subjects, which should be considered in formulating test practices and records:

(1) Relative advantages of the different sizes of ties: Example—Comparison, size 1 with size 3, size 3 with size 5.
(2) Results with different intensities of traffic, other variables being the same.
(3) Relative advantages of different kinds of preservative treatment.
(4) Advantages of pre-boring and pre-adzing ties for treatment.
(5) Relative economies of large and small-sized tie plates.
(6) Determination of density of traffic which makes use of tie plates economical.
(7) Relative economy of cross-ties 8 feet long compared with ties 8 feet 6 inches long, under different traffic and ballast conditions.
(8) Relative values of different kinds of wood.

A compilation of completed service test records of ties in the annual Proceedings indicates that in the past the tests have not provided for all the factors that affect tie life, some of the more important ones not having been covered at all. Neither have tests been devised so as to cancel out the variables other than those the tests were instituted to develop.

It seems evident that, to evolve definite and exact information on any one element, the other variables must be eliminated, and it is proposed to devise test sections for this purpose. For example, ties of sizes 3 and 5, of the same kind, with the same treatment, and equipped with the same size plates, should be tested simultaneously in the same track; ties of the same size, kind, etc., should be tested in adjoining main and sidetracks to develop the effect of traffic.

It is generally conceded that treatment of ties has brought about marked economies, but definite and correct information is not available to prove which method of treatment is the best for given service conditions. The practice of boring and adzing ties before treating has become prevalent, but whether this is economical for all classes of ties cannot be proved from any test data.

In the case of tie plates, all are convinced of their advantages, but there are plates of many sizes in use and there is no data to prove what dimensions, considering cost, are proper. On branch lines of light traffic the use of treated hardwood ties, such as birch and maple, without plates, may or may not be economical and the information indicated by No. 6 above is needed for proper answer.

A considerable mileage of track in this country is now laid with ties 8 feet 6 inches long. Other railways are considering this length, and it is desirable to ascertain if the advantages of the longer ties include longer life.

In the past, most attention has been paid to treatment and kind of wood in connection with tests of tie life, and proper attention has not been paid to cancelling out other variables, such as differences in traffic, size, ballast, subgrade conditions, etc.

The Proceedings of 1920-21-22-23 contain information and recommendations for installing test sections. It will be the purpose of this Sub-Committee to utilize the data which has been prepared and during the coming year formulate forms and practices which should permit properly supported decisions on questions involving the economics of the use of various cross-ties.

All members of the Association are invited to give to the Committee recommendations for variables to be considered in the study of tie life.

Appendix D

(4) ADHERENCE TO SPECIFICATIONS

John Foley, Chairman, Sub-Committee; A. R. Dewees, R. L. Cook, F. H. Ellsworth, R. M. Leeds, S. E. Sims.

Specifications which are not enforced might as well not exist. Those for ties adopted by the American Railway Engineering Association in 1921 have been favored with more widespread acceptance by railroads than had been the case with any prior tie standards. If publication and paper adherence to the American Railway Engineering Association specification provided standard ties, all troubles with that item of track materials would be eliminated. But the persistent bugbear of the difference between specification and inspection has prevailed as a source of criticism among consumers and of excuse among producers.

So long as each railroad maintains independent inspection forces, operating under varying instruction and interpretation of the standard specification, absolute uniformity of inspection is unlikely. Yet the departures from the standard known to have taken place in the past few years are not to be explained by any mere failure to understand the specification.

With a view to ascertaining the facts regarding tie inspection, two trips of observation were made by the Committee on Ties during 1925. The surveys were made where ties of railroads under observation were accumulated in sufficient quantities as to be representative of their stocks in general. The accumulations of ties seasoning at wood preserving plants provide opportunities for seeing inspection and for comparing the results on different roads which would not otherwise be available. Approximately 3,000,000 cross-ties accepted by 15 railroads with over 75,000 miles of line were observed at five concentration points in the Mississippi Valley, from Texas to Minnesota, inclusive.

The 1925 examinations of inspected ties clearly showed:

(1) That ties meeting fully the American Railway Engineering Association specifications for ties can be and were being produced in large numbers.

(2) That on certain railroads practically all ties fully meet the requirements of the A.R.E.A. specifications. The few ties which do not are the negligible errors which are to be expected under the conditions which control inspection.

(3) That certain railroads overgrade their ties. In some cases this is apparently due to carelessness, the ties being overgraded one grade where wane was seemingly overlooked by the inspector. In other cases the overgrading calls 1s grade 3 ties, and 3s grade 5, and is evidently the result of deliberately disregarding the standard.

(4) That certain railroads accept decayed ties. In some cases such ties are degraded on account of the decay. In other cases they are

accepted in disregard of the decay, under the assumption that the decay is not serious and that the progress of decay is stopped by preservative treatment.

(5) That certain railroads allow sound ties to decay while seasoning under improper conditions.

During 1926 more inspections of accepted ties will be made. Meanwhile all members of the Association are urged to make observations of their own ties. In the first place, they should insist that each tie be somehow marked to show the grade at which it was accepted. Then the membership will be able to see whether ties accepted and paid for as of a given grade actually meet the standard requirements of that grade. Interest in the character of ties delivered on the part of those responsible for their use would correct much of the fault in the procurement of ties. The overgrading of ties will cease whenever those receiving them question the marking of any which are too narrow or too thin for acceptance at the given grade. The sole object of accepting a grade 1 tie at the price paid by another railroad for a grade 2 or grade 3 tie and of designating such a tie as Grade 2 or Grade 3 is to fool those consuming the ties into the belief that they are getting standard material at market prices.

Appendix E

(5) SUBSTITUTE TIES

REPORTS FROM RAILWAYS MAKING TESTS

L. J. Riegler, Chairman, Sub-Committee; J. F. Deimling, A. J. Neafie, F. W. Pfleging, J. W. Williams, W. W. Wysor.

Baltimore & Ohio Railroad

Reported by Earl Stimson, Chief Engineer Maintenance.
Date—October 7, 1925.
Kind—Wyckoff.

Recent inspection shows that these ties and rail fastenings are still in good condition.

Bangor & Aroostook Railroad

Reported by Moses Burpee, Chief Engineer.
Date—October 17, 1925.
Kind—Maine Concrete Tie.

Ten of these ties were installed in track on December 11, 1923, the ties being interlaced with cedar ties. On August 30, 1924, the cedar ties were removed and 59 additional concrete ties put in, making a total installation of 69 ties.

The tie is illustrated on pages 727, 728, and the appearance of the ties in track is shown in the photograph on page 729.

Cleveland, Cincinnati, Chicago & St. Louis Railway

Reported by Hadley Baldwin, Chief Engineer.
Date—July 18, 1925.
Kind—CARNEGIE.

Three thousand of these ties were placed in track in 1908, of which 2948 remain. Those ties are laid on gravel ballast, support 105-lb. rail and carry high-speed two freight and one passenger trains.

Detroit, Toledo & Ironton Railroad

Reported by J. M. Bennett.
Date—July 8, 1925.
Kind—U. S. INDESTRUCTIBLE.

Fifty of these ties were installed in 1922 and 1923. The ties were placed in main track on slag ballast, support 85-lb. rail and carried a light traffic. All were removed in May, 1925, account of being badly shattered by derailment.

Duluth & Iron Range Railroad

Reported by W. A. Clark, Chief Engineer.
Date—July 16, 1925.
Kind—HATCH-CARNEGIE.

Eleven Hatch ties were placed in tracks at Two Harbors, Minn., in August, 1923. The ties are laid on gravel ballast, under 80-lb. rail. The traffic is heavy service, exclusively freight. All are still in service.

Two thousand Carnegie ties were put in track at various places in 1905, of which 1083 are still in track. The ties are laid on gravel ballast, under 80-lb. rail and carry a heavy freight service and a light passenger service. Seven of these ties were removed since last report on account of breaking inside of the rail.

Duluth, Missabe & Northern Railway

Reported by W. H. Hoyt, Chief Engineer.
Date—July 28, 1925.
Kind—CARNEGIE-KIMBALL.

Of 22,380 Carnegie ties installed in tracks in 1908 and 1909, 20,867 remain. The ties carry a high-speed, heavy passenger and freight service. The ties are laid on stone ballast and support 100-lb. rail.

The thirty Kimball ties installed in 1914 are still in track, giving good service. These ties are laid on gravel ballast and carry 100-lb. A. R. A. Type "B" rail.

Elgin, Joliet & Eastern Railway

Reported by Arthur Montzheimer, Chief Engineer.
Date—June 27, 1925.
Kind—BATES—CARNEGIE CROSS-TIES AND SWITCH-TIES.

The sixty-two Bates ties installed in 1912 are still in track. These ties are laid on gravel ballast and support 85-lb. A.S.C.E. rail. They carry a heavy service, exclusively freight traffic.

Carnegie cross-ties (Section M-21) have been put in at various times on gravel ballast, cinder and slag ballast, supporting 85 and 100-lb. rail. The ties are in main track and carry a heavy service, exclusively freight traffic.

Number placed in track		15,514
Removed—1916	50	
1917	260	
1918	182	
1919	453	
1920	306	
1921	1165	
1922	641	
1923	2620	
1924	1341	
1925	89	7107
Remaining in track		8407

The Carnegie switch ties are of Section M-21 and are in yard tracks with heavy switching. They carry 80-lb. A.S.C.E. and 85-lb. A.S.C.E. rail on cinder, gravel or slag ballast. The number of steel switch-ties placed and removed is as follows:

Year	*Lin Ft. of Ties Used in Renewals*	*Lin. Ft. of Ties Taken Up Account Renewals*	*Lin. Ft. of Ties Used in Construction*	*Lin. Ft. of Ties Taken Up Account Track Retired*
1912	30,452		5,580	
1913	196,333		11,527	430
1914	142,939		5,135	
1915	58,314		2,023	1,615
1916	17,856	10	7,120	16,498
1917	3,789	1,907	8,623	17,340
1918	4,511	3,006	6,564	5,453
1919	6,483	526	1,582	1,582
1920	575	22,737	2,588	2,774
1921	4.712	24,855	717	4,744
1922	241	21,903	444	527
1923	846	19,451		
1924	2,300	18,124	441	1,394
Jan., 1925, to May, 1925, incl.	180	12,947		690
Total	469,531	125,466	52,344	53,047

Linear feet of steel switch-ties in track at present........ 343,362

Long Island Railroad

Reported by L. V. Morris, Chief Engineer.
Date—October 7, 1925.
Kind—CARNEGIE STEEL.

Of the original installation of 30 Carnegie steel ties in track at Hicksville, in 1909, 18 still remain in the track. Twelve ties were removed due to the fact that it was impossible to hold the track in line. The ties shift very easily in cinder ballast.

Los Angeles Railway

Reported by B. J. Eaton, Engineer Way and Structures.
Date—July 11, 1925.
Kind—McDonald Concrete.

These ties were installed in Broadway, between First and Main streets, Los Angeles, Cal. Forty have been removed due to installation of special work. The ties are in solid concrete and carry 87-lb. rail. The traffic is heavy, exclusively passenger.

Norfolk & Portsmouth Belt Line

Reported by Geo. S. Shafer, President.
Date—October 6, 1925.
Kind—American Concrete Tie.

On June 4, 1919, 18 concrete ties were put under a 33-ft. rail at the head of Port Norfolk Yard in Portsmouth, Virginia. These 18 ties are in as good condition as the day they were installed, and should last an indefinite period.

On September 18, 1923, 100 concrete ties were installed in our track at Portsmouth in one stretch near the George Washington Highway, and on October 20, 1923, 20 concrete ties were installed in maintenance work, that is, between white oak ties. Up to date nine of the 100 ties, installed in September, 1923, have broken, which is entirely due to the ties not having been constructed according to specifications; the other 91 ties are giving good service, and are in excellent shape. The 20 ties installed in October, 1923, are in good condition and are giving satisfactory service.

The Belt Line is a road engaged exclusively in freight switching service, and does not maintain a high rate of speed, but handles freight cars loaded to their capacity as delivered to the Belt Line by the different connections in Norfolk and vicinity. There are thirty trains a day passing over these ties, and the 18 at the head of Port Norfolk Yard are subjected daily to heavy and continuous switching.

Pennsylvania Railroad System (Eastern Region)

Reported by W. G. Coughlin, Chief Engineer Maintenance of Way.
Date—August 10, 1925.
Kind—Champion Steel Ties.

The ties have all been removed from track and the following is a complete summary:

In June, 1920, 995 Champion Steel Ties were installed in the eastbound low-grade freight track, just west of Lenover. The wooden blocks were untreated white oak. Bridge tie plates were installed to obtain bearing on practically the entire width of the wooden blocks.

In April, 1922, 128 of these ties were removed from track because of injuries due to derailment.

Inspection of July, 1922, showed slight damage to 528 ties, which damage was not of such character as to affect the efficiency of the ties, in that it consisted of slight deformity of top edges of angles. Otherwise all of the ties appeared to be in good shape.

Inspection of July 16, 1924, showed 866 ties in track; 528 showed damage to upper edge of vertical leg of angles. Over these ties, line was poor, and surface only fair. Many ties were badly slewed and spacing was very irregular; this irregularity was evidently due to ties being pushed along by rail anchors. These ties in cinder ballast did not offer enough resistance to movement along the rail, with the result that two anchors against a tie resulted in tie being pushed forward with a wide space back of it. One anchor against a tie resulted in slewing an average of 6 inches. One joint tie was slewed as much as 15 inches, with the result that spikes on outside of rail pushed through the oak blocks. This slewing of ties resulted in tightening gage at those points. Many blocks showed wear and were beginning to split. While corrosion was noticeable, it did not appear serious nor were track conditions unsafe. The ties showed evidence of having been pushed down through the cinder ballast more than adjacent wood ties, but since this tendency was uniform for all ties in the stretch, it was undesirable only as an indication that the ties would require more frequent surfacing.

Inspection of January 19, 1925, revealed the same characteristics in an aggravated condition. Ties were very badly slewed with resultant irregular gage. Many blocks were so far gone as to necessitate renewal. Line and surface were both very bad, and erosion was so noticeable that we predicted the necessity of an early removal.

An inspection made on January 28, 1925, revealed the fact that some of the ends of the flange angles were reduced by corrosion to $\frac{5}{32}$ inch in thickness, cracks had developed in some of the bottom flanges and some were bending up on end due to thin flanges. The tie plates were deeply imbedded in the joint blocks and 52 joint ties needed new blocks. As their condition did not warrant the making of repairs, all of the remaining ties were removed from track in May, 1925.

These ties were on cinder ballast. The traffic was very heavy and exclusively freight.

Pennsylvania Railroad System (Central Region)

Reported by W. D. Wiggins, Chief Engineer Maintenance of Way.
Date—August 21, 1925.
Kind—Metal Safety—Riegler—Snyder.

Metal Safety Ties—All of the 20 ties placed in the westbound freight track at Wampum, Pa., in November, 1922, are still in service. Some trouble was experienced at first from the keys working loose, but after opening the wedges on the split end, the keys have held in satisfactory manner. Cracks developed on three ties under the rail in April, 1924, but after laying new 39-ft. rails, the joint was removed from these ties and the cracks are not considered serious enough to warrant removal of the ties. The rail is well anchored and we have no difficulty in maintaining line. The ties are not insulated. They are on stone ballast with 100-lb. rail and carry a heavy passenger and freight traffic.

Riegler Concrete Ties—These ties are illustrated in Volume 24 of A.R.E.A. Proceedings. Fifteen of these ties were placed in the westbound passenger track, at Emsworth, Pa., in May, 1908. They were taken up in December, 1914, and re-laid in the eastbound heavy-service freight track in May, 1915. This track is normally used for freight traffic, but during rush hours is used for through passenger service.

The rail was changed from 85-lb. A.S.C.E. to 100-lb. P.S. in 1910, and again to 130-lb. P.S. in 1921. The ties were taken up in October, 1921, in order to provide new clips for 130-lb. rail, and were re-laid again in July, 1922. All of the original 15 ties are in track, and have given 17 years' total service. Some repairs to the concrete have been made from time to time (two ties having been repaired this year). The ties were inspected August 18, 1925, and found in good condition except that the concrete was slightly crumbled on three ties.

The rail is held by four clips on each end of the tie, which are secured by bolts with square nuts. Seven of the clips were found slightly loose, requiring tightening of nuts. The ties are insulated from the rail and no trouble is experienced with the signal circuits. These ties appear to be good for indefinite service with occasional repairs to the concrete filling.

Snyder Composite Ties—A total of 2255 of these ties were put in yard tracks in 1906-07. Only 244 ties, or about 10 per cent, have been removed to date. None of the ties were removed during the past year, and they have proved satisfactory for yard tracks.

Pittsburgh & Lake Erie Railroad

Reported by A. R. Raymer, Chief Engineer.
Date—July 15, 1925.
Kind—Standard Steel Tie.

We have had some Standard Steel Tie Company's ties in service in our westward main track east of Glassport Station since May 4, 1914. These ties have about reached the end of their usefulness; the wooden blocks under the rail are becoming badly decayed and the steel portion of the tie is badly corroded. Three of the ties are in such shape that it will be necessary to remove them at an early date.

Pittsburg, Shawmut & Northern Railroad

Reported by J. N. Thompson, Superintendent Maintenance of Way.
Date—July 13, 1925.
Kind—Carnegie.

These ties are in gravel ballast and support 85-lb. A.S.C.E. rail. They carry heavy service, exclusively freight traffic. 795 were put in track in 1907, of which 33 are now in track. Average weight of ties put in, 177 lb.; when removed, 135 lb.

Southern Pacific Lines

Reported by H. M. Lull, Chief Engineer.
Date—July 15, 1925.
Kind—U. S. Indestructible.

These ties were placed in 1916 on cinder ballast and support 80-lb. rail. They are subjected to light main track service and light switching. The ties are in good condition. An additional 100 are being made to be tested under heavy switching and high-speed traffic. This tie is illustrated on page 730. The photograph, same page, furnished by the U. S. Indestructible Tie Manufacturing Company, shows the condition of these ties, while exposed, due to raising tracks account of grade change in 1925.

St. Louis-San Francisco Railway

Reported by F. G. Jonah, Chief Engineer.
Date—June 27, 1925.
Kind—GRANT STEEL TIE—CLARK OR APPLEGATE STEEL TIE.

GRANT STEEL TIE—These ties have all been removed from track.

CLARK OR APPLEGATE—These ties support 85-lb. rail in chats ballast. The traffic is heavy, exclusively freight service.

The tie is a steel channel stamped out of ¼ inch metal and measures 8½ feet in length by 8½ inches in width. There is a creosote wooden block 8 inches x 8 inches x 17 inches long inserted under the rail near each end of tie to which the rail is fastened by spikes. These ties have been in the track now nearly 11 years. The steel is pretty badly corroded, and the ties will probably fail on this account. The creosote wooden blocks are still in fair condition. This tie is illustrated on page 731.

Terminal Railroad Association of St. Louis

Reported by H. J. Pfeifer, Chief Engineer
Date—July 3, 1925.
Kind—CHAMBERLAIN.

These ties are in a yard track with light switching, on cinder ballast and support 80-lb. A.S.C.E. rail. Ten ties were installed in 1920. The ties are still in the track but are broken through the center and on the ends. It would have been necessary to take them out long ago if gage rods had not been applied.

Reported by Henry Miller, President.
Date—May 19, 1925.
Kind—MILLER TIE.

The ties under test were made of scrap 100-lb. rail. The work was all performed by track forces in the material yard, except the making of the bolts. No machinery or skilled labor is necessary in producing them. Four ties 8 ft. 3 in. long are cut from one 33-ft rail.

For the purpose of the test and to minimize the cost of the initial installation, five ties were put under each rail, thus having the track well secured to gage. Additional metal ties will replace the other wooden ties as renewals are necessary, finally getting the same bearing area with 14 or 15 ties of this design as with 19 or 20 wood ties to a 33-ft. rail. The extension of the flanges on the inverted rails beyond the base of the tie affords some additional bearing on the ballast, and it has been found that the flange confines the ballast and reduces the tamping required to maintain a proper surface. The ties are in stone and cinder ballast and carry 100-lb. rail. The traffic averages 39 trains, 876 cars or 28,530 tons daily. There will be some scrap value when these ties are removed from the track that is not present in the standard wood tie in general use.

Carnegie clips and bolts used by the Steel Corporation on its railways were used in this test and experience has shown that they are not heavy enough. We have designed a heavier fastening which engages both bolts and therefore cannot turn or become loose as the clip does, making a more uniform and stronger fastening. Inasmuch as no plates are necessary in a tie of this description, also considering that every railroad has an abundant supply of scrap rail that normally sells from $10.00 to $12.00 a ton, this device, because of its strength and durability, will prove economical.

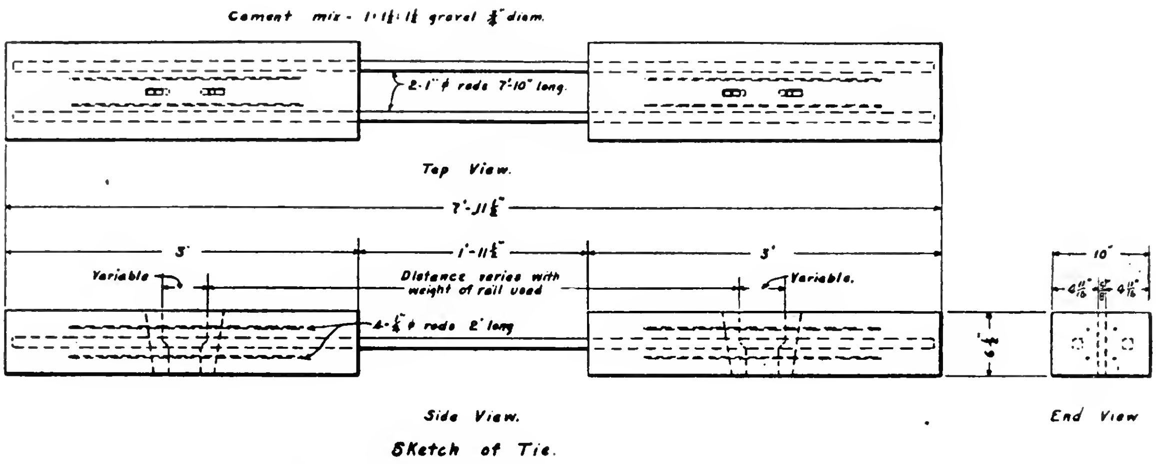
A recent inspection shows that the ties are giving satisfactory service. This tie is illustrated on page 732.

Tests of Substitute Ties Now in Progress—1925

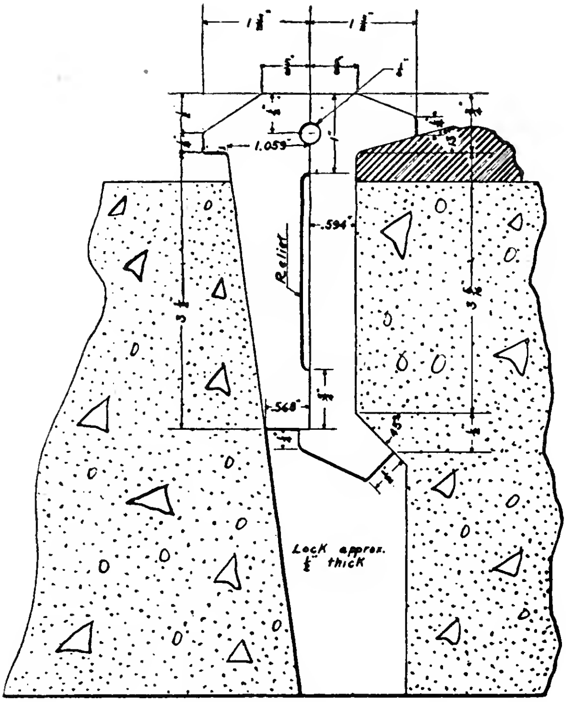
Railroad	Name of Tie	Location	Date	Number		Ballast	Rail Section	Traffic
				Put In	Now In			
Baltimore & Ohio	Wyckoff	Baltimore, Md.	1920	4	4	....	....	....
Bangor & Aroostook	Maine Concrete	Hudson, Me.	1924	69	69	Gravel	85 lbs.	A
Bessemer & Lake Erie	Carnegie	Various	Jan., 1905, and Subsequent	H Many	Many	....	....	A
C. C. C. & St. L.	Carnegie	New Point, Ind.	1908	3,000	2,948	Gravel	105 lbs.	A
D. T. & I.	U. S. Indestructible	Detroit, Mich.	1923	50	None	Slag	85 lbs.	D-E
Duluth & Iron Range	Hatch	Two Harbors	1923	11	11	Gravel	80 lbs.	C
	Carnegie	Various	1905	2,000	1,083	Gravel	80 lbs.	C-D
Duluth, Missabe and Northern	Carnegie	Duluth and Proctor	1908-9	22,380	20,867	Stone	100 lbs.	A
	Kimball	Virginia, Minn.	1914	30	30	Gravel	100 lbs.	A
Elgin, Joliet & Eastern	Bates	Whiting, Ind.	May, 1912	62	62	Gravel	85 lbs.	C
	Carnegie	Various	Various	15,514	8,407	Gravel, Cinder and Slag	85-100 lbs.	C
	Carnegie Switch	Various	1912 and later	G521,875	G343,362	Gravel, Cinder and Slag	80-85 lbs.	E
Long Island	Carnegie	Hicksville, N. Y.	1909	30	18	Cinder	100 lbs.	A
Los Angeles Ry.	McDonald	Los Angeles, Cal.	1911	4,323	4,283	Solid Concrete	87 lbs.	B
Norfolk & Portsmouth Belt Line	Am. Concrete Tie	Portsmouth, Va.	1919	18	18	....	....	E
		Portsmouth, Va.	1923	120	111	....	....	C
Pennsylvania System— Eastern Region	Champion	Lenover, Pa.	1920	995	Removed 1925	Cinder	....	C
Central Region	Metal Safety	Wampum, Pa.	1922	20	All	Stone	100 lbs.	A
	Riegler	Emsworth, Pa.	1908	15	All	Stone	85-100-130 lbs.	A
	Snyder	In Yards	1907	2,255	2,011	Cinder	100 lbs.	F
Pere Marquette	Kimball	Bay City, Mich.	1902	3,400 ft. of Track	No Report	Concrete Base	75 lbs.	D
Pittsburgh & Lake Erie	Standard	Glassport, Pa.	1914	20	20	Stone	115 lbs.	A
Pittsburg, Shawmut & Northern	Carnegie	Byrndale Branch	1907	795	33	Gravel	85 lbs.	C
Southern Pacific	Indestructible	Eagle Pass, Texas	1916	23	23	Cinder	80 lbs.	D
St. Louis-San Francisco	Grant Steel Tie	Sapulpa, Okla.	1914	4	Removed 1925	....	....	....
	Clark or Applegate Steel	Springfield, Mo.	1914	125	125	Chats	85 lbs.	C
Terminal R. R. Assn. of St. Louis	Chamberlain	St. Louis, Mo.	1920	10	10	Cinder	80 lbs.	F
	Miller	St. Louis, Mo.	1924	100	100	Stone and Cinder	100 lbs.	A

A—High speed, heavy service, passenger and freight.
B—High speed, exclusively passenger.
C—Heavy service, exclusively freight.
D—Main track, light service.
E—Yard track with heavy switching.
F—Yard track with light switching or storage usage.

NOTE: G—Linear Ft.
H—534,650 in 1923.

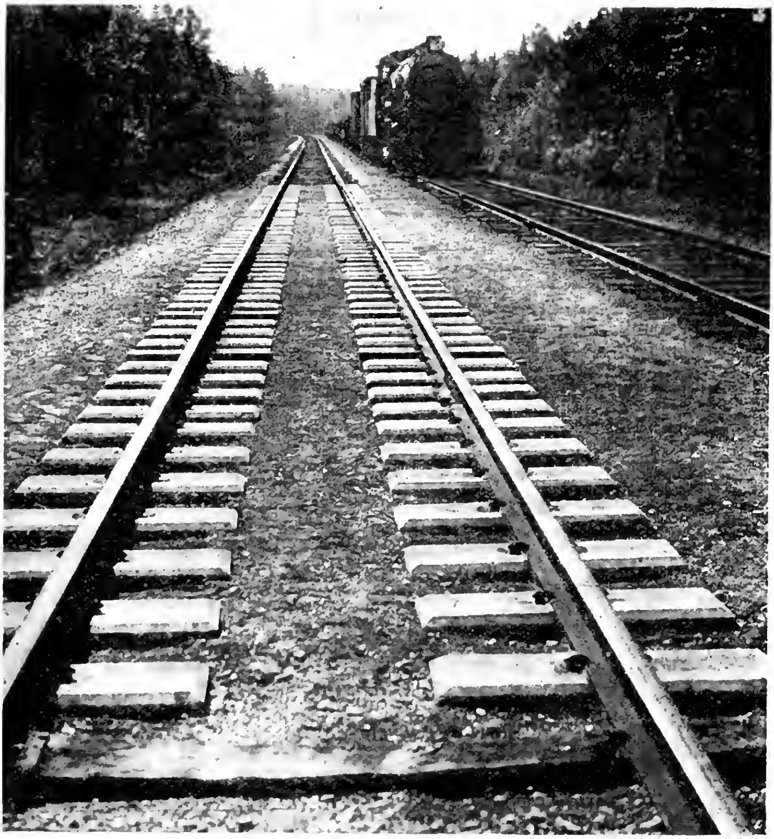


Maine Concrete Tie—Bangor & Aroostook Railroad

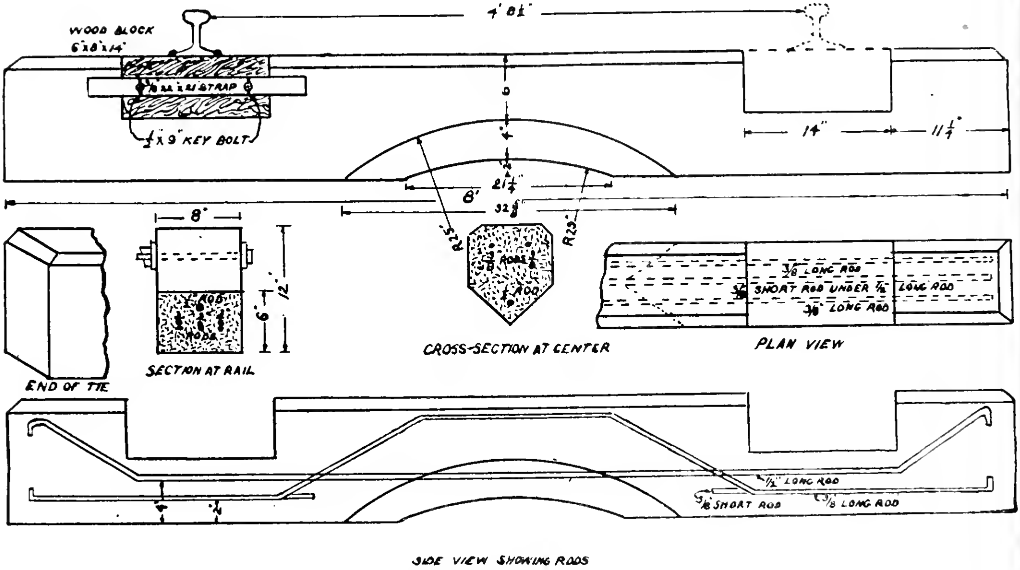


Detail of Lock.

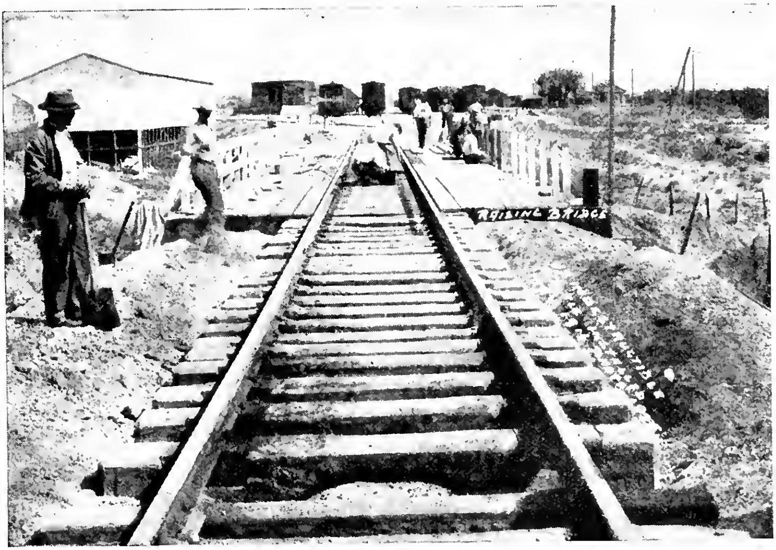
MAINE CONCRETE TIE



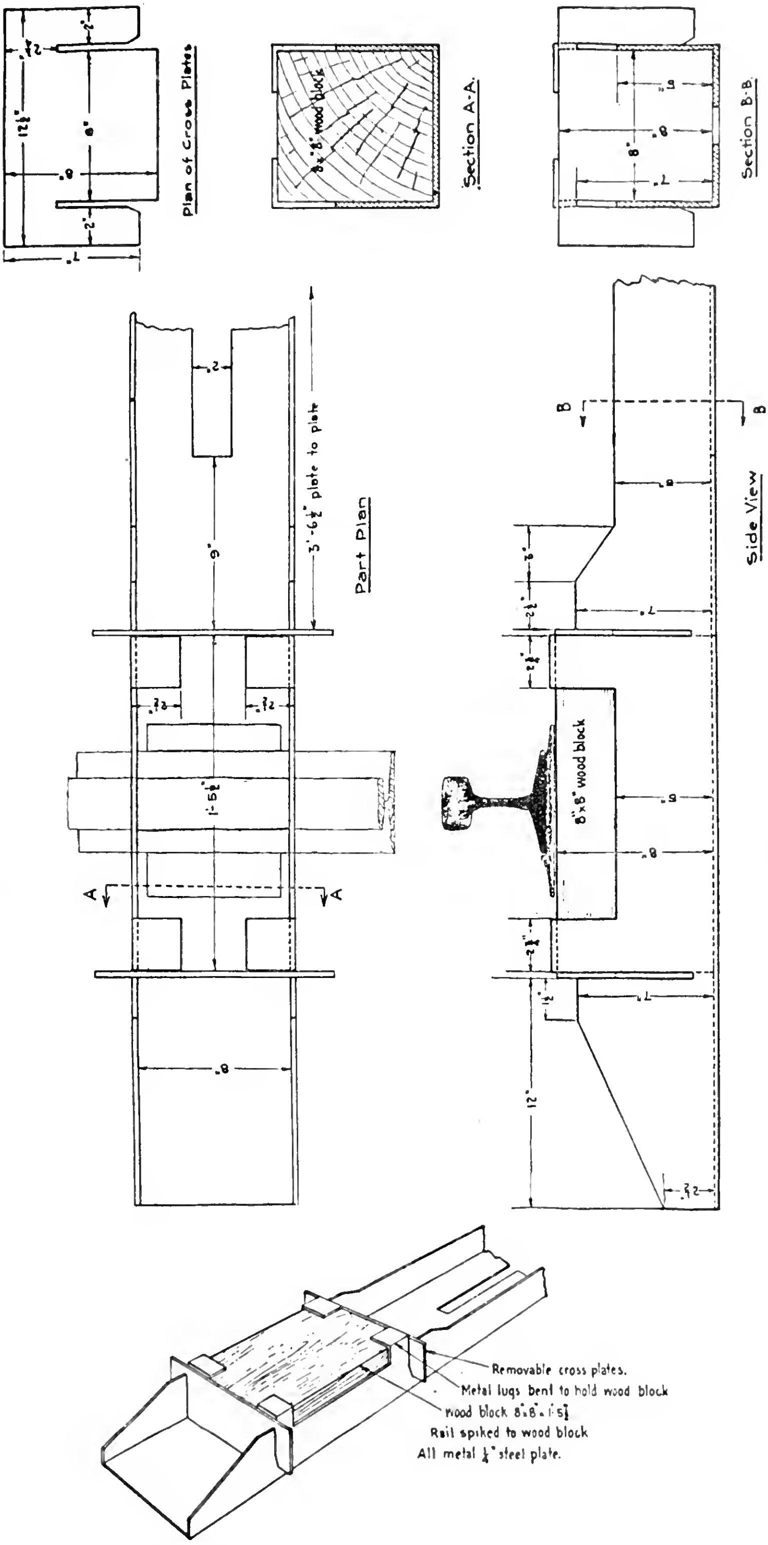
Maine Concrete Tie—Bangor & Aroostook Railroad



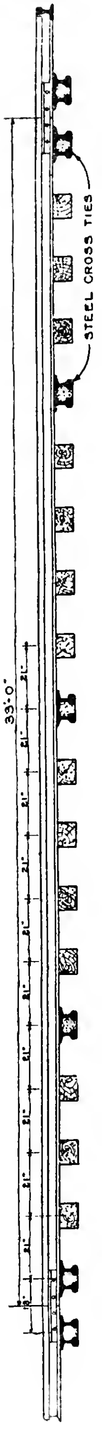
U. S. Indestructible Tie



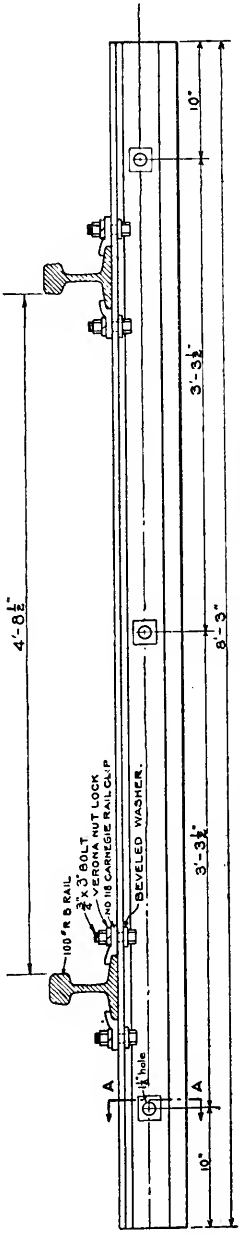
U. S. Indestructible Tie—Southern Pacific Lines



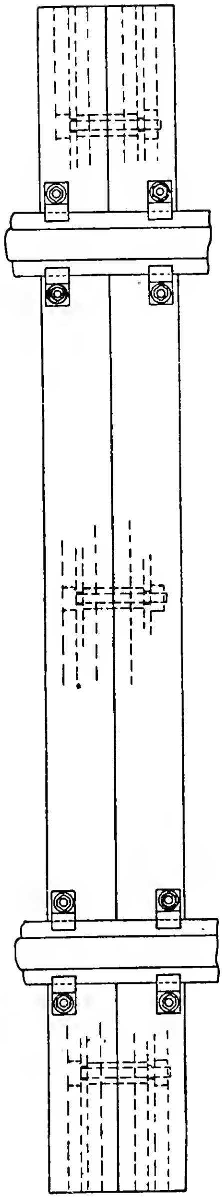
Clark Metal Tie—Frisco Lines



Side Elevation Of Track Showing Location Of Steel Cross Ties.



Elevation Of Steel Cross Tie.



Plan Of Steel Cross Tie.

Miller Steel Cross-Ties—Terminal Railroad Association of St. Louis

REPORT OF COMMITTEE XXI—ECONOMICS OF RAILWAY OPERATION

G. D. Brooke, *Chairman;*	J. M. Farrin, *Vice-Chairman;*
E. G. Allen,	W. G. Raymond,
B. T. Anderson,	H. A. Roberts,
G. E. Boyd,	L. S. Rose,
J. M. Brown,	Mott Sawyer,
J. W. Burt,	R. T. Scholes,
W. J. Cunningham,	B. J. Schwendt,
E. J. Correll,	M. C. Selden,
H. C. Crowell,	V. I. Smart,
C. S. Gzowski,	M. F. Steinberger,
G. F. Hand,	H. Stringfellow,
E. T. Howson,	J. E. Teal,
E. E. Kimball,	Barton Wheelwright,
M. F. Mannion,	J. L. White,
F. H. McGuigan, Jr.,	C. L. Whiting,
H. T. Porter,	C. C. Williams,
J. F. Pringle,	Louis Yager,

Committee.

To the American Railway Engineering Association:

Your Committee respectfully presents herewith report covering the following subjects:

(1) Revision of Manual. (No revisions are recommended.)
(2) Effect of speed of trains upon the cost of transportation (Appendix A).
(3) Methods of increasing the traffic capacity of a railway (Appendix B).
(4) Methods of analyzing costs for the solution of special problems, including the costs of starting and stopping trains (Appendix C).
(5) The utilization of locomotives to determine:
    (a) The percentage of time they should be available to perform actual transportation.
    (b) Methods of obtaining maximum efficiency while so available (Appendix D).
(6) Methods of operation by which intensive use of facilities may be secured (Appendix E).
(7) Develop suitable units for comparing costs of operation and equipment maintenance (Appendix F).

Action Recommended

1. No revisions of the Manual are recommended.

2. That the report of the Sub-Committee (Appendix A) be received as information and the subject discontinued.

3. That the report of the Sub-Committee (Appendix B) be received as information.

Bulletin 284, February, 1926.
A

4. That the progress report of the Sub-Committee (Appendix C) be received as information.

5. That the progress report of the Sub-Committee (Appendix D) be received as information, and the subject discontinued.

6. That the progress report of the Sub-Committee (Appendix E) be received as information.

7. That the progress report of the Sub-Committee (Appendix F) be received as information.

Recommendations for Future Work

1. Revision of the Manual.
2. Methods of increasing the traffic capacity of a railway.
3. Methods of analyzing costs for the solution of special problems, including a study of the costs of ,starting and stopping trains.
4. Methods of operation by which the intensive use of facilities may be secured.
5. Develop suitable units for comparing costs of operation and equipment maintenance.
6. Outline of work for ensuing year.

Respectfully submitted,

The Committee on Economics of Railway Operation,
G. D. Brooke, *Chairman.*

Appendix A

(2) EFFECT OF SPEED OF TRAINS UPON THE COST OF TRANSPORTING FREIGHT

C. C. Williams, Chairman, Sub-Committee; G. D. Brooke, J. F. Pringle, W. G. Raymond, L. S. Rose, Mott Sawyer, R. T. Scholes, M. C. Selden, C. L. Whiting.

During the past year the Sub-Committee has studied particular cases with a view to testing the validity of the deductions suggested in last year's report. After considerable inquiry, the Sub-Committee feels that it has exhausted the sources of information practically available and offers the following summary application of data previously submitted as a conclusion to the assignment.

Graphical Expression of Data Previously Submitted.—In order to indicate the significance of analysis and data previously submitted, curves are plotted in Fig. 1, showing the effect of speed of freight trains on the major items affected, namely, wages, fuel, maintenance of way and structures, maintenance of locomotives, and fixed charges, together with the resultant curves. Minor items are omitted because they do not appreciably affect the total.

In last year's report attention was called to three cases according to traffic density which would influence the relation between speed and cost of transportation. These cases briefly were:

(1) Where the traffic at hand to be hauled is less than the capacity of the line and equipment available.

(2) Where the traffic at hand to be hauled exceeds the capacity of the rolling stock (either motive power or cars) operated at low speed.

(3) Where the track capacity at low speed is exceeded by the available traffic.

In the case represented in Fig. 1, it is assumed that traffic is at hand to be hauled so that the additional gain in capacity of rolling stock due to increased speed may be realized. The case virtually assumes also that there is no interference from passenger or fast freight traffic. These assumptions render the study of analytic interest, but not directly applicable, except perhaps on industrial roads where drag freight constitutes the entire traffic. The case is predicated on a 100-mile district.

The results are not quantitatively applicable to any one railroad, the data being compositely taken from various sources. The curves show general relationships only.

Maintenance of Way and Structures.—Assume a 4,000-ton train and 266-ton locomotive. According to Table 1 of the 1924 report increasing speed from 10 m.p.h. to 20 m.p.h. would increase the engine mileage 25 per cent and according to 1925 report, a locomotive ton miles damages track three times as much as does a car ton mile.

The increase in Maintenance (items affected) due to increased locomotive mileage would be $(1 + 3/15 \times 1.25) / (1 + 3/15) = 1.042$ or 4.2 per cent. The increase in Maintenance (items affected) due to increased speed of freight trains (Report of Committee, Proc. Vol. 22, p. 771), may be about 2.5 per cent for an increase in speed from 10 to 25 m.p.h. The total increase in M. of W. and S. expenses (portion allocated to freight traffic) due to increase in speed from 10 to 20 m.p.h. would therefore be 1.042×1.025 or 1.068.

On the X. & Y. Railroad the M. of W. expenses were $16,376,000. If $5,700,000 of this be allocated to freight business and one-third of this amount assumed to vary with the traffic (Report of Committee, Volume 24, page 1058), $1,900,000 would be increased directly as the equivalent traffic. Then with a traffic of 7,200,000,000 gross ton-miles,

$$\frac{1{,}900{,}000}{7{,}200{,}000} = \$0.26 \text{ per } 1{,}000 \text{ G.T.M.}$$

The increased cost per 1,000 G.T.M. would be $\$0.26 \times 1.067 = \$0.28$. A. & B. and the C. & D.

Maintenance of Equipment.—Records of the A & B and the C & D railroads indicate that repairs to machinery and brakes amount to 72 per cent of the total locomotive repairs on these roads. These expenses and half of the boiler expense (20 per cent of the total) may be assumed to vary with the mileage run. That is about 80 per cent of the total expense of locomotive repairs is assumed to vary with the mileage, the remaining 20 per cent being dependent on load hauled, time, weather, etc.

According to Table 1 of last year's report, to increase the speed from 10 to 20 miles per hour would increase the locomotive mileage by 25 per cent in hauling a given amount of traffic, hence each m.p.h. increase in speed would increase the locomotive repair expenses $.025 \times 80 = 2$ per cent. In the case considered, the maintenance of locomotives is taken as $0.35 per thousand gross ton miles when the average speed is 12.5 m.p.h.

Comparison of costs of locomotive repairs on coal roads having heavily loaded drag trains with those on general freight roads carrying more rapidly moving loads approximately agrees with the above estimates.

For transporting a given amount of traffic the car mileage would be independent of the speed, hence the maintenance of freight cars would not be increased by any additional mileage. Greater speed doubtless does increase maintenance somewhat but the exact amount is conjectural. Only repairs to brakes and trucks (amounting to about 28 per cent of the total) would be affected by speed and this effect is probably not great, and, moreover, the influence in no case could seriously alter general conclusions. Repairs to freight cars are therefore omitted from the curve sheet.

Fixed Charges on Locomotives.—The investment in freight locomotives on the road under consideration is $24,000,000. The total fixed charge may be taken as 10 per cent. The total traffic was 7,200,000 thousand G.T.M.

The annual fixed charge $= \frac{2{,}400{,}000}{7{,}200{,}000} = \$0.33$ per M G.T.M.

Locomotives are in service about 25 per cent of the total time and in line service about 80 per cent of the service time. Assuming 20 per cent of the fixed charges in locomotives to vary reciprocally with the transporting capacity (Fig. 11 of 1925 Report) the curve of fixed charges is obtained. This is equivalent to assuming that all other demands on the locomotive require an undiminished amount of time.

Fixed Charges on Freight Cars.—The investment in freight cars on the road considered is $34,600,000. The annual fixed charge taken as 11 per cent on freight cars would be $3,806,000, or $\frac{3{,}806{,}000}{7{,}200{,}000} = \$0.53$ per thousand G.T.M. If freight cars are in motion 8 per cent of the time, 8 per cent of this fixed charge may be assumed to vary in proportion as the carrying capacity of cars is affected by speed, illustrated in Fig. 12 of the 1925 Report. This assumption is premised on all demands on freight cars other than travel requiring an undiminished amount of time.

Fuel.—Fuel cost data for fuel curves are taken directly or by interpolation from Fig. 1 and 2 of the 1925 Report.

OTHER FACTORS THAN ACTUAL COST AFFECTING ECONOMIC SPEED

Other operating factors may easily outweight minimum operating expenses in determining the desirable speed of trains. These chiefly pertain to operating revenues. Some of the more important are: (a) competition; (b) demand for expeditious service by the public; (c) interference with higher class trains by slow freights; and (d) loss of revenues through diminished capacity at slow speeds.

The interest on the cargo of a train of coal is about 15 cents per hour; of a cargo of other freight, it may be considerably greater; yet this factor, except in the case of unusually expensive commodities, would be inconsiderable as a factor influencing economic speeds.

Conclusions

The summarizing statements in last year's report may be repeated:

"1. The effect of speed on transportation costs per ton-mile depends upon circumstances of traffic density and physical characteristics of the district considered, viz., ruling grade, length of district, rise and fall, and curvature.

"2. In general, the cost of transportation per gross-ton-mile or per net-ton-mile increases whenever the speed of operation is increased by reducing the tonnage rating below the maximum practical rating."

Conclusion No. 2 is shown to be true by theoretical considerations, by the results of test trains run and by results of normal operation in the cases studied by the Committee, where operating costs of drag freight transportation only are considered. However, other factors mentioned above are usually of such magnitude as greatly to modify deductions as to economy of speed based on operating costs only and to limit the application of the above conclusion very narrowly. Studies in economic speeds are complex and must necessarily include inquiries as to effects on operating revenues as well as on operating expenses.

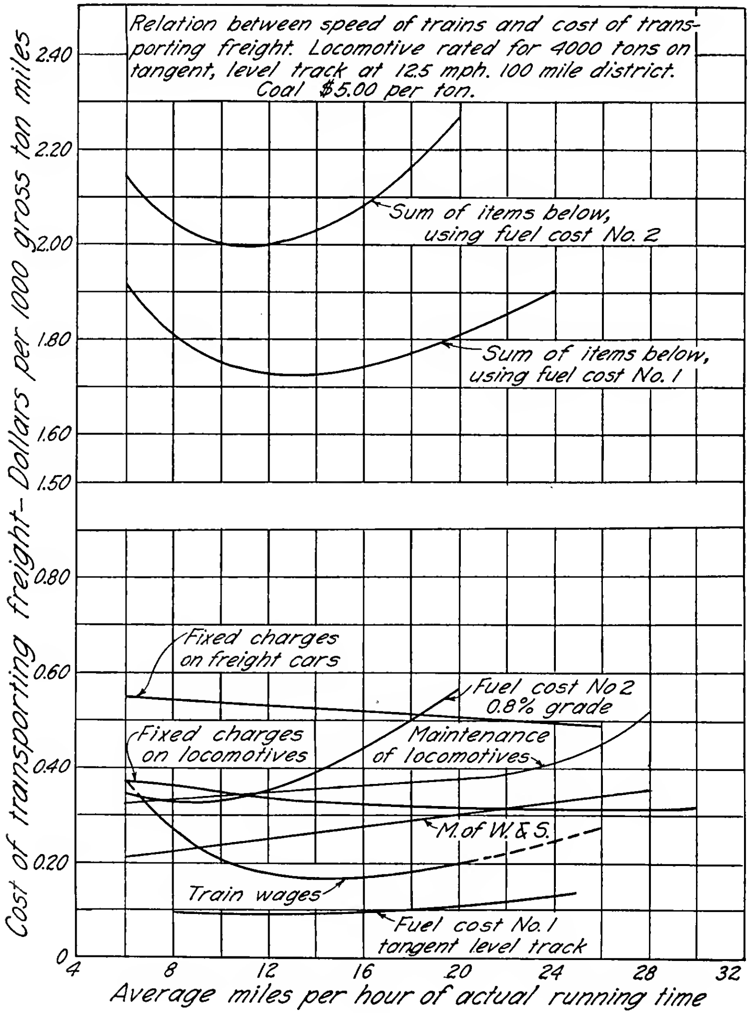


FIG. 1

The Committee believes that a further study of this subject based on theoretical analyses only will be barren of result and therefore recommends that the subject be discontinued until more observed data under normal operation may become available.

Appendix B

(3) METHOD OF INCREASING THE TRAFFIC CAPACITY OF A RAILWAY

M. F. Mannion, Chairman, Sub-Committee; B. T. Anderson, G. E. Boyd, G. D. Brooke, J. M. Brown, W. J. Cunningham, E. E. Kimball, H. A. Roberts, L. S. Rose, B. J. Schwendt, V. I. Smart, B. Wheelright, J. L. White, C. L. Whiting.

History

The primary object of this Sub-Committee's work has been to study the effects of various changes in operating conditions upon freight train performance, to determine the extent to which these changes increase the traffic capacity of the railroad.

Thus far the Committee has investigated the following:

(1) The effect of the number of trains per day.
(2) The effect of the length of engine district.
(3) The effect of double-tracking.
(4) The effect of passenger train operation upon freight train performance.
(5) The effect of supervision.
(6) The effect of substituting heavy steam power for light.

In this year's study the effect of installing automatic signals upon freight train performance is discussed. In addition, another study was made to show the effect of several operating conditions, principally double-tracking upon train performance for the purpose of comparing the results with a previous report.

I. THE EFFECT OF INSTALLING AUTOMATIC SIGNALS

Fig. 1 is a sketch map of the sections of the road on which this study was made. It shows how the trains are operated and the distances. It will be noted that A is the hub of four radiating lines.

A study was made of the Sections A-C and A-E. The Section A-C is 42 miles long and is a heavy freight district. Section A-E is 66 miles long and is a heavy passenger district.

Fig. 2 shows plan and profile of Section A-C and Fig. 3 shows plan and profile of Section A-E. Both these sections are single track lines.

Before the installation of signals all trains were operated by train orders and timetables. All meets were by "31" order. Trains were spaced by ten-minute time intervals. Under automatic block rules now in force trains can follow another as soon as block clears.

There was no change in the yard limit rules after the installation of automatic signals.

No marked change in power used after installation of signals.
No change in supervision.
No change in sidings.
No change in grades or alignement.
No change in number of operators.
No change in speed limit of trains.

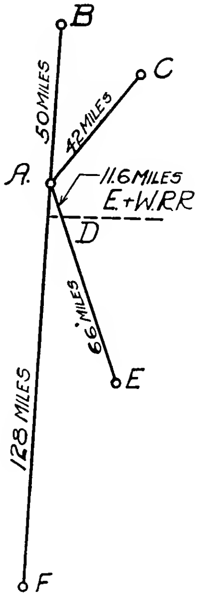


FIG. 1.
SKETCH MAP OF SECTIONS OF ROAD
SHOWING OPERATION OF TRAINS
C. TO F.
C. TO A. (TURN AROUND)
B. TO E.
A. TO E.
A. TO D (TURN AROUND)
B TO A. (" ")

Before installation of automatic signals there were no telephones in use. After installation, a telephone was installed at each absolute signal. This telephone is used for communication between dispatchers and trainmen when trains are blocked by absolute signals.

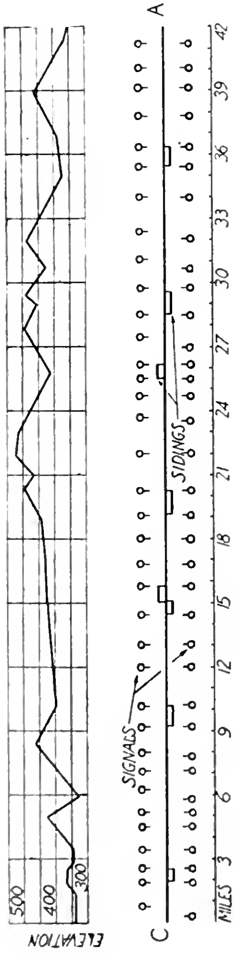


Fig. 2- Plan and Profile Section C to A

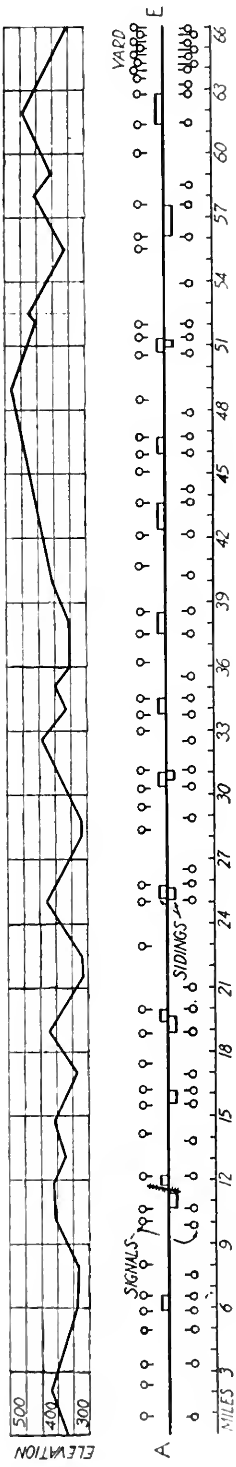


Fig 3- Plan and Profile Section A to E

SECTION A-C

Operating Conditions and Statistics

	Before Automatics	*After Automatics*
Average distance between train order stations	8.4 miles	8.4 miles
Minimum distance between train order stations	5.5 miles	5.5 miles
Maximum distance between train order stations	10.6 miles	10.6 miles
Average distance between passing sidings	5.3 miles	5.3 miles
Minimum distance between passing sidings	2.7 miles	5.3 miles
Maximum distance between passing sidings	7.5 miles	7.5 miles
Average number of freight trains per day	18	18
Average number of passenger trains per day	8	8
Average adjusted tons per freight train	2019	2027
Average road time per freight train	3 hrs. 26 min.	2 hrs. 55 min.
Saving in road time per freight train		31 min.
Average number of "19" orders delivered per day	44	50
Average number of "31" orders delivered per day	55	0

	Northward	*Southward*	*Total or Average*
Number of automatic signals	35	36	71
Average distance between signals	1.15 Mi.	1.13 Mi.	1.14 Mi.
Minimum distance between signals	.6 Mi.	.6 Mi.	.6 Mi.
Maximum distance between signals	1.8 Mi.	1.8 Mi.	1.8 Mi.

Usually the best criterion for judging the traffic capacity of a section of road is the traffic it can handle regularly for a period of 15 days or a month. In this connection Fig. 4 shows the average road time A to C per train plotted against the average number of trains per day. Fig. 5 shows the average road time A to C per train plotted against the average tons per day.

To determine the minimum road time for these charts, or the point where the slope line intersects the horizontal axis, the actual minimum road time was taken from the train sheets. The train curve formula discussed on page 739, Bulletin 243, was also used, and the results obtained from the formula checked almost exactly with the train sheets.

In Fig. 4 the horizontal dotted line represents the saving in road time, 31 minutes. The dotted vertical line represents an increased capacity of 6.7 trains, or an increase in capacity of 37.2 per cent.

In Fig. 5 the horizontal dotted line represents the saving in road time of 31 minutes, for the average tonnage per day. The dotted vertical line represents the increased capacity, or 13,725 tons per day, or an increase in tonnage capacity of 37.8 per cent, or slightly greater than the increased number of trains.

The installation of Automatic Block Signals and telephones on the Section A-C resulted in a saving of 31 minutes in road time per train.

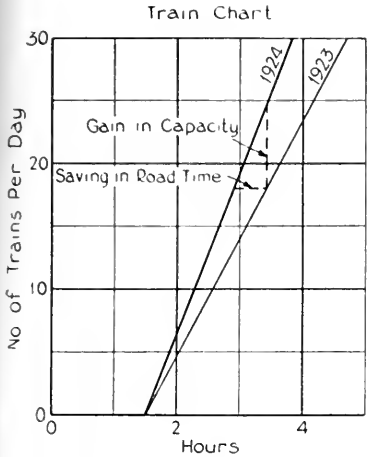


Fig. 4

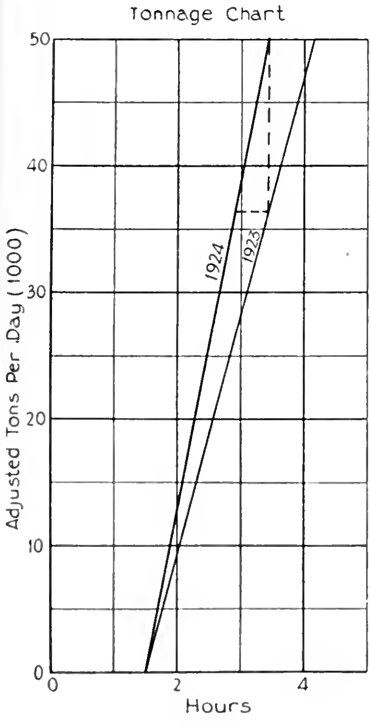


Fig. 5

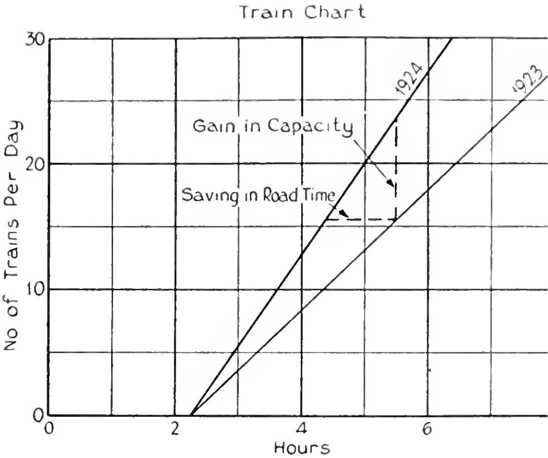


Fig. 6

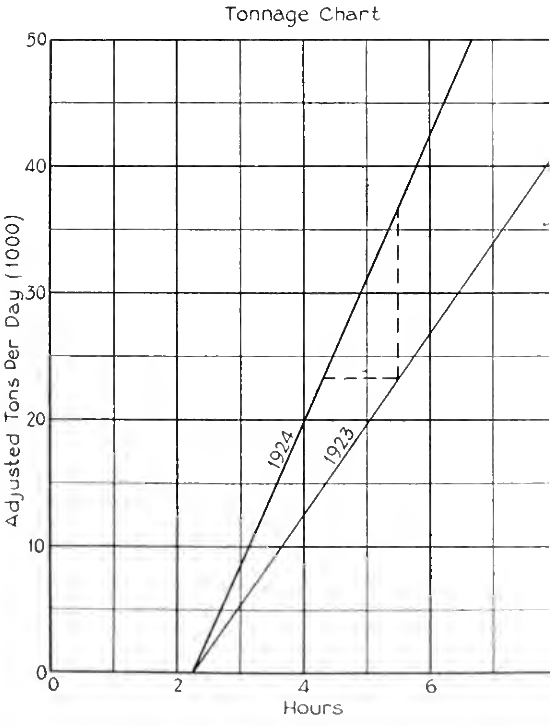


Fig. 7

On an average of 18 trains per day for 365 days per year, this resulted in a total saving of 18×365×31, or 203,670 minutes road time, or 3395 train hours per year.

Of the above saving in time the following amount can be accounted for in the reduction of train stops.

There was a saving of 55 stops per day on account of eliminating "31" orders, or a saving of 20,075 stops per year at an estimated average of 7½ minutes per stop, for 2000 ton-trains at a speed of 15 miles per hour, determined from previous studies, which equals 2509 train hours per year.

SECTION A-E

Operating Conditions and Statistics

	Before Automatics	*After Automatics*
Average distance between train order stations..	7.48 miles	7.48 miles
Minimum distance between train order stations.	2.0 miles	2.0 miles
Maximum distance between train order stations.	14.2 miles	14.2 miles
Average distance between passing sidings......	4.8 miles	4.8 miles
Minimum distance between passing sidings.....	3.3 miles	3.3 miles
Maximum distance between passing sidings.....	6.4 miles	6.4 miles
Average number of freight trains per day......	15.5	15.8
Average number of passenger trains per day...	11	10.2
Average adjusted tons per freight train........	1500	1567
Average road time per freight train...........	5 hrs. 30 min.	4 hrs. 26 min.
Saving road time per freight train............		1 hr. 4 min.
Average number of "19" orders per day delivered	74	86
Average number of "31" orders per day delivered	80	0

	Southward	*Northward*	*Total or Average*
Number of Automatic Signals............	54	53	107
Average distance between signals.........	1.27 Mi.	1.23 Mi.	1.25 Mi.
Minimum distance between signals.......	.25 Mi.	.55 Mi.	.40 Mi.
Maximum distance between signals.......	4.10 Mi.	3.60 Mi.	3.85 Mi.

Fig. 6 and 7 were plotted in the same manner as described for Section A-C. The minimum road times calculated from the train hour curve and the minimum road time shown on the train sheet were practically the same.

In Fig. 6 the horizontal dotted line represents the saving in road time, which is 1 hour and 6 minutes. The dotted vertical line, representing the increased capacity, is 8 trains, or an increase of 51.6 per cent.

In Fig. 7 the horizontal dotted line, representing the saving in road time, is 1 hour and 6 minutes. The dotted vertical line, representing the increased capacity, is 12,791 tons per day or an increase in tonnage capacity of 55 per cent.

The installation of Automatic Block Signals and Telephones on the Section A-E resulted in a saving of 1 hour and 4 minutes in road time per train. On an average of 15.5 trains per day for 365 days per year this resulted in a total saving in road time of 15.5×365×1 hour and 4 minutes, or 6035 hours per year.

On the above saving in time the following amount can be accounted for in the reduction of train stops.

There was a reduction of 80 stops per day on account of eliminating "31" orders, or a saving of 29,200 stops per year, at an estimated average of 7 minutes per stop for 1500-ton train at an average speed of 15 miles per hour, determined from previous studies, which equals 3407 train hours per year.

The following analysis was a process of elimination which brought up and disposed of each factor tending to produce the result of increasing the capacity of the railroad and decreasing the road time after the signals were installed. Items in which there were no changes cancelled out, leaving only those which brought about the increased capacity and reduction in road time.

The factors which brought about the increase in capacity and reduction in road time were about as follows:

(a) Elimination of the ten-minute rule and substituting a much shorter time due to automatic signals.

(b) Possible better movement under the new system in yard limit territory, even though the same yard limit rule is still effective.

(c) The elimination of "31" orders and the substitution to some extent of "19" orders (which under automatic signal protection is ample). The increase in "19" orders not being in proportion to the decrease in "31" orders due to better operation, keeping trains moving, and obtaining better meets.

(d) The improvement in road time of local freights, as under the Automatic Block System and telephones they can get their information relative to movements of other trains, and can take advantage of same.

(e) Assistance to dispatchers in putting out orders, as they are enabled under the new installation to get more information as to the location and movement of trains.

(f) Betterment to train movement against work extras.

Conclusion

Installation of Automatic Block Signals on a single track railroad will increase the capacity of the road, this increase varying with the length of the division on which installed, and with the number of passenger trains operated.

This method of increasing capacity being a very economical one, resulting in a saving in road time on present traffic, and increased earnings as traffic increases.

In addition to the increase in capacity, the above Automatic Block Signals and telephones provide the following intangible benefits, in addition to increase in capacity of the railroad and the saving in time.

(a) Increased safety.

(b) Increase in the capacity of the train dispatcher, including his ability to manage better, due to cutting the number of train orders in half. (This is of very great importance on most roads.)

(c) Reduction in damage to loading of cars due to the elimination of 49,275 freight train stops per year.

(d) Reduction in number of engines and cars to handle the same business in the same time, or the same number of engines and cars will handle greater business in the same time, the road capacities being increased 38 per cent and 55 per cent respectively.

(e) Increased good will of shippers on account of more speedy delivery of shipments, requiring less stock being carried by merchants, the increase in speed in one case being 14 per cent and in the other case 19.4 per cent. (It is claimed by the National Association of Lumber Dealers, this being quoted from a recent periodical, that the increased efficiency of railroads has affected the lumber industry, through the speeding up of shipments to the extent that the interest on the stock reduction resultant is sufficient to pay the freight.)

II—STUDY OF THE EFFECT OF DOUBLE-TRACKING AND OTHER CONDITIONS UPON FREIGHT TRAIN PERFORMANCE.

In 1922 this Sub-Committee made a study of freight train performance on an engine district nearly 140 miles long which contained both single and double track sections. By comparing the performances on the single-track sections with the performances on the double-track sections, a forecast was made to show what the performance on the single-track sections would be after double-tracking. The intention of this year's study was to check the forecasted performance with the actual. The Committee is disappointed that this program cannot be carried out because the double track contemplated in the forecast has not been completed. However, a number of important changes were made on the line since the previous study and the Committee felt that it would make a valuable report to study the effect which these changes made upon freight train performance.

A test period consisting of 21 days of April, 1925, was selected for comparison with the test period of 21 days of April, 1922, when the previous study was made. The principal changes in operating conditions can be briefly described by referring to Fig. 8 and 9, which show a condensed profile and track chart and typical train hour diagrams giving the class of equipment in use during the two periods.

The solid lines in Fig. 8 show the profile and track chart for the line in April, 1922. The dotted lines on the profile indicate the section where the grades were revised and the old lines abandoned. Likewise, the dotted lines below the track chart show the location of new double track. Prior to grade revision A-B constituted a helper district. Trains which needed help were assisted from A-B or from L-B. A few trains ran double

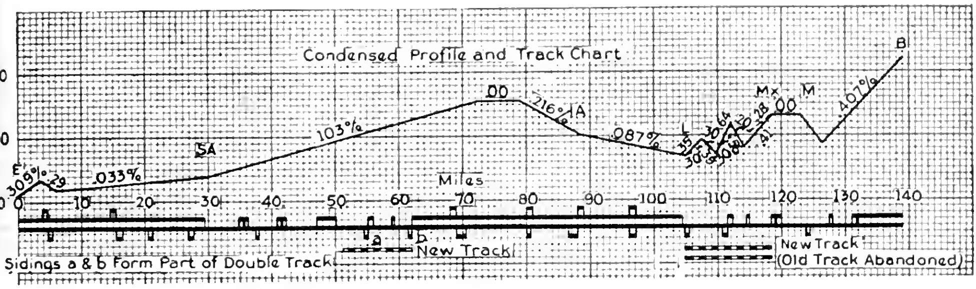

Condensed Profile and Track Chart
1200
1000
800
E
.309%
.29
.033%
5A
.103%
00
.216%
1A
.087%
L
.35
.30
.364
.43
.308
.28
.41
Mx
M
00
.407%
B
Miles
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
a
b
New Track
Sidings a & b Form Part of Double Track
New Track
(Old Track Abandoned)

Fig. 8

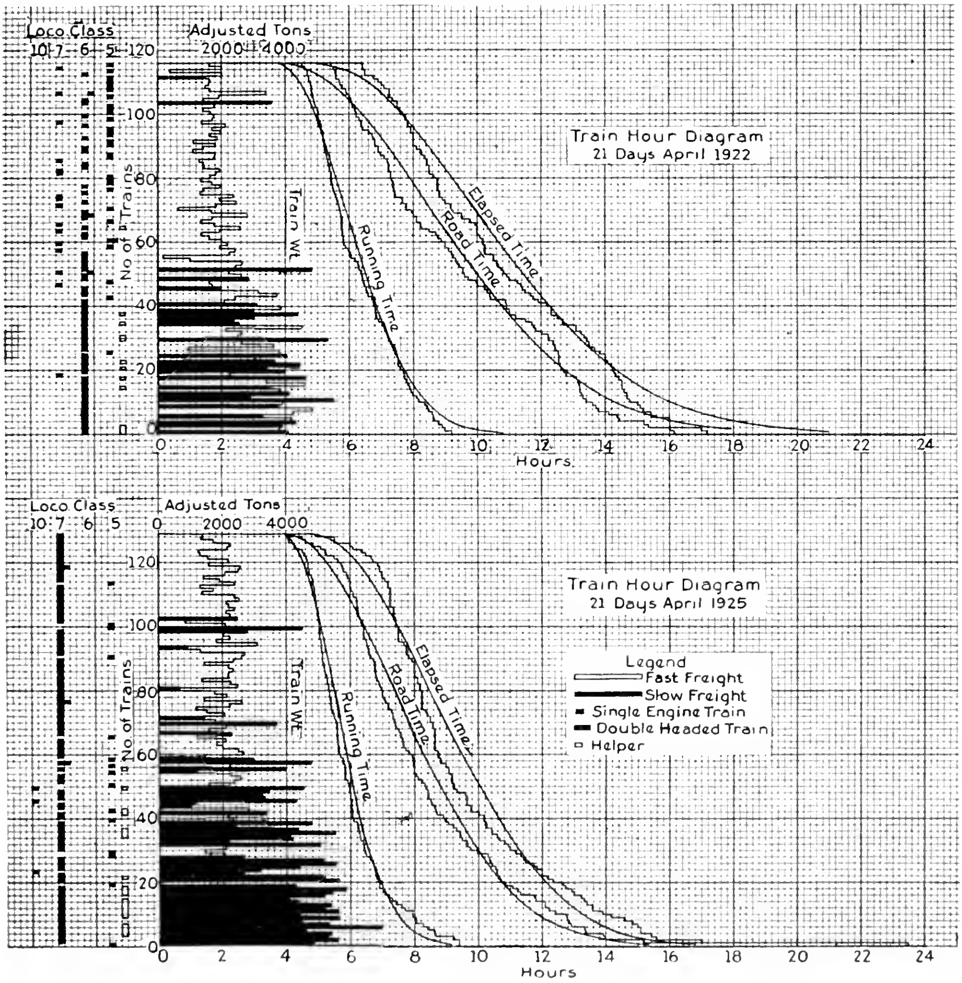

Loco Class
10 7 6 5
Adjusted Tons
2000 4000
120
100
80
60
40
20
0
No. of Trains
Train Wt.
Running Time
Road Time
Elapsed Time
Train Hour Diagram
21 Days April 1922
0
2
4
6
8
10
12
14
16
18
20
22
24
Hours
Loco Class
10 7 6 5
Adjusted Tons
0 2000 4000
120
100
80
60
40
20
0
No. of Trains
Train Wt.
Running Time
Road Time
Elapsed Time
Train Hour Diagram
21 Days April 1925
Legend
Fast Freight
Slow Freight
Single Engine Train
Double Headed Train
Helper
0
2
4
6
8
10
12
14
16
18
20
22
24
Hours

Fig. 9

headed over the entire district. Since the revision of grades helper service is restricted to the Section M-B.

The train hour diagrams in Fig. 9 offer a convenient way of showing the running time of trains and the corresponding adjusted tonnage leaving the terminal, as well as the road time and the elapsed time for both fast and slow freight trains. In addition the class of motive power employed is shown at the left of the diagram. From this chart it will be seen that Class 7 engines in 1925 replaced Class 6 engines and some Class 5 engines in service in 1922. Characteristics of the various class of engines are given in Fig. 10, characteristics of Class 10 engines are not shown, but this class includes modern Mikado locomotives equipped with feed water heaters and boosters, in addition to automatic stokers, superheaters, etc., and are, roughly, one-third larger in capacity (neglecting booster) than Class 5 engines.

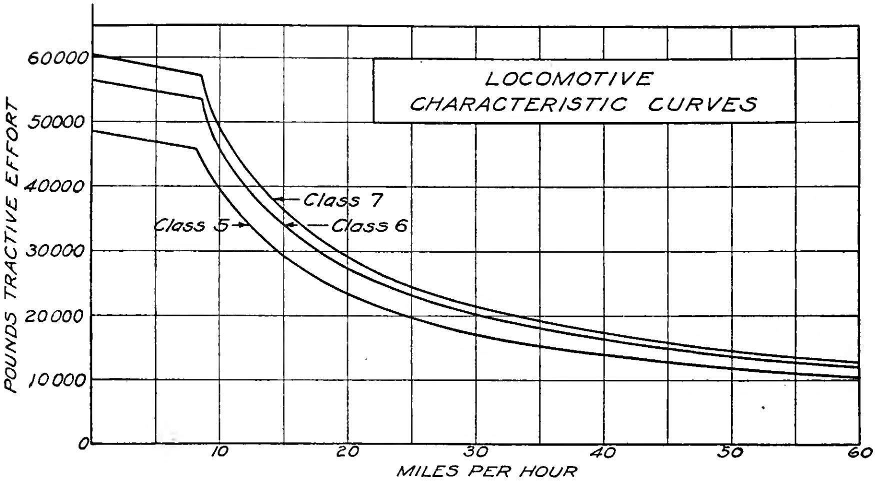


FIG. 10

The legend explains the symbols used to indicate those trains which were double headed over the entire district, and likewise those which used helpers part way.

A fair idea of the effect of these improvements and changes in operating conditions upon train performance can be obtained by comparing the train hour diagrams for the two periods. It is more satisfactory, however, to calculate the theoretical train hour diagrams as explained in A.R.E.A. Proceedings, Vol. 23, page 739, and from them construct the train and tonnage charts as shown in Fig. 11 and 12 and further discussed in Exhibit A.

Data for the construction of similar train hour diagrams for the Sections E-SA, SA-A, E-A, A-L and L-B were obtained from train dispatcher's sheets in order that the sections could be studied separately and the results analyzed for the effect of various operating conditions. Thus Section E-A was studied for the effect of substituting larger power. Section SA-A for the effect of larger power plus some double track; A-L for the effect of down grades and L-B for the effect of larger power, grade revision, double track, and partial elimination of helper service. The following table and Fig. 11 and 12 give a summary of the results of these studies. A further discussion of the problem comparing theory and practice is given in Exhibit A.

SUMMARY

Comparison of Freight Train Performance Showing Effect of Double-Tracking and Other Causes

TRAIN PERFORMANCE BASED ON 170 TRAINS PER MONTH EASTBOUND.

	Sections of Road					
	E-SA	SA-A	E-A	A-L	L-B	E-B
Average road time, hours, 1922	1.339	3.252	5.143	.692	2.452	9.916
Average running time, hours, 1922	1.264	2.571	3.859	.593	1.901	6.475
Average road time, hours, 1925	1.151	2.943	4.715	.744	1.791	8.087
Average running time, hours, 1925	1.095	2.275	3.435	.691	1.596	5.759
Average road delay per train, 1922	.075	.681	1.284	.099	.551	3.441
Average road delay per train, 1925	.056	.668	1.280	.053	.195	2.328
Reduction in road delays, hours	.019	.013	.004	.046	.356	1.113
*Reduction in Average road time, hours	.188	.309	.428	—.052	.661	1.829
*Equivalent No. of freight trains	231.5	207.2	203.7	144.9	329.0	245.2
*Ratio No. of trains, same road time	1.362	1.219	1.198	.853	1.934	1.442
Ratio lengths passing tracks in service	1.000	1.217	1.115	1.000	1.900	1.175
Diff = increase from other causes	.362	.002	.083	—.147	.034	.267
Tonnage performance based on 331,000 tons per month, eastbound.						
Average road time, hours, 1922	1.339	3.252	5.143	.692	2.452	9.916
Average road time, hours, 1925	1.108	2.823	4.531	.714	1.732	7.739
*Reduction in Average road time, hours	.231	.429	.612	—.022	.720	2.177
*Equivalent tons per month (1000)	492.2	440.5	433.1	308.1	699.5	521.3
*Ratio tons per month, same road time	1.487	1.331	1.310	.932	2.112	1.575
Ratio lengths passing tracks in service	1.000	1.217	1.115	1.000	1.900	1.175
Diff = increase from other causes	.487	.114	.195	—.068	.212	.400

Conclusion

From the above table it will be seen that the total road delays, including delays at intermediate terminals, amount to 3441 and 2328 hours for 1922 and 1925 respectively. The sum of the road delays for the various sections which compose the total district amounts to 1206 hours in 1922 and .972 hours in 1925. These sums for the individual sections do not

---

*See Fig. 4 and 5. The dotted horizontal lines in these diagrams indicate the savings in road time corresponding to the operation of 170 trains or 331,000 tons per month. Following the dotted vertical line to its intersection with the average road time for 1925 gives the number of trains or tons per month which can be operated without exceeding the average road time obtained in 1922. The ratio of the number of trains or tons which can be operated per month for the same average road time indicates the relative capacities obtained.

include the delays at intermediate terminals, consequently 3.441—1.206 and 2.328—.972 leave 2.235 and 1.356 hours, which represent the delays at intermediate terminals for the two periods respectively. The total reduction in road time amounted to 1.829 hours, of which .879 hours, or 48 per cent, represents improvements in intermediate yard operations, which were or were not brought about by virtue of improvements in track and motive power. Further detail study would determine the manner in which these delays were reduced. It may follow from such detail studies that legitimate claims for improved service in excess of the theoretical can be made due to the fact that yard as well as road operations are affected by road improvements.

In order to properly interpret the results obtained by the study it is felt that a further discussion of the subject is necessary to show how nearly the actual results agree with the theoretical. This discussion is contained in the following exhibit:

Exhibit A

The following explanations are given for the purpose of showing the application of the theory of train operation to the analysis of actual results.

In general the procedure is as follows:

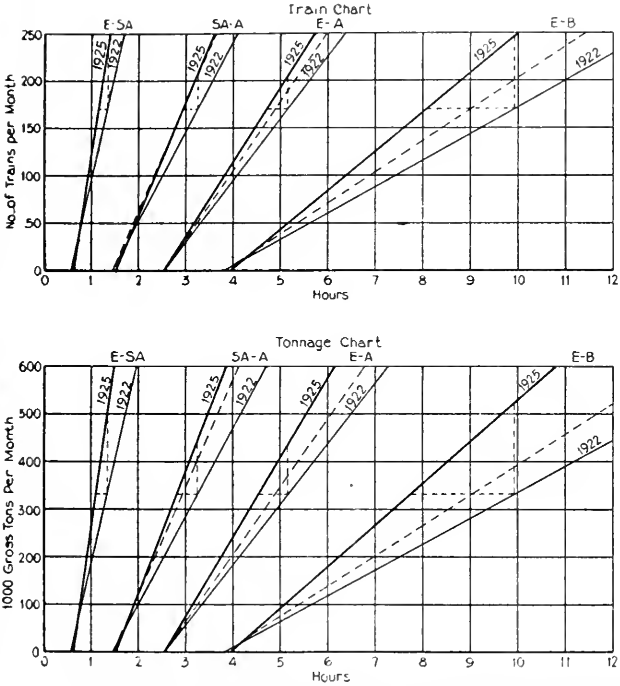
1. Construct the actual train hour diagram for each section from data obtained from the train sheets.
2. Calculate the theoretical train hour diagrams as described on page 739, Vol. 23, of A.R.E.A. Proceedings of 1922.
3. The above calculation will give the value of to which is the point where the lines representing average road time (or average running time), Fig. 11 and 12, intersect the horizontal axis.
4. The value of "*n*" for a given number of trains will be found by the calculation described in 2.
5. The average road time "T" corresponding to the given number of trains is found by the formula $T = t_o + \frac{\sqrt{\pi}}{2n}$.
6. Plot this value of T corresponding to the given number of trains and draw a straight line to intersect the horizontal axis at t_o.
7. When dealing with several classes of trains the actual train hour diagram for *road time* is likely to be distorted and values of t_o obtained will be too small. In these cases it is better to work with train diagrams for running time as well as *road time,* for the reason that the actual train hour diagram for running time is less likely to be distorted, consequently more nearly correct values of t_o will be obtained. See Fig. 9 for example. In this instance care has been taken to be sure that the theoretical minimum *road* time is not less than the minimum *running* time.
8. If t_o needs to be corrected recalculate n by the formula $n = \frac{\sqrt{\pi}}{2\,(T\text{-}t_o)}$
9. The tonnage charts corresponding to the train performance are obtained by multiplying the number of trains by the average weight per train and plotting the prdouct to the corresponding values of t_o and T.

This procedure was applied to the train hour diagrams for each section and the train performance and tonnage charts shown in Fig. 11 and 12 obtained (based on a 30-day period instead of 21 days).

Section E-SA

From a preliminary inspection, the only change which was made in the section E-SA between the two test periods was the adoption of larger motive power. If the train weights increased in proportion to the motive power capacities then the light and heavy lines in Fig. 11 representing train performance should coincide and the divergence between the light and heavy lines on the tonnage charts should indicate the increase in capacity due to increased weight of trains. In these respects the actual results do not agree with the theory. This may be due to the fact that this section is low grade and the motive power was not taxed to capacity during the test period of 1922, whereas, during the test period of 1925 better use was made of the motive power capacity.

FREIGHT TRAIN PERFORMANCE
Calculated from Train Hour Diagrams
Road Time East Bound Trains



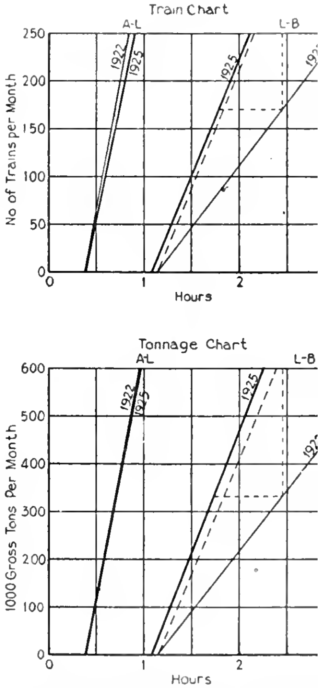


Chart Compares Average Time on Road in 1922 with that in 1925 Dotted Lines Represent 1922 Performances Corrected for New Track (See Profile and Text) The Superior Performance Obtained in 1925 is Due to Additional Trac Facilities, Heavier Power and Changes in Operating Methods

Fig. 11

Fig. 12

In this connection the car limit of 75 cars in 1922 was governed by the length of passing tracks east of SA, whereas in 1925 the car limit was

100 cars per train, or a potential increase of 33⅓ per cent. It will be seen by comparing the two train hour diagrams (Fig. 9) that advantage was taken of this fact, as shown in the loading of trains and the operation of a greater number of slow freight trains in 1925 than in 1922.

What actually happened to improve the train performance on this section brought about the utilization of reserve power in the locomotives which was not utilized in 1922. That is, by reason of the reserve power the heavier loaded trains in 1925 ran about as fast as the lighter loaded trains in 1922 and the lightly loaded trains in 1925 used the reserved power to run, on an average, faster than in 1922.

This explanation gives a reason why lines showing the train performance for the Section E-SA do not coincide and indicate that the lengthening of passing tracks has brought about changes in operating methods which make it possible to use the full capacity of the locomotives. As far as train operation is concerned the improved performance is equivalent to operating the same weight trains with 36.2 per cent more power. The tonnage chart indicates the operation of 9.2 per cent heavier trains, or a total increase in tonnage capacity of 48.7 per cent, based upon the average tonnage handled eastbound.

Section SA-A

This section, for the most part, is slightly heavier grade than Section E-SA, and for this reason it can be assumed that the locomotives were operated up to capacity during both test periods. On this basis the train performance chart would be expected to show only the effect of the new double track and the tonnage chart the effect of larger power and new double track. The dotted lines showing the theoretical performance for new double track were calculated on the basis of the amount of new track added since 1922. In other words, adding 20 per cent more passing track to any section of line increases its capacity 20 per cent. (See A.R.E.A. Proceedings, Vol. 22, 1921, page 745.)

From the following table the ratio of second and third track in the Section SA-A for the 1925 and 1922 test periods was $51.0/41.9 = 1.217$, or 21.7 per cent, greater track capacity in 1925 than in 1922. The actual increase in track capacity obtained from the train hour diagrams and shown on train performance chart is 21.9 per cent. Theoretically the three performance curves should intersect at the same point, but the calculations show different values for t_o for 1922 and 1925, but the difference is so slight that practically no error is introduced by assuming the same value of the t_o for both test periods.

Assuming that heavier power produces the same effect on the Section SA-A as on the Section E-SA, namely: 9.2 per cent, then the tonnage chart should show an increase in tonnage capacity of ($1.217 \times 1.092 = 1.329$ or) 32.9 per cent, as compared with 33.1 per cent found from train hour diagrams and based upon the average tonnage handled eastbound.

LENGTH OF TRACKS

	1922	1925
E-SA		
First track	30.5	30.5
Second track	30.5	30.5
Third track	6.2	6.2
Total second and third track	36.7	36.7
SA-A		
First track	57.8	57.8
Second track	35.5	43.9
Third track	6.4	7.1
Total second and third track	41.9	51.0
A-L		
First track	16.6	16.6
Second track	16.6	16.6
Third track	2.8	2.8
Total second and third track	19.4	19.4
L-B		
First track	34.0	34.0
Second track	11.1	21.1
Third track	....	....
Total second and third track	11.1	21.1

Section E-A

This section is composed of the Sections E-SA and SA-A. Theoretically the time saved over the total section is equal to the sum of the times saved over the individual sections. Data given in the following table for average *running* time corresponding to 170 trains per month (30 days) shows that the theory agrees closely with practice.

In this connection the train performance shown in Fig. 11, based upon average *road* time, does not show this agreement for the reason that the performance obtained from test for the total section includes stops and delays at SA, whereas the sum of the performance for the individual sections does not include these stops and delays. In addition it has been shown that the actual train hour diagrams for road time are more likely to be distorted than the actual train hour diagrams for running time, consequently data from the theoretical diagrams based upon road time may be open to greater errors.

Section A-L

Fig. 12 shows comparisons of train performance for the test periods of 1922 and 1925 for the Sections A-L and L-B plotted to a larger scale for hours. No changes were made in the Section A-L, which is down grade, consequently the motive power was not taxed to capacity during either period. In fact, the average road time of trains was longer in 1925 than in 1922, but from the tonnage chart the performance for the two years is practically identical.

Section L-B

Section L-B contains the new grade line and new double track section. Prior to placing these improvements in service, helper locomotives, when needed, were used between A and B. After these improvements were put in service the use of helpers was limited to the Section M-B. The performance shown for the test period of 1925 is the result of several changes in conditions arising from these improvements. Some of these changes in conditions, such as the elimination of helped service and grade revision, have opposing effects. If the effects of these conditions happen to balance then it can be assumed that the operation during 1922 is equivalent to single-track operation over the new line and the net effect shown is due to double tracking and heavier power. The dotted lines on these charts represent the theoretical effect of double-tracking. The dotted line on the train performance chart is obtained by increasing the ordinate for any point on the line showing the performance for 1922 by the ratio of second and third track in 1925 to the amount of second and third track in 1922. Thus from Table page 916, the amount of second and third track in 1925 was 21.1 miles, against 11.1 miles in 1922, and the ratio 21.1/11.1 = 1.90. The average road time in 1922, corresponding to 170 trains per month, was 2.452 hours. According to the theory the effect of double tracking would make it possible to operate 1.9 × 170 = 329 trains per month, without exceeding an average of 2.452 hours per train. The dotted line on the tonnage chart is obtained by multiplying the number of trains by the average tons per train and plotting accordingly.

It is evident from the charts for the Section L-B that the net effect from the improvements is greater than expected from double-tracking alone. There is a slight decrease in the minimum road time which is probably the result of grade revision and increase in size of motive power.

Section E-B

Actual operations over the Section E-B are more or less irregular; that is, the operation is made up of through runs and turn-around runs to some intermediate point. The train hour diagrams include only those trains which ran over the entire district and a correction was made in arriving at the number of trains per month by dividing the train miles by 137.2 miles, the distance between E and B.

The following table gives a summary of the operating statistics for April, 1922, and April, 1925, from which the average tons per train—1947 and 2126—were used to construct the tonnage charts from the train performance charts:

Summary of Operating Statistics

	April, 1922	April, 1925
1000 gross ton miles	48,902	56,685
Train miles by classes of locomotives.		
Class 5	6,699	4,068
Class 6	14,668	.....
Class 7	3,748	22,226
Class 10	.....	368
TOTAL	25,115	26,662
Average tons per train	1,947	2,126
Equivalent number of trains	183.1	194.3
Total train hours road time	1,778.6	1,596.8
Average road time per train	9.73	8.22

In order to arrive at a comparison of the relative sizes of locomotives in service during the two periods the following weighted average was obtained:

Equivalent Locomotive Miles Based on Class 5 Engines Being Unity

	April, 1922	April, 1925
Class 5 engine = 1.0	6,692	4,068
Class 6 engine = 7/6	17,113	.....
Class 7 engine = 5/4	4,685	27,783
Class 10 engine = 4/3	.....	491
Total equivalent locomotive miles	28,490	32,342
Actual locomotive miles	25,115	26,662
Ratio equivalent/actual	1,134	1,213
Ratio 1925/1922	.....	1.09

From the above it will be seen that the average capacity of locomotives in service in 1925 was about 9 per cent greater than in 1922. This indicates that the average train weight increased in proportion to the capacities of the locomotives and agrees closely with results obtained from the train hour diagrams.

The improvement shown in the freight train performance for the total Section E-B is greater than the sum of the improvements on the individual sections for the reason that in addition to the reduction in time on the road an almost equal reduction in delays at intermediate terminals was brought about. The reduction in delays at intermediate terminals may or may not be independent of the road improvements. It can be shown theoretically that increases in yard capacity will produce increases in track capacity on the road and conversely increases in track capacity on the road will produce an effect similar to increased yard capacity. That is, trains can often be put through the yards in quicker time if there is plenty of track capacity outside the yard which can be used. In this case it was impractical to attempt to assign a cause for the reduction in yard delays.

Appendix C

(4). METHODS OF ANALYZING COSTS FOR THE SOLUTION OF SPECIAL PROBLEMS, INCLUDING THE COSTS OF STARTING AND STOPPING TRAINS.

J. E. Teal, Chairman, Sub-Committee; M. F. Steinberger, J. M. Brown, H. T. Porter, M. C. Selden, C. S. Gzowski, E. G. Allen, Barton Wheelwright, C. C. Williams.

The Committee has continued the study of the problem "Cost of Starting and Stopping Trains" by the use of data taken from dynamometer records of tonnage freight trains operated on the Cincinnati Division, having low grades, and the Clifton Forge Division, having mountain grades, of the Chesapeake & Ohio Railway.

Progress has been made towards the development of a formula applicable to this problem. However, by reason of the late period in which the dynamometer records were made, it was not possible to complete the study for this year's report.

The Committee, therefore, reports progress and it is recommended that the study be continued during the next year, with the view of completing the specific problem now being pursued.

Appendix D

(5) THE UTILIZATION OF LOCOMOTIVES TO DETERMINE:

(a) The percentage of time they should be available to perform actual transportation.

(b) Methods of obtaining maximum efficiency while so available.

J. M. Farrin, Chairman, Sub-Committee; E. T. Howson, G. E. Boyd, E. E. Kimball, Mott Sawyer, H. A. Roberts, J. W. Burt, G. F. Hand, E. J. Correll, J. E. Teal, J. F. Pringle, M. F. Mannion.

The Committee held no meetings, but made special study in the field of locomotive utilization on two railroads and on one division of another railroad. This information has not been worked up in final form.

In view, however, of the very thorough investigation of this subject being conducted by a joint committee of the Mechanical and Operating Divisions of the A.R.A. and the prospect of an early report which will doubtless be very constructive, it is the opinion of the Sub-Committee that this subject be discontinued.

Appendix E

(6) METHODS OF OPERATION BY WHICH THE INTENSIVE USE OF FACILITIES MAY BE SECURED

E. T. Howson, Chairman, Sub-Committee; L. S. Rose, V. I. Smart, B. T. Anderson, J. L. White, E. E. Kimball, Mott Sawyer, E. J. Correll, J. F. Pringle, C. L. Whiting, R. T. Scholes, M. C. Selden, B. J. Schwendt.

In the investigation of the subject assigned to it, the Committee selected for its work for this year the investigation of the "peg" system as a means of promoting the intensive use of facilities, and made preparations to investigate the operation of this system in the movement of trains on the Buffalo, Rochester & Pittsburgh, where it had been employed for a number of years. Early in the summer, however, the traffic on this road fell off to such an extent, as a result of the disorganization in the the coal mining industry, that the line ceased to be taxed to capacity and the merits of this system could no longer be ascertained. The Committee, therefore, postponed its investigation of this subject. Late in the season, when it was apparent that no radical change in conditions would occur in time to permit the Committee to study operation on this road, work was undertaken on the investigation of signals as a means of increasing the capacity of tracks. This investigation has not proceeded sufficiently far, however, to enable the Committee to report other than progress.

Appendix F

(7) DEVELOP SUITABLE UNITS FOR COMPARING COSTS OF OPERATION AND EQUIPMENT MAINTENANCE

W. J. Cunningham, Chairman, Sub-Committee; L. S. Rose, H. C. Crowell, M. F. Steinberger, J. M. Farrin, F. H. McGuigan, Jr., E. G. Allen, V. I. Smart, W. G. Raymond, H. Stringfellow, J. L. White, Louis Yager.

The Committee has made some progress in surveying the whole field of statistical data and has formulated a suggested schedule of unit costs or other indices in maintenance of way, maintenance of equipment, transportation and net return.

With this report of progress, the Committee's recommendation is that it should be continued.

REPORT OF COMMITTEE I—ROADWAY

C. M. McVay, *Chairman;*
C. W. Baldridge,
H. B. Barry,
E. J. Bayer,
A. E. Botts,
G. S. Crites,
C. C. Cunningham,
C. A. Daley,
C. F. Hinchman,
J. R. Hoagland,
W. M. Jaekle,
J. E. Johnson,
W. M. Kelly,
J. C. Wrenshall, *Vice-Chairman;*
R. L. Latham,
E. C. Oyler,
O. V. Parsons,
J. K. Pettus,
Blair Ripley,
G. L. Sitton,
E. M. Smith,
D. W. Thrower,
H. E. Tyrrell,
W. D. Wiggins,
J. R. Wilks,
W. H. Woodbury,
Committee.

To the American Railway Engineering Association:

Your Committee respectfully presents herewith report covering the following subjects:

(1) Revision of Manual (Appendix A).
(2) Economics of Filling Bridges (Appendix B).
(3) Corrugated Metal Culverts (Appendix C).

Action Recommended

1. That Appendix A be approved and the revised version substituted for the present version in the Manual.

2. That Appendix B be approved as recommended practice and published in the Manual.

3. That Appendix C be received as information.

Recommendations for Future Work

1. Revision of Manual.

2. Continue the study of corrugated metal culverts.

3. Continue the study of unusual methods of handling problems in connection with slips, slides and water pockets.

4. Continue the study of deformations of roadbed in light of information developed by Committee on Stresses in Railroad Track.

5. Continue the study of methods of drainage of roadway in yards or main lines where there are three or more tracks.

6. Begin the study of methods and advisability of constructing a permanent roadbed, with assistance from other committees as may be desired.

7. Outline of work for ensuing year.

Respectfully submitted,

The Committee on Roadway,
C. M. McVay, *Chairman.*

Bulletin 284, February, 1926.

Appendix A

REVISION OF THE MANUAL

C. W. Baldridge, Chairman, Sub-Committee; C. F. Hinchman,
W. M. Jaekle, W. D. Wiggins.

In addition to some changes of matter in the Manual, the Committee decided that in line with President Fairbairn's letter of August 1st, it was appropriate to submit recommendations for the eliminations of considerable matter from the Manual which is of undoubted value as information, but is scarcely in form of recommended practice.

The following changes are recommended:

Page 17

Preceding definition of "Washout," insert definition of "Flood Damage."

Present Reading

Page 17

Washout. The carrying off of the permanent way by the impact and erosion of waters.

Page 18

Center Line. A line indicating the center of an excavation, embankment or track.

Page 19

Channel. The depression or cut in which a stream is confined.

Page 19

Tile Drain. An artificial waterway for conducting water from the roadway.

Page 21

(5) The width between center lines of main tracks on tangent should preferably be not less than 13 feet; on curves this distance may be increased.

Page 21

(8) "Information on profiles should be so given and arranged that the contractor can intelligently figure the costs of grading in terms as required by the contract."

Page 22 (First paragraph at top of the page):

"Slopes of Roadway Cross-Section."

"Local conditions and the character of material should invariably be taken into account in determining the permanent slopes of the roadway cross-section."

Page 22

5. "The slopes of embankements and excavations shall be of the following inclinations, as expressed in the ratio of the horizontal distance to the vertical rise:

Proposed Reading

FLOOD DAMAGE. Any and all damage to Railway property caused by any unusual flow of water.

WASHOUT. An erosion of the permanent way by storm or flood to such an extent as would cause delay of trains, or endanger traffic.

CENTER LINE. A line adopted to be the center line of the track or tracks.

CHANNEL. A depression in which a stream flows.

TILE DRAIN. An underground drain constructed of clay or cement pipe.

(5) The distance between center lines of main tracks on tangents should be not less than 13 feet; on curves this distance should be increased enough to maintain an equivalent clearance between equipment on adjoining tracks.

(8) Information on profiles should be so given and arranged that units and costs of grading can be intelligently estimated.

Slopes of Roadway—Cross-Section

Local conditions and the character of the material should always be taken into account in determining the construction slopes of the Roadway cross-section.

In cuts the slopes should be as steep as the material will stand permanently, while on embankments, because of operating and maintenance conditions, the slopes should not be steeper than one and one-half to one unless the embankment is made very wide.

5. The slopes of embankments and excavations shall be of the following inclinations, as expressed in the ratio of the horizontal distance to the vertical rise:

Present Reading

Embankments: Earth—One and one-half to one;
Rock—From one to one, to one and one-half to one.
Excavations: Earth—One and one-half to one;
Loose Rock—One-half to one;
Solid Rock—One-quarter to one.

"These ratios may be varied according to circumstances, and the slopes shall be made as directed in each particular case."

Page 23 (Article 10—"Cutting and Piling Wood"):

"All trees which may be reserved shall be stripped of their tops and branches, made into ties, or cut to such lengths as may be directed, and neatly piled at such places on the right-of-way as may be designated, for which service payment shall be made by the tie, or by the cord of one hundred and twenty-eight (128) cubic feet."

Page 24 (Article 16, Omit the words "foundation pits.")

16. "The term 'Grading' in these specifications includes all excavations and embankments for the formation of the roadbed, ditching, diversions of roads and streams, foundation pits, and all similar works pertaining to the construction of the railway, its sidetracks and station grounds."

Page 24 (Solid Rock.)

18. " 'Solid rock' shall comprise rock in solid beds or masses in its original position, which may be best removed by blasting; and boulders or detached rock measuring one cubic yard or over."

Page 24 (Loose Rock.)

19. " 'Loose Rock' shall comprise all detached masses of rock or stone of more than one cubic foot and less than one cubic yard, and all other rock which can be properly removed by pick and bar and without blasting; although steam shovel or blasting may be resorted to on favorable occasions in order to facilitate the work."

Page 24 (Common Excavation.)

20. " 'Common Excavation' shall comprise all materials that do not come under the classification of 'Solid Rock,' 'Loose Rock,' or such other classifications as may be established before the award of the contract."

Page 25 (Excavation Below Subgrade.)

22. "Rock Excavation shall be taken out .... (......) inches below subgrade and refilled to subgrade with approved material.

Page 25 (Excess Excavation and Slips.)

23. "Excavation in excess of the authorized cross-section, as well as slides extending beyond the slope lines, shall not be paid for unless due to causes beyond the control of the contractor or his agents. In all cases the surplus material shall be removed by the contractor without delay and the slopes reformed. The classification of the material shall be in accordance with its condition at the time of removal, regardless of prior conditions. The measurement of the material shall be the original space occupied, regardless of the classification."

Proposed Reading

Embankments: Not steeper than one and one-half to one.
Excavations: Ordinary Earth—One and one-half to one;
Loose Rock—One-half to one;
Solid Rock—One-quarter to one.

These slopes may be varied according to circumstances, and the slopes shall be made as directed in each particular case.

10. All trees which may be reserved shall be stripped of their tops and branches, made into ties, or cut to such lengths as may be directed, and neatly piled at such places on the right-of-way as may be designated, for which service payment shall be made by the tie, or by the cord of one hundred and twenty-eight (128) cubic feet, or by the thousand feet, B. M. top scale measure, as may be specified.

16. The term "Grading" in these specifications includes all excavations and embankments for the formation of the roadbed, ditching, diversions of roads and streams, and all similar works pertaining to the construction of the railway, its sidetracks and station grounds.

Solid Rock.

18. "Solid Rock classification" shall comprise rock in solid beds or masses or boulders, measuring one cubic yard or more, and all other material which can most economically be removed by blasting.

Loose Rock.

19. "Loose Rock classification" shall comprise all detached masses of rock or stone of more than one cubic foot and less than one cubic yard, and all other rock which can be properly removed by pick and bar and without blasting; although steam shovel or blasting may be resorted to on favorable occasions in order to facilitate the work.

Common Excavation.

20. "Common Excavation classification" shall comprise all materials that do not come under the classification of "Solid Rock," "Loose Rock," or such other classification as may be established.

Excavation Below Subgrade.

22. Rock excavation shall be taken out .... (......) inches below subgrade and be refilled to subgrade with approved sub-ballast or ballast material. Measurement of excavation shall be made to the bottom of the material removed.

Excess Excavation and Slips.

23. The classification of the material excavated shall be in accordance with its condition at the time of its removal, regardless of prior conditions. The measurement of the material shall be the original space occupied, regardless of the classification. Excavation in excess of the authorized cross-section shall not be included in the measurement except in removal of unpreventable slides.

Present Reading

Page 25 (Borrow Pits.)

26. "Where the quantity of excavation from the cuttings of standard cross-section is insufficient to form the embankments, the deficiency shall be made up by widening the cuttings on one or both sides of the center line, as may be directed. No material shall be taken from borrow pits unless such borrow be indicated either on the profiles or by written order.

Page 26 (Subdrains.)

32. "Subdrains of tile shall be constructed of the size and location as directed. Trenches for these drains shall be taken out at least .... (......) inches below frost line; the tiles shall be laid on a bed which shall be true, with half-round sections, with a filling of at least .... (......) inches of cinders or other suitable material on either side and above the tile, and then covered with ordinary soil to the top of the trench.

Measurement and payment for such drains shall be by the linear foot, according to the diameter of tile, including excavation and refilling; the contractor to furnish all material."

Page 28 (Finishing Subgrade.)

40. "The subgrade shall be compact and finished to a true plane, thus leaving no depression that will hold water."

Price and Measurement of Grading

Page 29 (Basis.)

46. "Grading shall be estimated and paid for by the cubic yard at the prices specified for the respective materials. Measurements shall be made in excavation only, except as hereinafter mentioned."

Page 29 (Work included in price.)

47. "The contract price per cubic yard shall include the excavation of the material by any method whatsoever; the loading, transportation and deposit of the same in the manner prescribed by these specifications and in the places designated; the plowing or benching of the slopes, and all other expenses incident to the work of grading."

Page 29 (Haul.)

48. "Unless otherwise specified, it is distinctly understood that the contract price per cubic yard covers any haul found necessary. No allowance will be made for any so-termed overhaul."

Page 29 (ALTERNATE OPTIONAL OVERHAUL CLAUSE.)

(The following alternate optional overhaul clause is recommended to be substituted for clause No. 48 of the Specifications for the Formation of the Roadway in case it is desired to allow overhaul.)

Proposed Reading

Borrow.

26. Where the quantity of excavation from the cuttings of standard cross-section is insufficient to form the embankments, the deficiency shall be made up by widening the cuttings on one or both sides of the center line, as may be directed. No material shall be taken from borrow pits unless such borrow be indicated either on the profiles or by written order.

When steam shovels are used borrow pits should, if possible, be so located that the bottom of the pit will not be below subgrade, or prospective subgrade. Where it is necessary to borrow from below subgrade the borrow pit should be made far enough away from the roadbed so that it will not require refilling at some future time, also so that water which may stand in the pit will not affect the roadbed.

Subdrains.

32. Subdrains of tile shall be constructed of the size and location as directed, and to the depth and grade established for them. The tile bed shall be cut true in line and where practical with half round bottom. Where impractical to provide the half round bottom, planks or strips of wood must be so set or other provision made to hold the tile in true line and grade. The tile trench must be filled with cinders or other suitably porous material, to a depth of twenty-four inches above the top of the tile, and the remainder of the trench filled with any material which is sufficiently porous to permit of good drainage. Pure clay should not be used for refilling any part of a drainage ditch.

Finishing Subgrade.

40. The subgrade shall be compact and finished to a true sloped or crowned surface as called for by the plans, and must leave no depression or irregularity which will hold water or prevent proper drainage.

Measurement of Grading

Measurement.

46. Measurement of grading shall be by the cubic yard, and in accord with the proper classifications. Measurements shall be made in excavation only, except where otherwise specifically directed.

Completion of Work.

47. The completed work shall include the excavation of the material, by whatever method is adopted, the loading, transportation and deposit of the same in the place, or places designated, and in the manner prescribed, the plowing or benching of slopes and the finishing of the roadbed, slopes and ditches, and all other work which may be incident to the completion of the grading.

48. Omit.

Omit.

A

Present Reading

Page 29 (Haul.)

48-a. "No payment shall be made for hauling material when the length of haul does not exceed the limit of free-haul, which shall be ...... feet.

"The limits of free-haul shall be determined by fixing on the profile two points—one on each side of the neutral grade point—one in excavation and the other in embankment, such that the distance between them shall equal the specified free-haul limit and such that the included quantities of excavation and embankment shall balance. All haul on material beyond the free-haul shall be estimated and paid for on the basis of the following method of computation, viz.:

"All material within this limit of free-haul shall be eliminated from further consideration.

"The distance between the center of gravity of the remaining mass of excavation and center of gravity of the resulting embankment, less the limit of free-haul as above described, shall be the overhaul distance.

"Overhaul shall be computed in units of one cubic yard moved 100 feet and compensation to be rendered therefor shall be computed on such units.

"In case material is obtained from borrow pits along the embankment and runways constructed, the haul shall be determined by the distance the team necessarily travels. The overhaul shall be determined by multiplying the number of cubic yards so hauled by one-half the round distance made by the team, less the free-haul distance. The runways shall be established by the Engineer."

Page 30 (Article 53.)

"Blasting shall be done with all possible care, so as not to damage the roof and sides. All insecure pieces of rock beyond the standard cross-section shall be removed by the contractor."

Page 31 (Article 59.)

"The Contractor shall, without loss or liability to the Company, construct all roads necessary for his use in the execution of this contract.

Page 31 (Article 61.)

"The Contractor shall arrange his work so that there will be no interference or delay in any manner with the train service of the Company. He shall be responsible for any damage to the Company's property caused by his acts or those of his employees. Whenever the work is liable to affect the movement or safety of trains, the method of doing such work shall first be submitted for approval, without which it shall not be commenced or prosecuted. If continuous detention occurs to the train service, the Company reserve the right to complete the work at the expense of the contractor after giving him written notice."

Page 32 (Article 62.)

"Heavy blasting shall not be permitted close to the main tracks, nor shall the contractor be permitted to transport material along or between the Company's tracks, except when properly authorized. Whenever the work as authorized affects the safety of the trains or tracks, the Company shall take such precautions as it may deem advisable to insure safety. The cost thereof shall be charged to the contractor and deducted from his estimate."

Proposed Reading

48-a. Omit.

53. Blasting shall be done with care to avoid damage to the roof or sides. All insecure pieces of rock beyond the authorized cross-section must be removed at once, but shall not be included in the excavation measurement.

59. Omit.

61. The work shall be so arranged that there will be no delay or interference in any manner with the operation of trains.

Whenever the work is liable to affect the movement or safety of trains, the method for doing such work must be submitted for approval, without which it must not be commenced or prosecuted.

62. Heavy blasting close to the operated tracks shall not be done until the proper precautions have been taken and arrangements made to protect all trains and other property and to quickly clear all debris from the track.

Present Reading

Page 32 (Article 63.)

"The contractor shall not move the Company's tracks, or in any way interfere with them under any circumstances. Whenever it becomes necessary that the main line or sidetracks be moved, it shall be done by the Company, and the actual cost thereof charged to the contractor and deducted from his estimate."

Page 32 (Article 64.)

"The location of the additional track shall be on the .... side of existing line. But whenever it is expedient to change any portion to the opposite side, the altered alinement shall be shown upon the maps or diagrams furnished by the Company, and the contractor shall conform to the same without extra charge."

Page 32 (Article 66.)

"Whenever it is necessary for material of any description to be transported across the existing track or tracks, the location of the crossings must be approved. The material and labor of placing and maintaining the same shall be furnished by the Company. The actual cost shall be charged to the contractor and deducted from his estimate."

Page 32 (Article 67.)

"Day and night watchmen shall be furnished by the Company at the places it may consider necessary for the safety of the Company's trains and works. The cost shall be charged to the contractor and deducted from his estimate. It is distinctly understood, however, that the providing of such watchmen shall not relieve the contractor from the liability and payment for damages caused by his operations."

Page 33 (Article 68.)

"The cost of installment, maintenance and operation of all signals necessary to ensure the safety of trains, consequent upon the contractor's work, shall be borne by the contractor, and all instructions regarding their observance shall be strictly obeyed by him."

Page 35

Transfer the matter following to the Proceedings as information and insert the matter opposite in the Manual.

Proposed Reading

63. Omit.

64. Omit.

66. When a crossing is necessary to transport material across the track, or tracks, the location and construction of the crossing must be approved.

67. Watchmen shall be provided when and where it is considered necessary for the safety of trains and other property.

68. All signals necessary to insure the safety of trains shall be placed, maintained and operated by the proper department of the Company. All instructions regarding their observance must be strictly obeyed.

CONSTRUCTION MACHINERY

The use of steam shovels, locomotive cranes, dragline excavators, power ditchers, etc., is constantly increasing on railways; their construction needs to be given attention.

However, as most of such machinery is made by proprietory manufacturers it is not feasible to write definite specifications for their construction. In the purchase of such machines the following points should be given especial attention:

(1) Select machines each part of which is made of the kind and grade of material which is most suitable for that part, be sure that steel is used where steel is needed, special or alloy steels used where such material is best suited for the purpose, etc.

(2) Select a machine which is designed for strength and durability without sacrifice of serviceability.

(3) Select machines which are capable of maximum production.

Present Reading

MECHANICAL SHOVELS; LOCOMOTIVE CRANES AND DRAGLINE EXCAVATORS; SHOVEL METHODS AND OPERATIONS.*

In the following matter, too detailed specifications are avoided, it being desired to direct attention to important features of good practice and point out proper methods of study and investigation, by which any competent Engineer may draw his own conclusions and secure the best possible results at minimum cost.

The recommendations which are made are not in the nature of a specification, but are intended as a guide in the selection of this important equipment. Many manufacturers already embody the major part of these features in their standard design, and many others can incorporate them without materially affecting the cost or standardization of their product. Certain features, however, are so important that radical changes in design, to those here recommended, would be a vast improvement in some cases. While it is recommended to buy standard equipment, care should be taken to select that of the best-known and most reliable makers and secure machines embodying as many of the features recommended here as possible. It is also advantageous for the maker to control the manufacture in every detail of all parts going into his finished product. The purchaser should have access to all parts of the manufacturers' plants at all times for purposes of inspection, etc.

Three cardinal points should be given careful attention in selecting machinery for roadway construction. These are in their order:

(1) Care in the selection, inspection and acceptance of all material that enters into every part of the machine.

(2) Design for strength and durability.

(3) Design for production.

The prompt delivery of repair parts and the accurate fit of these parts when received, is of utmost importance. This may be best judged by the general reputation of the different makes upon the market, and the supply of repair parts stocked at the nearest depot of supplies.

The machine should be so designed, in proportioning the strength of all parts, that breakage will be avoided. This is especially so with an over-powered engine, as a careless operator may easily wreck his machine.

The engines and other machinery should not be crowded, or unhandy to get at in case of repairs. The open-frame type of engines are the most desirable. All parts, as far as possible, should be free and not interfere with others so as to cause delay either in case of repairs or when moving.

The boilers should have ample capacity to operate continuously under full load, but the pressure regulation should be such as to eliminate danger of overtaxing the engines or other parts of the machine. Where lugs or braces are riveted to the boiler, or where pipe connections are made, the plates should be reinforced.

All parts should be interchangeable as far as possible, and bronze bushings are recommended for bearings in place of babbitt, split bushings being preferred where possible.

---

*Adopted, Vol. 18, 1917, pp. 626, 1510.

Present Reading

STEAM SHOVELS

The general requirements for steam shovels are either so standard as to require no particular explanation or so very special as to make generalities impossible. A standard size and type of shovel manufactured by a well-known reliable maker in a general way carries in itself ample guarantee, both in regard to its proper design and in respect to the quality of materials and workmanship entering into its construction. Certain special features, however, are noted that should be carefully borne in mind when purchasing this equipment.

Size.

The size of shovel used for any work must be decided by the character and quantity of excavation and the local conditions. In general, the commonest sizes are 60- to 80-ton shovels for the usual railway work. The following gradient of sizes may, however, be of service: For light grading, up to 25,000 cu. yd. per mile, where a shovel can be used economically, a light revolving shovel is to be desired. For 25,000 to 40,000 cu. yd. per mile, a shovel of 50 tons is a good size. For 40,000 to 60,000 cu. yd. per mile, a shovel of 60 to 80 is well suited. For anything over 60,000 cu. yd. per mile, the shovel may run up to well over 100 tons economically if its transportation is not too expensive, and if the ground is fit to carry the weight on sub-grade during excavation.

Special Specification.

Although it is usually unwise to depart materially from the standard design of a manufacturer in purchasing a steam shovel, mainly on account of the increase in cost resulting from such changes, and the liability of delays and other troubles connected with repairs, yet there are certain special features that are very often worth especially specifying. Also, as these are of distinct general advantage, the universal adoption of such a demand by all members of the American Railway Engineering Association would very quickly make them a standard practice with all reputable manufacturers.

The following list covers the principal items:

(1) As far as practical, all parts now made of cast-iron should be made of commercial cast-steel, except those made of manganese steel or similar alloy.
(2) The following parts should be made of manganese steel or a similar alloy:
    Shipper shaft pinions,
    Rack or dipper stick,
    "A" frame collar,
    Dipper breast, lip, teeth bases, teeth, hinges and latch catch.
(3) "A" frame should have bronze bushing.
(4) Swinging circle should have bronze bushing.
(5) All bearings should have bronze bushings instead of babbitt, split bushing to be used where possible.
(6) All sheaves for either chain or cable to be of steel and interchangeable, with bronze of metalline bushings. Rope sheaves should have turned grooves.

Present Reading

(7) All gears, except the shipping shaft pinion, to be of steel with cut teeth.
(8) Shafts and bearings to be the same size as far as possible.
(9) Both air brakes and hand brakes to all wheels.
(10) Double-bolt yoke design instead of saddle-block "U" bolt.
(11) When "U" bolt is used, the cross-section area should be increased 50 per cent and flattened to fit the saddle yoke.
(12) An oil pump with forced lubrication in engine room.
(13) Rocking grates in boilers.
(14) All gears and dangerous moving parts to be guarded.
(15) Standard M.C.B. automatic couplings and M.C.B. trucks.
(16) Standard steel grab-irons, foot-steps and ladders outside house, as in freight car.

There are several radical structural changes that might be suggested, but as structural changes reduce the efficiency of shovel runners who are used to standard equipment and very seriously complicate the matter of repairs, such suggestions are not considered desirable here.

Delays.

The greatest cause of delay in steam-shovel work is in the removal of the excavated material. Too great care and attention cannot be given to securing proper and ample equipment in the matter of cars and locomotives, and in the proper systematization of service, track, transportation and disposal. The economic success of a steam shovel depends, above everything else, on having an empty car always ready to replace a loaded one under the dipper. Too great stress cannot be laid on this point. Careful management, thorough organization and unceasing superintendence and foresight only, however, can accomplish satisfactory results even with a thoroughly equipped plant.

As the plant charge against steam-shovel work is always an important item, especially where the haul is long, requiring a large equipment in cars and locomotives, continuous operation is desirable. For this reason, either three 8-hour shifts or two 10-hour shifts are recommended. Where the service is not too trying on the machinery, three 8-hour shifts are more economical, if they do not upset other parts of the organization. When, however, the work is severe, two 10-hour shifts are preferable, as this arrangement gives two hours between each shift for repairs and overhaul in the plant. For night work, where electricity is not available, a small turbo-generator set, similar to that used on a locomotive, can be set up on the shovel for lighting the immediate works.

An old locomotive tender is a very valuable adjunct to a steam shovel, especially where delays may be caused from irregularity in coal and water supply.

The greatest cause of stoppage in the shovel proper is due to carelessness or incompetence in the operator. He should see that his engine-room and all moving parts are kept thoroughly cleaned and accessible. He should train his pit gang to watch the under-gearing and track. He must see that his boiler is washed out as often as necessary, depending on the water used, and that his flues, heads and sheets are tight and in repair. He must continually inspect all parts liable to wear or extraordinary strain and make renewals *before* the accident occurs. He must

Present Reading

have a light and accurate hand on the propelling lever and must judge his load on the hoisting chain or cable, especially in an over-powered shovel. Heavy breakage in hoisting chains in such a case is almost always due to an unskilled or careless operator. The mechanical delays on a good shovel operated by a good runner are almost negligible.

A good Works' Superintendent or Master Mechanic can develop good shovel runners if he has time and patience. This, of course, is often difficult on railway work, especially in the Maintenance of Way operations. With average runners, the commonest repairs are as follows:

Hoisting cables.
Hoisting chains.
Swing cable.
Teeth and tooth bases.
Friction bands and blocks.
"U" bolts or double bolts and yoke.
Pinions (especially shipper shaft).
Dipper latch and hinges.
Dipper stick (in hard digging).
Sheaves and pins (especially at
  end of boom and padlock block).
Shipper shaft.
Crankshift on boom engine.
Eccentric straps.
Bearings.
Arm jacks.
Rack bolts.
Clevis strap between dipper and bail.
Ordinary engine repairs.
Ordinary boiler repairs.
Ordinary pipe fittings.

In the above list of most common repairs much of the trouble is undoubtedly due to lack of proper inspection and judgment in removing worn parts before they actually break, also to careless handling of the shovel when unusual strains arise in heavy digging. Where a good runner is secured the repairs will be very small. Where the work is near a base of supplies, the stock parts carried may be very small. There are also many repairs that may be made by the job blacksmith without special stock.

Repair parts to be stocked for emergencies when shovel is built as recommended, are as follows:

6 cold shuts for hoisting chain.
3 cold shuts for propelling chain.
1 swinging cable.
1 cable sheave and pin.
1 chain sheave and pin.
1 set teeth.
1 tooth base.
1 clevis strap connecting bail and dipper.
2 bolts for yoke block, or 2 "U" bolts.
1 set friction blocks.
1 pair each size, bronze bushings.
  babbitt, if used anywhere.
1 set piston rings.
6 water glasses.

Present Reading

Miscellaneous assortment of packing, bolts and pipe and fittings.

The following list of tools is generally recommended. The assortment is very complete and may be reduced at discretion, depending on the proximity of other ready means of supply and repairs:

100-lb. Anvil.
1 Axe, chopping, 4½-in.
1 Bar, buggy, 3-ft.
1 Bar, claw.
6 Bars, lining.
1 Bar, slice, fire, 5-ft.
1 Set blacksmith tools.
2 Blocks, snatch, 6-in.
Set of bolt taps and dies, with holders.
1 Brush, chain, long handle.
2 Buckets, G. I., 2-gallon.
1 Cable, ⅝-in., 60 ft. long.
1 Can, oil supply, 1-gallon (kerosene).
3 Carriers, timber.
6 Chisels (two flat, two round, two cape).
2 Containers, oil, 5-gallon.
1 Cooler, water, 8-gallon.
2 Cups, drinking, enamel.
1 Cutter, pipe.
1 Cutter, gage glass.
Set of twist drills.
1 Flue cleaner.
Forge, blacksmith, portable (with coal).
1 Gage, track.
1 Pair frogs, rerailing.
Set of taps and dies, with holders.
1 Hacksaw, adjustable, 8-in. to 12-in.
2 Hammers, B. P., 1½ and 2 lb.
6 Hammers, sledge, double-face, 8-lb.
1 Hammer, sledge, double-face, 16-lb.
1 Hoe, fire, 5-foot.
50 Feet hose, canvas, 1¼-in.
2 Jacks, ball-bearing (size dependent on shovel).
1 Lantern, hand.
2 Oilers, long spout.
3 Padlock.
3 Picks, clay.
1 Pot, tallow.
1 Rake, fire, 5-ft.
1 Ratchet, drill.
1 Saw, crosscut (two-man), 5-ft.
1 Saw, hand, crosscut, 26-in.
1 Screwdriver, 12-in.
6 Shovels, round point, short handle, No. 2.
1 Shovel, scoop, No. 3.
1 Vise, combination, pipe and bench.
4 Wrenches, monkey, 6-in., 8-in., 12-in. and 18-in.
4 Wrenches, Stillson, 6-in., 18-in., 24-in. and 36-in.
1 Set wrenches, single-end, ½-in., to 2½-in.

Air-Operated Shovels.

The use of compressed air on a steam shovel is very common on tunnel and subway work, and is sometimes found in mining. It is not generally economical on outside work on account of the excessive plant charges. Its main object is to eliminate smoke and gas in a confined space where ventilation is difficult and expensive.

The main difference between air and steam operation is that air operation is quicker, and until an operator becomes accustomed to it he is liable to damage his machine, especially in the case of an over-powered shovel. Where air is used the boiler is ordinarily used as a receiver. Where this has been done, great care must be exercised in cleaning the boiler out completely before steam is used. As the air exhaust is inclined to freeze, a reheater is sometimes necessary. The boiler is sometimes used for this purpose, but great care must be exercised and a separate heater is preferred. Coke is the common fuel. Reheating, while an economy, is not generally advisable, on account of the gases, unless absolutely necessary.

Electric Shovels.

Electricity is sometimes applied to shovels as an operating power, but this is not in common use and has not yet met with general approval. It may, however, be readily applied to almost any standard shovel. The action is apt to be very sudden and the control sometimes unreliable, or at least difficult to an ordinary operator. The great irregular peaks in the power consumption is also a serious factor as regards cost and in its effect on lights and other machinery on the same circuit. If power is purchased, care should be taken as to how the contract is worded in this respect.

The commonest application is in the case of light revolving shovels, which use a single motor and friction drive. There are more of these shovels electrified than all the other types put together, and in this case seems to give good satisfaction. Of the heavier shovels, there are comparatively few cases of electrification. Where this occurs, however, the three- and four-motor drive is the most common practice.

On the whole, electric shovels are so little used and under such general discussion, even among the electrical manufacturers, that they may still be said to be in the experimental stage and not subject to definite recommendation. When, however, electric power is cheap, or other circumstances indicate the advantage of its adoption, a special study and investigation is advised.

Electro-Hydraulic Shovels

Electricity may very logically be applied indirectly to shovel operation. This is especially possible by means of hydraulic pumps and rams. This has been successfully done and the most desirable results obtained. By this means absolute control of the operation is obtained, with full power at all speeds, and the electric power curve will be gratifyingly uniform. No standard design has been devised for this type of shovel, however, so that its use will develop only gradually.

Present Reading

Gasoline Shovels.

Gasoline motors are sometimes used to drive shovels, especially in the light revolving types, such as ditchers. The general application, however, seems far from imminent, and, like electrification, should be considered specially when occasion arises. The most logical application would be in arid regions where water is scarce and of poor quality for boiler purposes.

Tunnel Mucker.

One type of mechanical shovel that deserves special mention is the mucking machine, adapted to small tunnels and headings. Here the headroom is very low, often less than six feet, and the lateral clearance is equally restricted. Often the heading progress is entirely dependent on the mucking, especially where free drilling rock is encountered. The best type of machine for this purpose seems to be an electrically-operated shovel that casts directly back onto a conveyor, which in turn elevates and conveys the muck to cars in the rear. It must be remembered that all machines of this sort are subjected to "congested design" and liable to break down and delay. This form of shovel, like the electric shovel, is still in a rather experimental stage and not subject to definite recommendation.

Locomotive Cranes—Industrial

Stability.

One of the greatest difficulties encountered when purchasing Locomotive Cranes arises from the absence of any standard rating for size and stability. At present, the term "15-ton crane," for instance, means absolutely nothing. As a matter of fact, the 15-ton crane of one make often has greater stability under equal loads and radii than a 20-ton crane of another. It is, therefore, recommended that the Association establish a standard rating, so that when a purchasing agent buys a 15-ton crane, American Railway Engineering Association rating, he knows exactly what he is getting in regard to capacity and stability. With this in view, the following general specification is recommended:

"The rating of a locomotive crane shall be given as the net tons that it will lift, at a 12-ft. horizontal radius, with the crane turned in any direction, the center of gravity remaining not less than three inches inside of the gage line of the track, when the water tank and coal bunkers are empty and neither rail clamps nor outriggers in use. Furthermore, the center of gravity shall also remain at least three inches inside the gage line of the track, with the crane turned in any direction, when the boom is raised to its highest position, the load removed from the hook, the water tank and coal bunkers full, and neither rail clamps nor outriggers in use."

Thus: A 15-ton crane is one that will raise 30,000 lb. under the conditions just described, and which will equally retain its stability without load, as described.

It is also very important that the center of gravity of a crane, under working conditions, be as low as possible, and that the load be as closely concentrated about the center of rotation as possible, i. e., the main counterbalance or ballast should be in the non-rotating lower frame and the overhang of the rotating part be as small as possible. This will require a much heavier crane for a given rating than is often now the case, but will reduce the probability of overturning, which is the source of the greatest damage in locomotive crane operations.

Special Features.

Besides the above matters of rating and stability, there are certain features that are very important in crane design and construction. The following should be borne in mind when selecting a crane for any service where heavy duties and absence of delays are important:

(1) On all, except most restricted yard and shop services, two 4-wheel M.C.B. trucks are most strongly recommended. The wheel base should be as long as possible, and the trucks of very heavy pattern, to withstand the concentrated load on side lifts. M.C.B. automatic couplers with spring-draft mechanism should also be furnished. Standard safety appliances as required by statutes must be provided. Air and steam brakes and hand brakes should also be supplied.

(2) The best propelling mechanism is so designed that all gears are in perfect mesh under all circumstances, i. e., on straight and curved track and under shock, except when purposely disconnected for train haul.

(3) The large rotating gear ring and pinion should be of the best quality steel with cut teeth; forged steel without welds is preferred. The slip-ring design is recommended. It must be remembered that the whole weight of crane rotator and load is carried on this ring and ample bearing should be provided, either in rollers or trunnions, especially under the boom end of the frame.

(4) All parts of the crane mechanism should be readily accessible. That is, the engines, drums, shafting, gearing, and especially the clutches, should be so placed that each may be individually repaired or replaced without other dismantling.

(5) All shafts should be of nickel steel, the same size, and with interchangeable bronze bushings, as far as possible. Split bushings are preferred, where possible.

(6) Drums should be interchangeable, as far as possible.

(7) Drums and sheaves should be large. This greatly increases the life of the cables.

(8) All gears should be of steel, with cut teeth.

(9) All castings should be of steel, where practical. Where cast-iron frames and beds are used, these should be very massive and properly webbed and filleted. Where steel frames and beds are used, however, care must be taken that actual strength and rigidity are not sacrificed to economy in weight.

(10) All sheaves should be of steel, with turned grooves, interchangeable, and have bronze or metalline bushings.

(11) Bolts and rivets at the rotating center should be avoided.

(12) No clutches or friction should be exposed to the weather.

Present Reading

(13) The levers should be simply and conveniently arranged and so located that the operator has a good view of his work.

(14) When the crane operates on parallel tracks, where a side swipe is possible from a passing train, convex mirrors should be so fixed as to give the operator a view back of his crane.

(15) All gears and dangerous moving parts should have safety guards.

(16) Boiler tubes must be replaceable without removing the boiler.

(17) The boom should be built up with the flanges of angles, channels, etc., turned in so as to expose the solid corner to possible blows and abuse.

Special Application.

A very valuable application for a locomotive crane, in excavation, is in combination with a steam shovel in deep, narrow cuts, where the spoil may be dumped at the side. The steam shovel may, in such a case, work at a high face in the cut, loading into large buckets, which would be picked up and dumped by the cranes traveling on the side of the cut above. This eliminates all complications usually incident to transportation and disposal under such circumstances.

It should also be remembered that a drag bucket may be used on a locomotive crane. When this is done, an extra large boom is usually erected and the rail clasps and outriggers put into service. The heavier sizes of crane are best adapted for this service, but even then the smaller sizes of drag bucket are recommended, and great care must be exercised by the operator not to put undue strain upon the frame and machinery.

Operator.

As in a steam shovel, the operator is responsible for most accidents and breakdowns. If careless, reckless or incompetent, he may upset or wreck his crane, even under the best operating conditions. Absolute cleanliness, careful inspection and the prompt replacement of worn parts before breakage occurs, as well as good judgment in handling loads, are the fundamental requirements for a successful and economical crane operator.

DRAG-LINE EXCAVATORS.

The drag-line excavator is an attempt to create a locomotive crane that will equal a steam shovel in capacity and handle certain classes of excavation for which a steam shovel is not suited. In this it has been partially successful, although under ordinary conditions and in heavy digging, the steam shovel is by all means the most popular. Where, however, the digging is light and may be deposited directly into the spoil bank without transportation, or where there is very much water or unstable bottom to contend with in the cut, the drag line finds its most useful field. Probably the greatest value of a drag-line excavator is in canal work, or sometimes on side borrows in railway work, especially where the digging is not too heavy and water is encountered.

Present Reading

In purchasing such equipment, only the most reliable and experienced manufacturers should be dealt with, and, where possible, it is advised to correspond with or personally discuss the actual performance of their individual machines with the users.

Regarding the construction details, the recommendations for locomotive cranes generally apply to drag-line excavators except in clearly distinct features, which are self-evident. The rotating circle is much larger. The propelling and traveling mechanism is very varied and deserving of study and careful consideration. The types of bucket are varied and the success of their application depends largely on the nature of their use. In general, a large amount of manganese steel should go into these buckets, especially where rock and boulders are to be encountered.

It is probable that with time and experience, drag-line excavators will become more highly perfected, the cost of maintenance will be greatly reduced and their use will become more general in all classes of work. At present they are still in the early stage of their development, as compared, for instance, with the steam shovel. With this in view, definite recommendations are not now considered expedient.

METHODS OF HANDLING STEAM SHOVEL WORK.

Locomotives.

The type and size of locomotives used on steam-shovel work must depend on the character of the work, weight of trains, the length of haul and the local conditions. On maintenance work, ordinary road engines are usually well suited, especially if an ample tail track is provided in the pit so that too much shunting is not required. On construction, where the track is apt to be bad and curves abrupt, the four- or six-wheeled saddle-tank type is preferable, at least near the shovel. If the haul is long and the track is fair, heavier locomotives should be used in transportation.

In general, on construction where the tracks are inclined to be rough and curves sharp, the shorter the wheel base on a locomotive the better, within limits. Where road engines, or even heavy switch engines, are used, there is always danger of derailments and frame breakage. Where "dinkeys" are used, it is well to pay special attention to springs, brakes and the location of the center of gravity with reference to the wheel base. Some makes are so balanced that under heavy loads and on steep grades, two wheels are sometimes lifted clear off the track, with the natural resulting delays, if not damage.

Track.

The shovel track should be made up of 6-ft. sections, with strap connections. Bridles of ½-inch by 2-inch iron should be used, with wedge grips. A notched tie should be used as a check, behind the front trucks, supported by steel saddle clamps attached to the rail with wedged grips. Similar clamps should be placed before the front wheel without tie check. Nothing less than 60-lb. rail should be used under a shovel, and heavier rail should be used under the larger models. No spikes are used.

Present Reading

On the muck track in tunnels standard-length rails are used, spiked to the ties. Where no tail track is possible and the excavation is at a breast, drive rails are very useful. These consist of half-length rails laid on their sides, with the ball of the rail against the inside of the web of the last rail spiked down. As the breast is cleared away, these short rails are driven ahead and the cars are run out on the balls of the capsized rails. When a half-length is thus driven out, it is turned right side up and spiked lightly in position and the other half-length driven out in a similar manner. When both half-lengths have thus been driven out, both are removed and a standard-length rail spiked down in their place.

All track should be standard gage for outside work.

Cars

Two-way side-dump cars are the most useful in general excavation. The best sizes are 12 to 30 cu. yds. They should be equipped with standard M.C.B. double trucks and be provided with both hand and air brakes. When air dumps are not employed the cars should be self-dumping when loaded, self-righting when empty, and have strong and easily operated hand brakes, with brake wheels instead of cranks. Where wooden bodies are used, these should be heavily reinforced around the upper rim with steel angles, and steel-plated floors are generally desirable, even in earth excavation. The angle of dump should be as steep as possible within reasonable limits of height and re-righting ability.

When cars of small capacity are used, such as 4 to 10 cu. yds., only four wheels are used, although all cars should be spring-borne. In the case of four-wheeled cars, the wheel base should be long and the trucks articulated, if possible, to avoid derailment. All cars should be very substantially built, steel cars usually being preferred.

In tunnel cars, the wheel base should be fairly long, with spring journals or drop axles, and where they are for heading use, the over-all height should not exceed 4 ft. 6 in. They should be very massively built, with heavy axles, fairly large wheels, steel linings and close clearances. End-dump cars for use on automatic dumping cage or tipple are usually preferred. When such cars are altered for steam-shovel work, the box may be raised to increase the capacity without serious expense.

Convertible cars, which may be used for commercial purposes, are often very valuable, as they may be used both as dump cars and as gondola cars.

Flat cars connected with aprons may be used on steam-shovel work where dumpers are not available. When such is the case, steel aprons are used over the bumpers, and an unloading plow is generally used for the dump. The following points should be observed in the selection of flat cars for steam-shovel work:

(1) The car should be strong enough for the purpose.

(2) Brake-wheels should be in good condition, and, in case material is to be plowed off, they should be placed at side of car.

(3) Stake pockets should be in good condition and not spaced too far apart. Four feet apart in the center of the car, and closer at the ends, is good practice.

Present Reading

(4) Stakes should be strong enough to prevent accident or the derailment of the plow.

(5) The floors of the cars should be kept in good repair.

PLOWS AND SPREADERS

For handling unloading plows, a cable with an auxiliary engine and drum is recommended. The machine should be able to develop sixty (60) tons pull, steam cylinders, 12 in. by 12 in.; diameter of drum 4½ ft., permitting four wraps of 1½-inch cable to be made. Steam supplied by the locomotive. The winding machinery should be placed on a specially-built or adapted car and protected from the weather.

When raising track, the center plow is recommended when the raise is light; side plows are recommended for making heavy fills or widening the bank.

The plow should be strong and massive. If the mold-board is curved throughout its length so as to make the angle of the entering wedge sharper than that of the tail of the plow, there is less breakage of stakes. The vertical slope of the mold-board should be sufficient to preclude climbing, especially towards the rear, in a side-dump plow. The larger and heavier plows are recommended for general use. The longer the plow and flatter the angle of thrust, the better satisfaction will be gained. The height of the mold-board should not be less than 48 in. on a center plow, or 54 in. on a side plow, and higher plows are usually more desirable.

The size of spreader selected will sometimes depend on special conditions or use, but in general the large size is most useful. For this type of machine the following features are recommended:

Form of spreader, 2 arms.

Pneumatic control by one man.

Maximum spread at least 40 ft., with extension.

Vertical range of wing operation should be about 2 ft. above and below top rail.

Minimum width 10 ft., wings closed.

Maximum height in train 15 ft., wings closed.

Air and hand brakes.

Front plow to flange 2 in. below top rail, with cast-steel cutting edge and manganese steel wearing plates over rail.

The front plow should have extension so that all material on track and 3 ft. to one side may be passed across track to the wing on the other side.

The center of gravity of the car should be as low as possible.

The wings should be heavy, strongly hinged and braced low to avoid twist.

In operation, the trucks should be watched and wheel flanges kept in perfect repair.

The locomotive runner should not be allowed to "charge the pile."

Vertical Limits.

It is impossible to establish set rules regarding the point where lifting track should stop and trestling begin when making embankments with trains. The character of the material is of great importance in the matter of cost. Some engineers consider that it is practically always preferable to trestle or block up the tracks without regard to the depth of fill, while others say it is advisable to raise the track as the fill progresses, up to 25 ft. or more. On the average, from 6 to 10 ft. are the commonest limits. With, however, the great fluctuation in the costs of both labor and materials, it is recommended that each case be treated as an individual problem. The cost of raising should be carefully figured, including the delays and interference caused to and by traffic where such exists, and this set against the cost of trestling, including labor and materials. It should be remembered that in some cases a "run-around" can be formed very cheaply, while in other places this requires either an auxiliary fill or trestle.

In estimating trestles for fills over which regular traffic is not to pass, the length of haul is important. Where the haul is less than two miles, light side-dumping cars may be used, and a very light trestle is required.

Of course, the geographical location of such work also has an important influence on this question, as climate, character and availability of fill materials, labor, lumber and other supplies vary enormously with different sections of the country.

Each engineer, familiar with this own section and the local conditions surrounding the work, is the man to estimate the relative cost and decide where raising track should stop and trestling should commence, either on new location or under existing track and traffic.

BLANK FORMS.

Five blank forms are recommended for reporting steam-shovel operations, as described further on.

No forms are recommended for reporting crane operations, as this is so various and heterogeneous that a standard form is impossible.

No forms are recommended for reporting drag-line excavators, as they are very uncommon on railway work, and when used may be reported on Steam Shovel forms, or a special form modeled on these and made to apply to the individual case.

Of the Shovel Forms recommended, the first two, I-1 and I-2, are the reports of the Shovel and Dump Foremen, if the work is done by the railroad forces, or the inspectors, if it is a contract job. They deal purely with field conditions and are to be made out on the work, mainly while it is in progress. The front of the form, besides certain information shown as required at the top, provides space for repair parts, materials and supplies wanted and received and remarks which should act in the nature of a dairy. The back is devoted to a tabulation of data and information covering the most important features of operation. Everything on this report, as far as possible, should be checked against the records of the timekeepers, storekeepers, etc., in the job offices. The size of the form is designed, when bound in a book, to fit comfortably into a man's pocket. These forms should be printed on good quality blue and yellow paper, respectively, and bound in books with stiff board covers, opening endwise. The sheets should be perforated at the top so that the forms may be torn out readily when completed. These forms

Present Reading

should go to the Job Superintendent, or whoever is in immediate charge of the piece of work, and should also be accessible to the Master Mechanic or person in charge of the job plant as well.

When forms I-1 and I-2 have been received from the various units of the job, the distribution clerk compiles form I-3 based on the information they contain, and from the records of the timekeepers, storekeepers, etc. This is laid before the Job Superintendent, or similar official, to be approved, signed and forwarded to the Division Engineer, or whoever has charge of that division or district. These figures should include everything chargeable to the job, including labor, clerical and engineering staff, material, plant and overhead of the job proper.

At the end of each month, Form I-5 should be made out and forwarded, as described in I-3. This is merely a monthly summary of the I-3 reports.

When the I-3 forms have been received from all the different jobs of that division or district, the distribution clerk of that office compiles the report shown in form I-4. .This summarizes the information contained in I-3 forms and is built up in combination with the previous I-4 forms, so that each interlocks with the one preceding and that immediately following it. When form I-4 is completed, it is laid before the Division Engineer or other proper official for his approval and signature, after which it is forwarded to the Chief Engineer or Vice-President in charge of construction and maintenance. In making out their report in daily form, the word "month" should be everywhere crossed out.

At the end of each month a monthly report should be made on the same form, I-4, crossing out the word "day" where month appears and takes its place. This form is made up from the I-3, I-4 and I-5 reports just received and forwarded as described for the I-4 forms.

In Forms I-3 and I-4 average yardage costs are given beside the daily or monthly yardage cost, so that the difference may be seen at a glance as to whether the cost is increasing or decreasing, and explanations be immediately in order. The partial individual summaries of work done also shows the proportion of work completed without the usual analysis and arithmetic.

While these forms may appear superficially elaborate, they are in reality simple and very easily compiled, provided the work is properly systematized and kept up to date. The subjects treated in detail are those most vitally required for successful and economical job operation and supervision, and are designed to give the most valuable information to the parties best able to utilize it. In this connection, the number of carbon copies of Forms I-3, I-4 and I-5 and their distribution to the various officials, other than those directly addressed, must be left to the local authority in that company.

These forms are designed for use on not over two-shift work. Where three eight-hour shifts are used, the forms may be readily altered to suit. No telegraphic report forms are recommended. If such are desired, they must necessarily be so brief and simple that their preparation from these here illustrated is so simple that special recommendation is not thought necessary.

Present Reading

If certain costs show increases that are not accounted for in the report, details may be secured from the distribution clerk, who should have all the individual items going to make up these costs posted and accessible in his distribution book. In the same way, details as to the cost of repairs to different pieces of equipment, the cost of individual supplies, etc., may be secured in the same manner. The distribution clerk should get his data daily from the timekeepers, storekeepers, etc., and should balance up with these separate departments every month. On contract work, he should be given access to the above records of the contractor, if such reports are desired. If possible, the man selected for this work should be so constituted that he can maintain amicable relations with the contractor's men under trying circumstances.

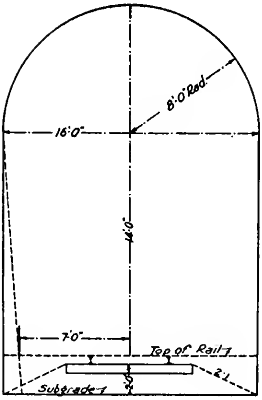
(Note.—The forms above described are illustrated on pp. 642-648 of Vol. 18, 1917.)

For a full discussion on steam shovels and kindred machinery see page 626 of Volume 18 of the Proceedings of this Association.

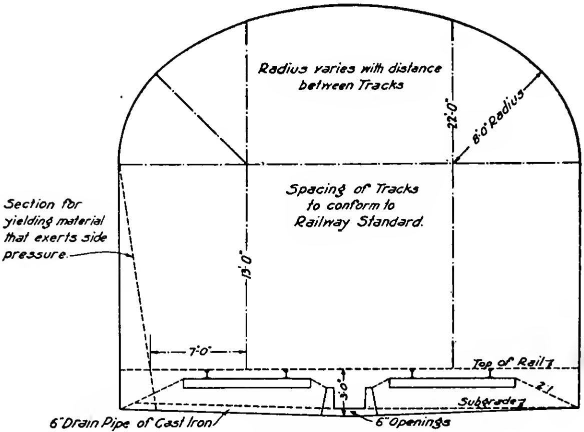
Page 57 and 58 (Tunnel Sections.)

In order to provide the same clearance, over the outside line of a car, in a double track tunnel that is provided by the section for a single track tunnel, also to provide the same clearance in tunnels that has already been adopted for steel bridges, as shown on page 744 of the 1921 Manual, the Committee recommends the withdrawal of the tunnel section diagrams for single and double track lines, as shown on page 58 of the Manual of 1921, and the substitution of the following diagrams for them.

The proposed sections, by increasing the height of the tunnels by one and seven-hundredths feet, provide the same clearance for tunnels as has already been adopted for steel bridges.



SECTION OF TUNNEL
Single Track
Tangent



SECTION OF TUNNEL.
Double Track
Tangent.

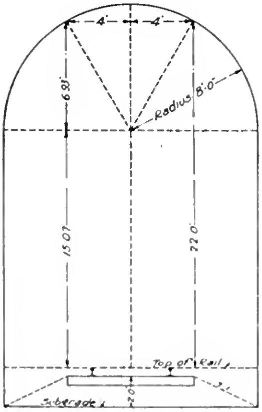
Proposed Reading

(4) Select the type of machine which will best serve the conditions under which it is going to be used throughout its lifetime, unless a sufficiently large amount of special work is in sight to justify the purchase of a special machine for the job.

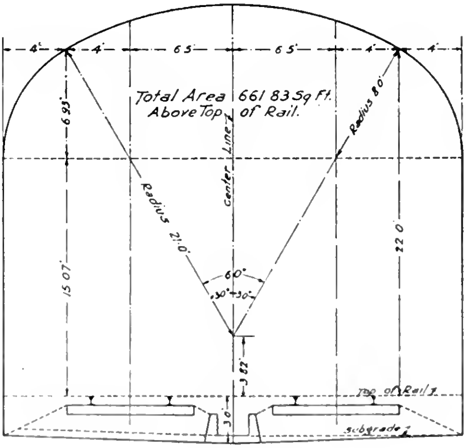
(5) Machines which are to be operated on tracks should, whenever practicable, be built to standard gage.

Operators of Steam Shovels and Kindred Machinery

The fundamental requirements for a successful operator are good judgment in handling loads, ability to keep work moving and care in maintaining the machine.



SECTION OF TUNNEL.
Single Track.
Tangent.



SECTION OF TUNNEL.
Double Track
Tangent

Present Reading

Page 64 (Article 7a) (Second paragraph.)

"All pipes should be covered 12 in. or more with engine cinders or equally porous material, and then the trench backfilled with the same material as removed if at all porous, otherwise backfill with engine cinders."

This sentence is a duplicate of Article (e) on page 65.

Page 65 (Article (e).)

"All pipes should be covered 12 in. or more with engine cinders or equally porous material, and then the trench backfilled with the same material as removed, if at all porous, otherwise backfill with engine cinders."

Page 67 (Near middle of page, the article headed:)

Grade Separation

(1) Whenever grade separation through densely built-up thoroughfares (short blocks, say, 12 to 15 crossings per mile), becomes imperative, elaborate studies of the kind and volume of traffic on each thoroughfare should be made and due record kept, with a view of eliminating or vacating certain of these crossings as wholly unjustifiable from a cost standpoint, and lateral streets at a less cost may be opened in their stead.

(2) If but a very few crossings are to be eliminated in an industrial district, with reasonable assurance that no others will be required, other things being equal, the method used should not disturb the tracks.

(3) If several crossings are to be eliminated in an industrial district, other things being equal, the most efficient method is by track elevation.

(4) In a residential district, if grades and other conditions on the railway will permit, complete depression, allowing the streets to remain at their original level, or nearly so, is the preferable method.

It is recommended that this entire article be omitted, as the subject is being handled by the Committee on Signs, Fences and Crossings.

Proposed Reading

(7) (a) (Second paragraph.) Omit.

(e) All drain tile, or underground drain pipes, should be covered 24 inches, or more, with engine cinders or equally porous material, and the remainder of the trench backfilled with material which is sufficiently porous to permit of good drainage.

Page 67. *Grade Separation.* Omit.

Appendix B

(2) ECONOMICS OF FILLING BRIDGE OPENINGS

J. C. Wrenshall, Chairman, Sub-Committee; W. H. Woodbury, J. R. Wilks, J. R. Hoagland, C. W. Baldridge, C. F. Hinchman.

This subject was reported on at the twenty-fifth and twenty-sixth Annual Conventions, but owing to continued differences of opinion which developed during open discussion on the floor was in each case referred back to the Committee for further study and report.

It is proposed in this report to study the subject from the standpoint of a justification of expenditures. It became evident as the investigation progressed that before it could be determined whether the replacement indicated the filling of the bridge openings or some other method of replacement, a careful analysis of all the component elements of cost must be made. In many cases, no doubt, methods other than filling may be found preferable, but the general principles laid down in this report are applicable to any bridge replacement problem. It is impossible to restrict it to the question of bridge filling alone. This discussion applies to any problem which involves economic comparisons between the renewing of a structure in kind and the replacing of it by a more permanent structure. Obviously, where a more permanent type of construction costs less than a renewal in kind, there can be no question as to the economy of making the improvement. Replacement or renewal of bridges and trestles takes place for one or more of the following reasons:

(1) **Obsolescence.**—In the case of a bridge, this will probably be due to heavier traffic or heavier equipment.

(2) **Deterioration** (natural decay or wear and tear, due to any cause).

(3) **Accident** (fire, wreck, flood or faulty design or construction, etc.).

The problem then resolves itself into whether it is more economical to fill, renew in kind or to replace with a more permanent type of structure at a greater investment outlay.

The question of full maturity should also be considered—care should be taken that the full life of the structure is obtained; as, for instance, a bridge that may safely last one or two years longer by an annual expenditure of an amount less than the interest and maintenance charges of new structure per year, should not be renewed or replaced until expiration of its full service life. The element of safety, including strength of structure and elimination of fire hazard, must be given consideration in all cases.

In the case of bridge openings on main lines, consideration should be given to the possibility of future changes in grade and alinement, and in estimating the life of the replacement structure or fill, this should be taken into account. Similarly, on branch lines traffic conditions should be investigated and any evidence of ultimate abandonment, either from depletion of natural resources or on account of competitive conditions, should not be overlooked in estimating the life of the new structure or the fill. When there is any occasion for doubt, low estimate of life should be made, and when the difference in annual cost favors the more permanent structure or fill by only a relatively small amount, preference should usually be given to the less permanent structure.

The problem is illustrated by analyzing the relative economy of renewing a 42-ft. pile trestle having an average life of 7 years, as compared with replacing it by a double 6 ft. by 10 ft. concrete box culvert and fill with estimated life cycle of 70 years.

The annual amortization charges are determined on the sinking fund basis.

The formula for this determination is:

$$\frac{P\ (\text{Principal}) \times r\ (\text{Interest rate})}{(1+r)^{n} \quad (\text{life in years})-1} = \text{Annual Amortization charge.}$$

In the first example shown in the "Analysis of Costs" the Principal is 722, the rate is 6 per cent, and the life is 7 years.

$$\text{Then}\ \frac{\$722 \times 0.06}{(1+0.06)^{7}-1} = \frac{43.32}{0.504} = \$86.01$$

which is the amortization charge for the existing structure and represents a portion of the \$168.33 in Column 9.

For the proposed structure a life of 70 years is assumed.

Then $\frac{\$119.28}{58.08} = \$2.05$. This is a portion of the \$129.33 in Column 17.

For convenience in determining this charge, a table of the values of $(1+r)^{n} - 1$ is made a part of this report.

If the life of the proposed structure may be assumed to be perpetual, then the amortization charges will be zero; but it is not reasonable to assume that any physical structure will have a perpetual life. However, if the life may be assumed to be so long that it is impossible at the time of construction to estimate whether it may be in excess of one hundred years (or so-called permanent) it seems proper to postpone the setting aside of an amortization fund until such time as the expected life may be estimated within reason. In fact, it is a question whether attempts should be made to estimate life in excess of, say, 50 years.

It also should be borne in mind that cost estimates are seldom sufficiently exact to warrant undue nicety in calculations. In short, good engineering is largely the application of good judgment to a problem after consideration is given to all the data available. There often is a great deal of data which is of very little value and to which small consideration need be given.

ANALYSIS OF COSTS—PRESENT AND PROPOSED STRUCTURES

Existing Conditions (Renewal)

1	2	3	4	5	6	7	8	9
	Center Line Length, Description and Established Life Cycle	Cost of Renewing in Kind	Cost of Maintaining Traffic During Renewal	Total Cost of Renewal in Kind	Annual Interest on Total Renewal Cost at 6%*	Annual Cost of Repairs and Maintenance	Annual Amortization Charge on Sinking Fund Based at 6%*	Total Annual Cost, Interest, Maintenance and Amortization Charge
79	42 ft. pile trestle, 7 years..........	$640.00	$82.00	$722.00	$43.32	$39.00	$86.01	$168.33
82	76 ft. frame trestle, 9.2 years.......	$1140.00	$135.00	$1275.00	$76.50	$60.00	$107.85	$ 244.35
76	112 ft. ballast deck trestle, 19.6 years............................	$1758.00	$180.00	$1938.00	$116.28	$55.00	$54.51	$225.79

TABLE OF VALUES OF $(1+r)^n - 1$ ON 6 PER CENT BASIS
$(1+0.06)^n$ (^{n} = Life in Years) — 1.

n $(1.06)^n—1$	n $(1.06)^n—1$	n $(1.06)^n—1$	n $(1.06)^n—1$	n $(1.06)^n—1$	n $(1.06)^n—1$
2=0.12360	9=0.68948	16=1.54035	26=3.54939	45=12.7647	80=104.80
3=0.19102	10=0.79085	17=1.69277	28=4.11170	50=17.4202	85=140.58
4=0.26248	11=0.89830	18=1.85434	30=4.74351	55=23.650	90=188.47
5=0.33823	12=1.01220	19=2.02560	32=5.45340	60=31.988	100=338.3
6=0.41852	13=1.13293	20=2.20714	34=6.25115	65=43.145	110=606.6
7=0.50363	14=1.26090	22=2.60354	36=7.14728	70=58.076	125=1455.3
8=0.59385	15=1.39656	24=3.04894	40=9.2855	75=78.057	150=6249.0

Conclusion

It is recommended that this report be accepted and printed in the Manual.

As a general outline by which the relationships between the various elements of cost may be analyzed, the following method of procedure is recommended (see tabulation of examples):

Identification—Column 1—Identification of Structure.

Existing Condition (Renewal).

ANALYSIS OF COSTS—PRESENT AND PROPOSED STRUCTURES

Proposed Conditions (Replacement)								Determining Factor		Replacement Accounting		
10	11	12	13	14	15	16	17	18		19	20	21
Type of Proposed Structure and Estimated Life Cycle	Cost of Proposed New Structure	Cost of Maintaining Traffic During Replacement	Total Cost to Replace	Annual Interest on Total Replacement Cost at 6%*	Annual Cost of Repairs and Maintenance	Annual Amortization Charge on Sinking Fund Basis 6%*	Total Annual Cost, Interest, Maintenance and Amortization Charge	Annual Gain for Loss by Replacement		Charge to Operating Expenses		Charge to Investment "A" or "B" or Both
								+	−	Maintaining Traffic During Construction	Property Retired and Replaced	
Double 6 ft.x10 ft. concrete box and fill. 70 years	$1799.00	$189.00	$1988.00	$119.28	$8.00	$2.05	$129.33	$39.00	....	$189.00	$640.00	$1159.00
Double 8 ft. x 8 ft. concrete box and fill, 100 years.	$3685.00	$430.00	$4115.00	$246.90	$15.00	$0.73	$262.63	....	$18.28	$430.00	$1140.00	$2545.00
80 ft. deck plate girder on concrete abutments and fill 75 years.	$12850.00	$80.00	12930.00	$775.80	$60.00	$9.94	$845.74	....	$615.95	$80.00	$1758.00	$10992.00

*Each railroad to use the rate of interest it deems proper

Column 2—Center line length, type and established life cycle of structure. The established life cycle in years is usually obtainable from major renewals. In other cases where renewals are continuous, this period may be arrived at approximately by dividing the cost of a complete new structure in kind by the average annual costs of piecemeal structural renewals.

Column 3—Cost of renewing in kind (Engineer's estimate).

Column 4—Cost of maintaining traffic during renewal (Engineer's estimate).

Column 5—Total cost of renewing in kind (sum of $640.00 plus $82.00 = 722.00). The sum of columns 3 and 4.

Column 6—Annual interest on total cost of renewal (6 per cent of $722.00 = 43.32).

Column 7—Annual cost of repairs and maintenance (546.00 ÷ 14 = $39.00).

This $546.00 is the sum of the maintenance and repairs for two life cycles taken from the maintenance records and adjusted to current prices. It should contain all costs for insurance, labor and materials, and interest, depreciation and repairs on tools and equipment.

Column 8—Annual amortization charge on sinking fund, basis at 6 per cent.

$$\frac{\$722.00 \times 0.06}{(1+0.06)^{7}-1} = \frac{43.32}{0.50363} = 86.01$$

When the life cycle contains fractional years, as in the second example,

$(1+0.06)^{9.2} - 1 = 0.7093$

Log $1.06 = 0.0253059 \times 9.2 = 0.232814 = \log 1.7093$

$1.7093 - 1 = 0.7093$

$$\text{Then } \frac{\$1275.00 \times 0.06}{(1.06)^{9.2}-1} = \frac{\$76.50}{0.7093} = \$107.85.$$

In the third example — $(1+0.06)^{19.6} - 1 = 2.133.$

$0.0253059 \times 19.6 = .495996 = \log 3.133.$

$3.133 - 1 = 2.133.$

$$\text{Then } \frac{\$1938.00 \times 0.06}{(1.06)^{19.6}-1} = \frac{\$116.28}{2.133} = \$54.51.$$

Column 9—Total annual cost, interest, maintenance and amortization charge. (The sum of Columns 6, 7 and 8.)

PROPOSED CONDITIONS—(REPLACEMENT)

Column 10—Type of proposed structure and estimated life cycle.

Column 11—Cost of proposed new structure (Engineer's estimate).

Column 12—Cost of maintaining traffic during replacement (Engineer's estimate).

Column 13—Total cost to replace (the sum of $1799.00 plus $189.00 = $1988.00, Column 11 plus column 12).

Column 14—Annual interest on total cost of replacing ($1988.00 at 6 per cent = $119.28).

Column 15—Annual cost of repairs and maintenance (Engineer's estimate).

Column 16—Annual amortization charge on sinking fund basis at 6 per cent for total cost of replacing:

$$\left(\frac{\$1988.00 \times 0.06}{(1+0.06)^{70}-1} = \frac{119.28}{58.08} = 2.05\right)$$

The 58.08 is taken from the table of values of $(1+r)^{n} - 1$ for 70-year life cycle.

Column 17—Total annual cost, interest, maintenance and amortization charge (the sum of Columns 14, 15 and 16).

Determining Factor

Column 18—Annual gain or loss by replacement. Difference between $168.33 in Column 9 and $127.33 in Column 17, which show a net annual saving of $39.00 by providing new structure over the old structure. Where the result shows a loss or deficit, consideration should be given to operating advantages which may offset loss by replacement.

ACCOUNTING

Columns 19 and 20—Charges to operating expenses:

(a) Maintaining traffic during construction—taken from Column 12. This is always an operating charge.

(b) Property retired and replaced, taken from Column 3. This is usually an operating charge, but under special circumstances may be a charge to profit and loss. (See page 13, Section 7, I.C.C. Classification of Investment.)

Column 21—Charges to investment (additions or betterment or both). This is the net additional investment—difference between Column 20 and Column 11, or $1799.00—$640.00 = $1159.00.

Columns 19, 20 and 21 show the accounting distribution of the entire cost of replacement.

Appendix C

(3) CORRUGATED METAL CULVERTS FOR RAILROAD PURPOSES. PREPARING SPECIFICATIONS, WITH ASSISTANCE OF COMMITTEE ON IRON AND STEEL STRUCTURES.

W. H. Woodbury, Chairman, Sub-Committee; E. J. Bayer, A. E. Botts, C. A. Daley, J. K. Pettus, J. R. Wilks.

INTRODUCTION

As stated in the Committee's report for 1924, this work has led to a consideration of corrugated culverts from a standpoint of strength, durability and economy. The following report covers the progress made to date on each of the above subjects.

Durability

We have received reports on several thousand culverts, a very large percentage of which are in excellent condition. Our endeavors to obtain information regarding failures have met with little success. A few have been reported, but in some cases the cause of failure has been careless installation. The Sub-Committee has no report to make at this time on the question of relative durability. This inquiry is being continued.

Economy

The economy of this type of culvert is dependent upon the relative durability and installation costs. Therefore, it must be the last phase of the subject to be developed. The gathering of information will be continued.

Strength

The Committee has collected considerable information covering spelter coating, methods of manufacture, riveting, etc.

A lack of definite information on the pressures to which these culverts are subjected in fill and the strength necessary to withstand these pressures made necessary an investigation of this subject.

The results of this investigation are presented herewith as information.

STATEMENT OF THE PROBLEM

Culvert specifications usually include a requirement for minimum strength as determined by what are known as the two- and three-point bearing tests. The manner of loading is illustrated in Fig. 1. (These methods of testing have been adopted as standard by the American Society for Testing Materials*.)

---

*Serial designation C-13-24, page 680, 1924. Proceedings A.S.T.M.

For rigid type culverts where failure is evidenced by fracture, the results seem fairly consistent. However, such a method of testing would be of little value in specifying strength for a culvert made of elastic materials. This seems obvious for the reason that in a fill deflection of a flexible culvert results in building up side restraint, thereby assisting the pipe to support its load.

Former investigators have apparently recognized these factors, as is shown by the fact that in tests on the flexible type they have used an apparatus as shown in Photo No. 1, that develops side restraint. Some of these tests will be briefly discussed.

REVIEW OF PREVIOUS TESTS

George L. Fowler, Consulting Engineer, used the type of apparatus illustrated in Photo No. 1, in tests made and reported by him in 1916 for a 48-inch diameter 12-gage corrugated culvert 8 ft. long, placed under 3½ ft. of sand. This pipe withstood a load of 124,000 lb. with a deflection of 66/100 inch.

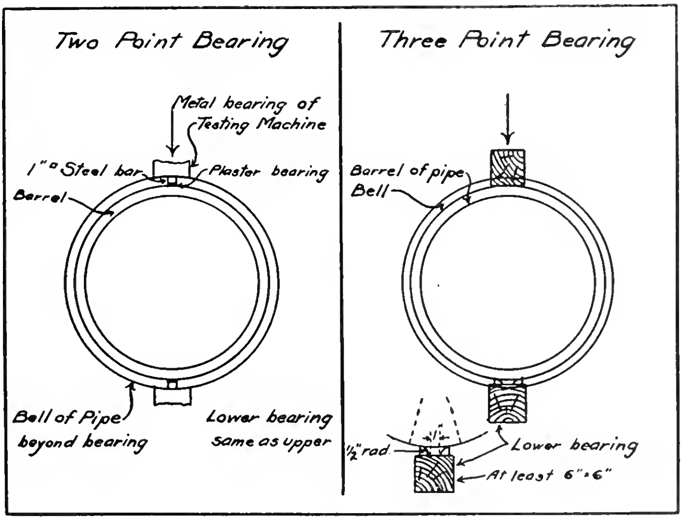


FIG. 1

TWO- AND THREE-POINT BEARING METHODS OF TESTING CULVERT PIPE.

This type of apparatus had been used also by Prof. A. N. Talbot in 1908, when he found an average vertical deflection of 1.44 inch, under a load of 120,000 lb. for a 36-inch diameter 12-gage culvert. The load in this case was increased to 184,000 lb. with an average deflection of 3.8 inches. The length of pipe was 8 ft.

In 1923, at the National Railway Appliances Exposition, the Armco Culvert and Flume Manufacturers' Association demonstrated a similar

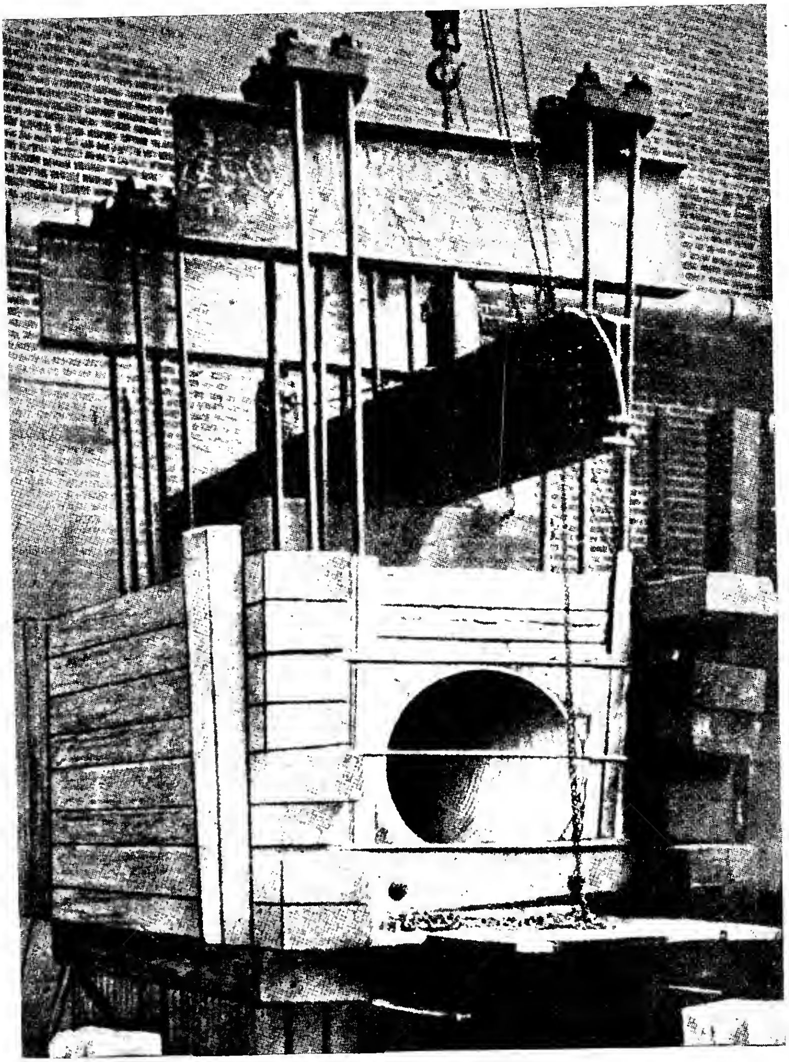


Photo No. 1

Type of Apparatus Used by George L. Fowler in Testing Culvert Pipe apparatus in which a 12-gage, 30-inch diameter corrugated iron culvert, 14 ft. long, was subjected to a load of 120,000 lb. with practically no deflection.

In all of these tests the sides of the box were rigidly held in place. It is probable, however, that due to this artificial restraint the pipe develops a great deal more strength than it would possess under an embankment.

The Committee, therefore, concluded that neither the two- or three-point bearing method, nor the method of testing used by Fowler and Talbot yielded results for the flexible type culvert which could be interpreted into actual installation conditions, unless some study was made of the behavior of the pipe in a fill and an equation factor developed. While the plans were being made for such a study, the Committee participated in some preliminary tests, which were made for the purpose of perfecting methods for making the final test under a fill.

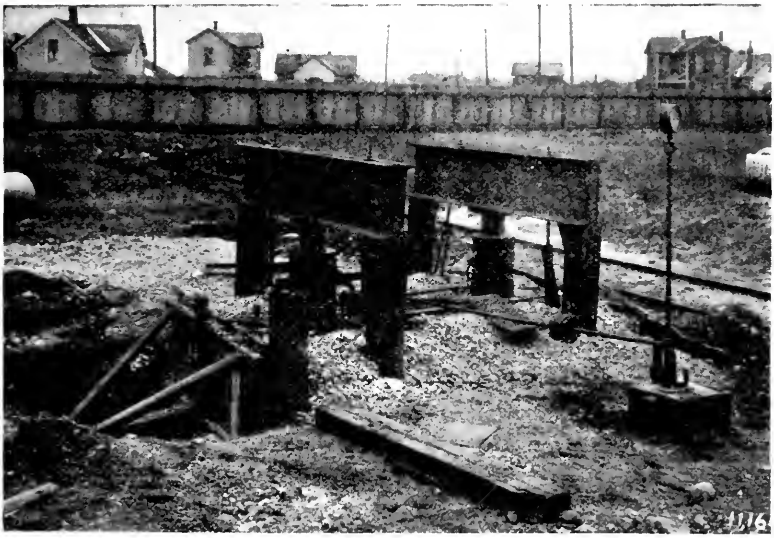


Photo No. 2

Preliminary Test No. 1. Sand box type of Testing Apparatus placed in ground, with sides removed.

Preliminary Test No. 1

This is the test referred to in last year's report. 24-inch, 10-gage corrugated metal and 24-inch reinforced concrete pipe were used. The concrete pipe was standard for Kentucky State Highways. The apparatus used for these tests is shown in Photo No. 2.

The load was applied through a cast-iron plate, 2 ft. by 7 ft. 6 in. by 5 in. thick, bearing on 3 ft. of earth cover over the top gf pipe.

The pressure was developed with an oil pump, having 1½ inch diameter piston directly connected to two 6-inch rams with a capacity of 100 tons each, spaced 4 ft. 3 in., center to center, and placed symmetrically over the plate.

The tests were made in a pit excavated from "made" ground composed partly of cinders. The filling material was a mixture of sand and cinders with a small amount of gravel, all of which would pass a 2-inch screen. A timber bulkhead was placed at each end of the pipe. There were no artificial sides in the test pit, the load being taken by the surrounding material. The pipes were tamped, both sides and top, and installed so far as possible under identical conditions. On account of rain during the day the filling was damp, which no doubt aided in compacting it. The results of the tests are given in Tables 1-a and 1-b. The corrugated metal pipe had received a permanent deformation consisting of a slight flattening in the upper sector after an application of one hundred tons pressure upon the plate; otherwise the pipe was undamaged. Photo No. 3 shows the pipe at the completion of the tests. The concrete pipe

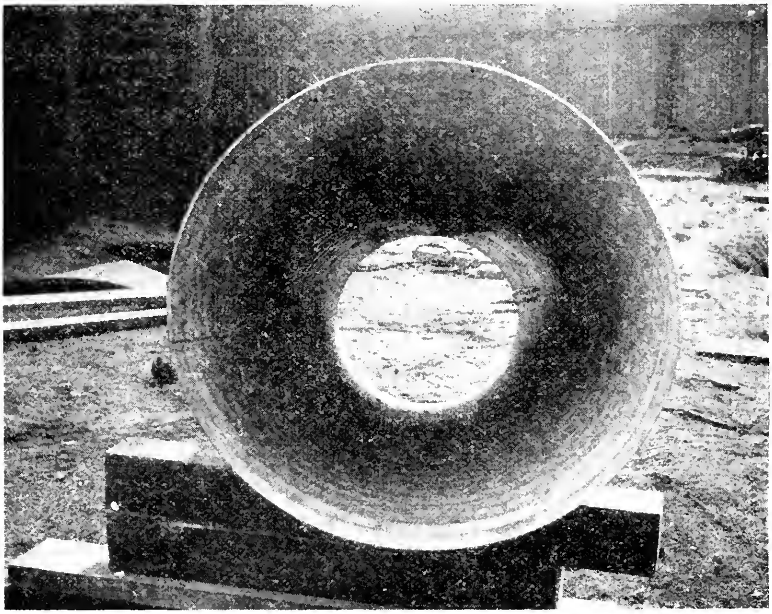


Photo No. 3

Preliminary Test No. 1. The 24-inch Diameter Corrugated Culvert at Conclusion of Test.

was completely wrecked with an application of seventy tons. Photo No. 4 shows the pipe at the conclusion of the test.

Table 1-a

Preliminary Test No. 1.—Test on Armco Corrugated Ingot Iron Culvert Pipe

No. 10-gage; 24-inch diameter; total length, 8 ft.

Total Live Load Tons	*Load per Lin. Ft. Tons*	*Horz. Dia. Inches*	*Vert. Dia. Inches*	*Deflection — Inches Horz.*	*Vert.*
00	0.0	24	23½	..	..
50	6.25	24½	23⅛	½	⅜
60	7.5	24½	22⅝	½	⅞
00	0.0	24⅜	23	⅜	½
90	11.25	25⅝	21¼	1⅝	2¼
00	0.0	25¼	21⅝	1¼	1⅞
100	12.5	26	21⅛	2*	2⅜*

---

*Permanent set after jacks released.

Table 1-b

Preliminary Test No. 1—Test on Reinforced Concrete Pipe

24-inch diameter; 3-inch wall thickness; total length, 9 feet.

Total Live Load Tons	*Load per Lin. Ft. Tons*	*Horz. Dia. Inches*	*Vert. Dia. Inches*	*Deflection — Inches Horz.*	*Vert.*
00	..	24	24	..	..
24	2.67	24	24	..	..*
		(Developed crack ⅛-inch wide in the invert of middle section, extending full length of joint.)			
40	4.44	24⅛	23⅝	⅛	⅜
		(Longitudinal cracks top and bottom extending from end to end all three joints.)			
55	6.11	24¼	23¼	¼	¾
		(Cracks ¼-inch wide and branching out, concrete spalling badly.)			
60	6.67	25¼	22⅝	¼	1⅜
		(Middle section in four distinct pieces held together only by reinforcing, on end sections were numerous cracks ⅛ to ¼-inch extending end to end, top and bottom and numerous circumferential cracks.)			
70	7.78	26	22	2	2
		(Joints broken so badly that almost impossible to increase load, account pipe offering little resistance.)			

---

*No attempt was made to read measurements less than ⅛-inch.

Talbot's report of sand box tests of 48-inch reinforced concrete pipe (see University of Illinois Bulletin No. 22) showed failure at from 2.45 to 9.25 tons and on 48-inch cast-iron pipe at 8.15 to 27.3 tons per linear foot.

The failure of the concrete pipe at slightly under three tons per linear foot is somewhat lower than the average for the sand box test. This may in part be due to the difference in lateral restraint.

While the results of Preliminary Test No. 1 are interesting because the test was a direct comparison of strength, the type of apparatus used tends to concentrate the load on the crown of the pipe. Photo No. 5 shows the actual measured displacement of the filling material which occurred during the test.

It is apparent that while this method of testing possibly approaches actual installation conditions more nearly than methods commonly employed, the method of loading produces a different reaction in the pipe. The load being concentrated only over the area of the pipe, gives less side compaction than would occur in a fill, and as a result develops less side restraint. (Again see Photo No. 5.)

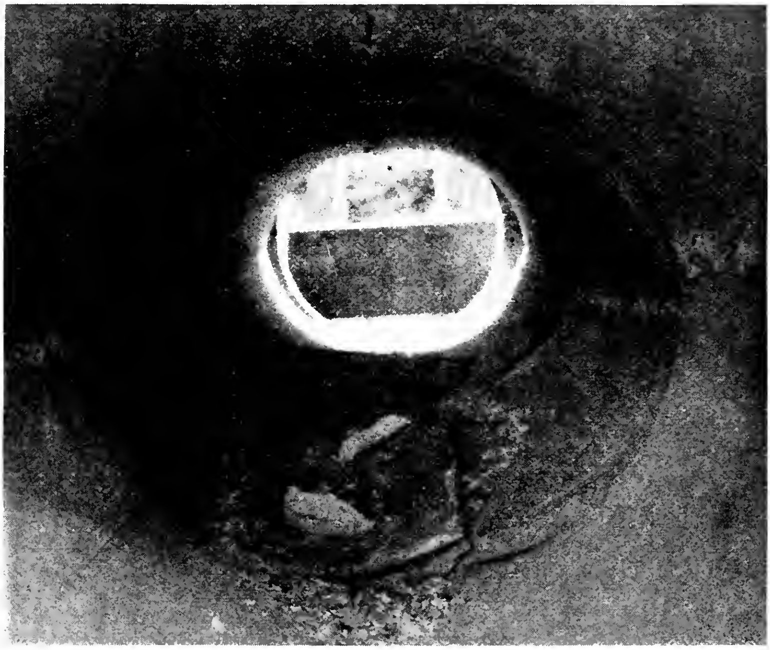


Photo No. 4

Preliminary Test No. 1. Condition of 24-inch Diameter Reinforced Concrete Pipe at Conclusion of the Test.

The value of side restraint was determined mathematically by Prof. A. N. Talbot, and is fully discussed in the University of Illinois Bulletin No. 22—1908, already mentioned.

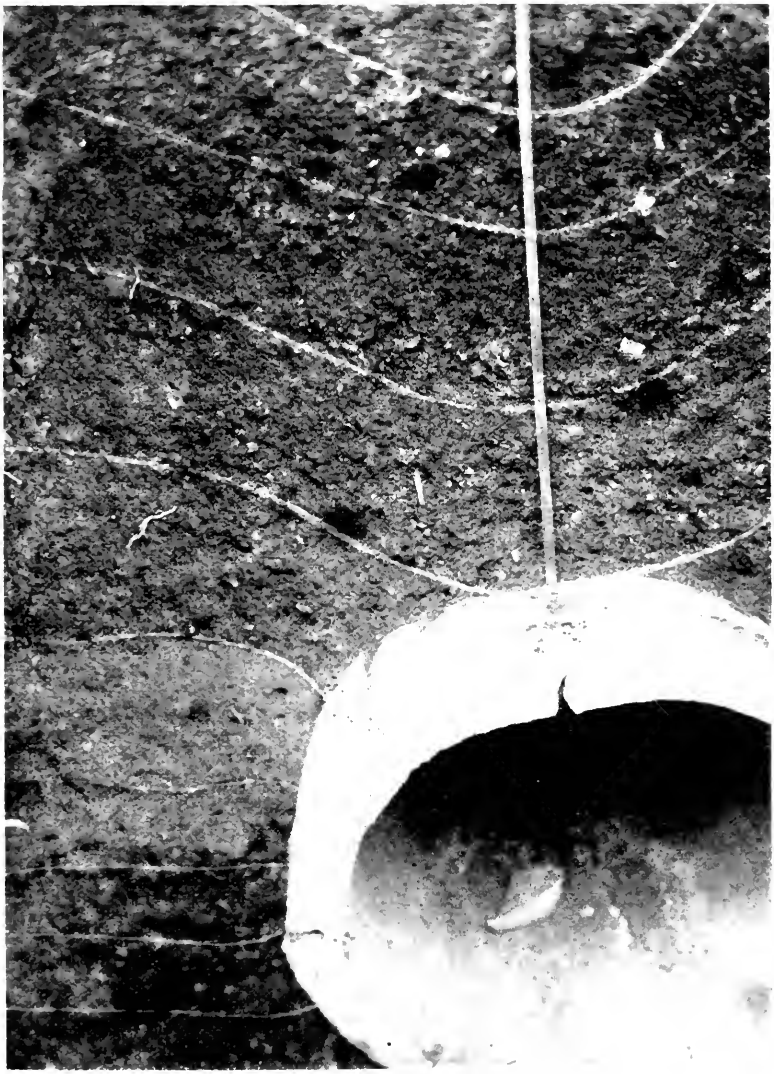


Photo No. 5

Preliminary Test No. 1. Cross-Section showing Displacement of Filling Material under Load.

He shows that for a concentrated load on a thin elastic ring the bending moment may be expressed by $-M_B = 0.159\ Q\ D$, where Q is the concentrated load per unit of length of pipe and D is the diameter. If a vertical load is distributed uniformly the resulting bending moment may be expressed by $M_B = \frac{1}{16}\ W\ D$ where $W =$ the total load per unit of length of pipe. If, however, the load be uniformly distributed both vertically and horizontally, then the bending moment is represented by $-M_B = \frac{1}{16}\ (1-q)\ W\ D$, where q is the ratio of horizontal to the vertical load. The importance of the manner of loading may be better understood by referring to charts 1 and 2, where for illustration "q" has been assumed to be .50, i.e., horizontal load $= \frac{1}{2}$ of vertical load. The Committee endeavored to determine the actual value of "q." The vertical load may be assumed to be uniformly distributed. The problem was to determine the relationship between the vertical and the horizontal loads. To solve this problem it is necessary to determine

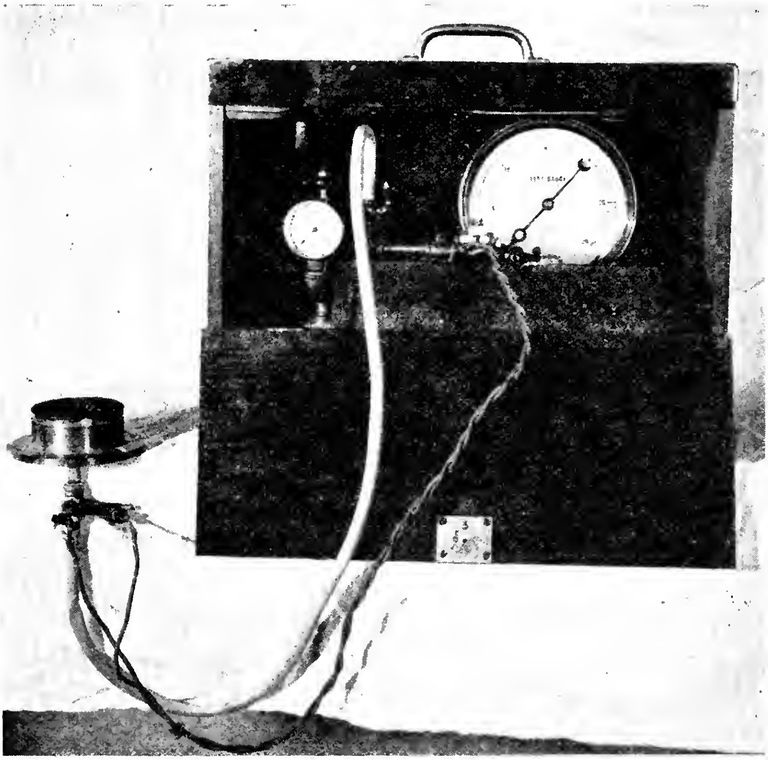


PHOTO NO. 6

Recording Apparatus connected up with Soil Pressure Cell (Goldbeck cell).

just how the loads in a fill are actually transferred to the culverts. This requires the measurement of pressures on the culverts under actual embankment conditions. The next test then was to develop means for measuring these pressures.

Preliminary Test No. 2

Apparatus Used

To measure these pressures, a pressure measuring instrument was required which would record pressures at any desired point on the periphery of the pipe.

Investigation of available pressure measuring devices led to the selection of the soil pressure cell, commonly called the Goldbeck cell. A diagram of this cell, which was devised by Messrs. Goldbeck and Smith of the U.S. Bureau of Public Roads, appeared in the 1924 Proceedings of the A.R.E.A. It is fully described in the 1917 Transactions of the American Society for Testing Materials. It is designed to operate with a diaphragm movement of as little as 0.0001 inch. The cell has been used by the Bureau of Public Roads for a number of years and is finding a constantly widening field of use.

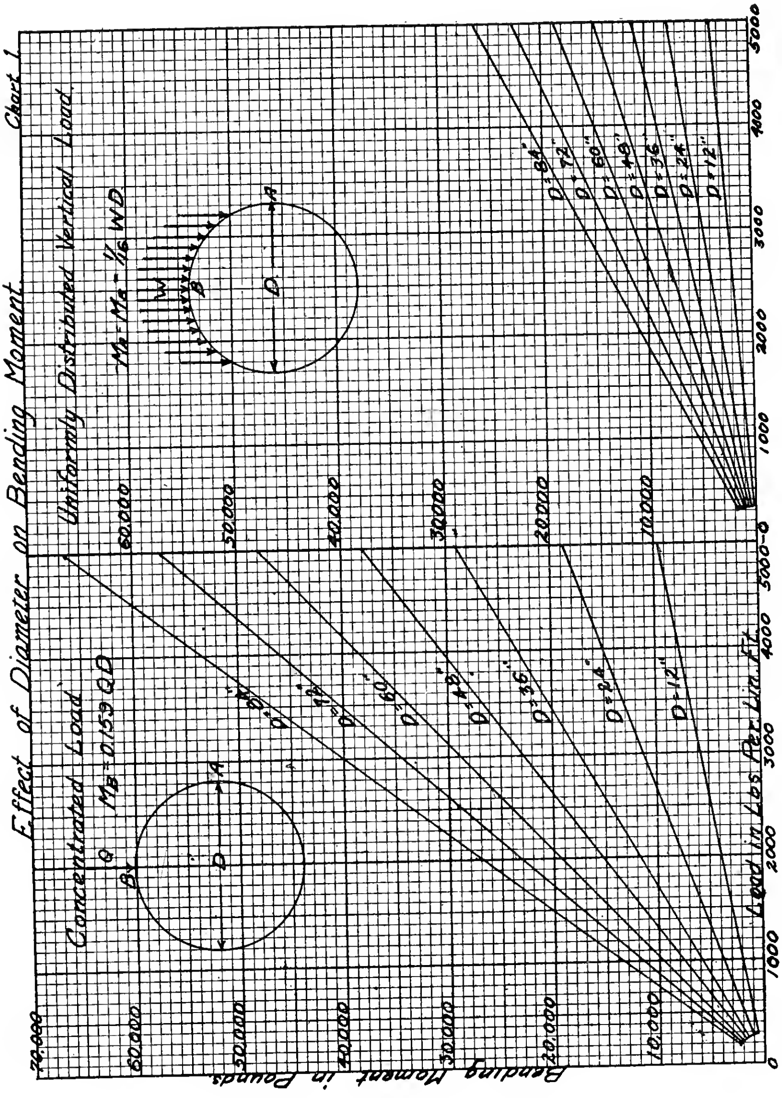
The apparatus shown in Photo No. 6 is used to record the air pressure required to balance the external pressure on the diaphragm of the cell. At the instant when the air pressure produces a slight outward movement of the diaphragm, an electric circuit is broken. This causes the small signal light in front of the large dial to flicker or go out. The gage pressure at this instant is noted. It is calibrated to show in pounds per square inch the external pressure on the diaphragm.

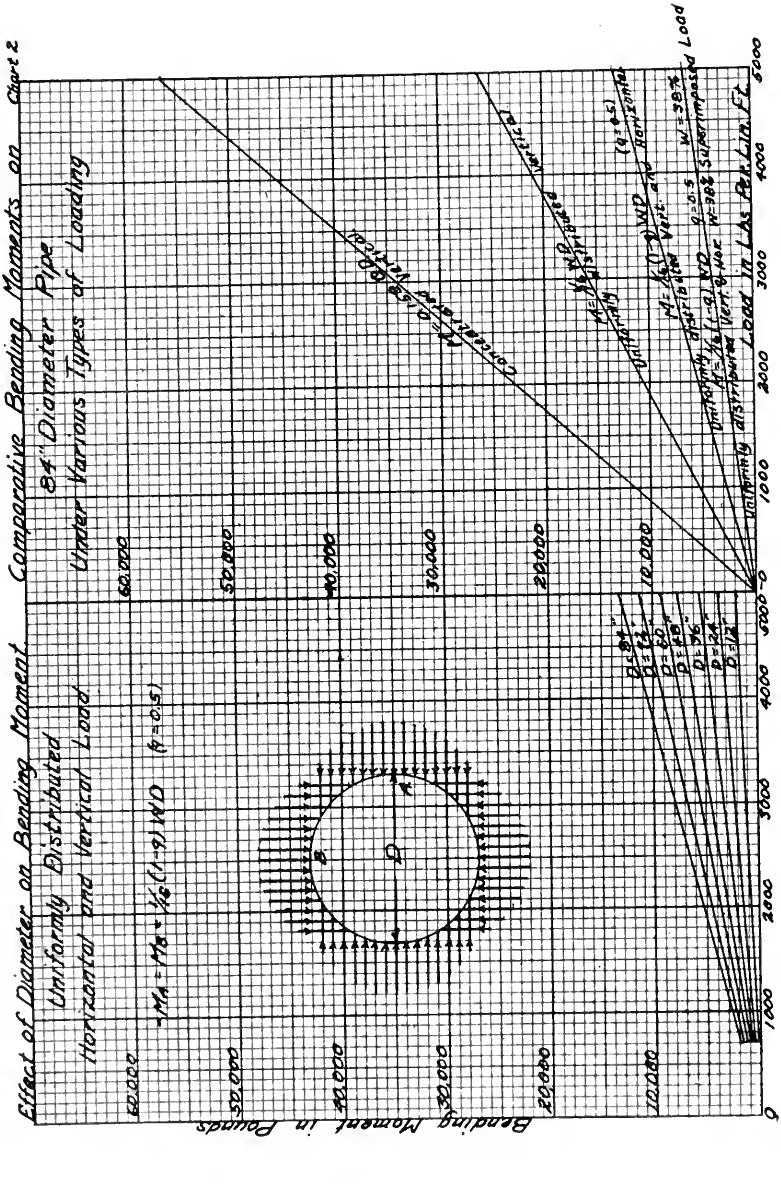
Photo No. 7 shows the cross-section charting board and the micrometer calipers with extension rods which are used in measuring the deflections in test culverts.

Every precaution was taken in this test to insure accurate readings and gages were tested daily with a mercury column. Before installation the cells were cleaned and tested under a water column and found to be extremely accurate.

The pipes tested were the following: One three-foot length of reinforced concrete pipe, 24-inch inside diameter with 3-inch walls, making the total outside diameter 30 inches. This was placed at the end of the line and blocked off with a small timber bulkhead having the same height as the pipe. Adjoining the concrete pipe at the open end was placed a two-foot section of 30-inch diameter 12-gage corrugated pipe, and next to this, a fourteen-foot section of 30-inch diameter 12-gage corrugated pipe.

The joints between the concrete pipe and the two-foot section of corrugated and between the two-foot section and the fourteen-foot section of corrugated pipe were left open about one-half inch and covered with three layers of twelve-inch wide strips of building paper, backed with two layers of muslin. This permitted free movement of the pipe sections and yet prevented any filling material flowing through the joints.


Effect of Diameter on Bending Moment.
Chart 1
Concentrated Load
Q
$M_B = 0.159\,QD$
Uniformly Distributed Vertical Load.
$M_B = M_A = \frac{1}{16} WD$
W
A
B
D
D=84"
D=72"
D=60"
D=48"
D=36"
D=24"
D=12"
0
1000
2000
3000
4000
5000-0
1000
2000
3000
4000
5000
10,000
20,000
30,000
40,000
50,000
60,000
70,000
Load in Lbs. Per Lin. Ft.
Bending Moment in Pounds


Effect of Diameter on Bending Moment
Uniformly Distributed
Horizontal and Vertical Load
$M_A = M_B = \frac{1}{16}(1-q)WD$ (q=0.5)
B
A
D
D=84"
D=72"
D=60"
D=48"
D=36"
D=24"
D=12"
Comparative Bending Moments on
84" Diameter Pipe
Under Various Types of Loading
Chart 2
Concentrated (M=0.15 W.D.) Vertical
$M = \frac{1}{8}WD$ Uniformly distributed Vertical
$M = \frac{1}{8}(1-q)WD$ Uniformly distributed Vert. and Horizontal (q=0.5)
$M = \frac{1}{8}(1-q)WD$ Uniformly distributed Vert. & Hor. q=0.5 W=38% Superimposed Load W=38%
Uniformly distributed Load in Lbs. Per Lin. Ft.
Bending Moment in Pounds
10,000
20,000
30,000
40,000
50,000
60,000
0
1000
2000
3000
4000
5000

For the concrete pipe the pressure cells were inserted in holes cut in the walls. The openings were made just large enough to clear the cell and so cut that when in place the cell diaphragm was just flush with the outside of the pipe wall. These cells, after being placed, were cemented in so they formed an integral part of the pipe.

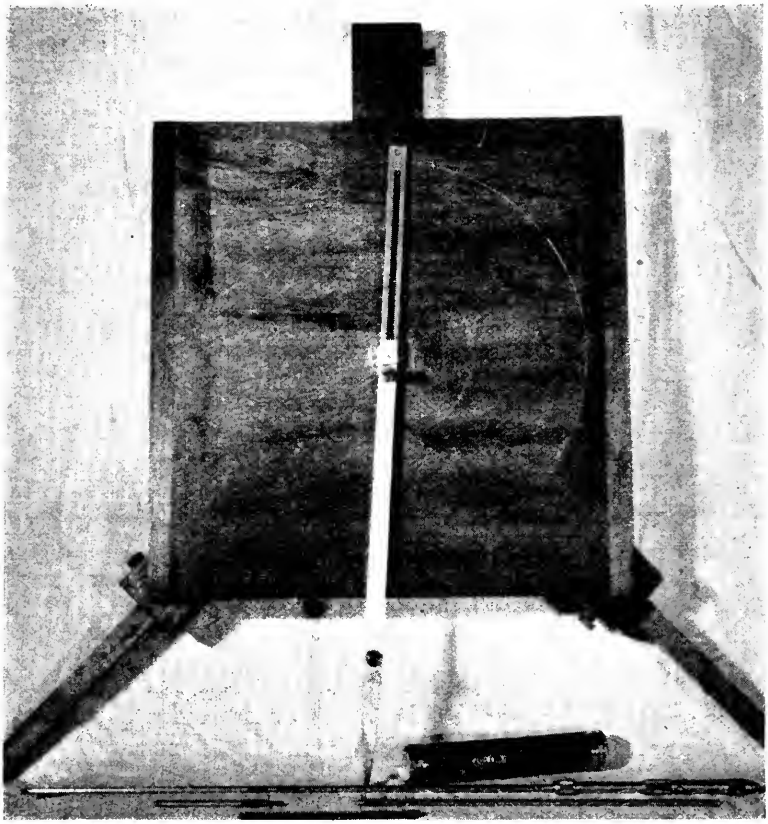


Photo No. 7

Cross-Section Charting Apparatus and Extension Micrometer Calipers Used in Measuring Deflections in Test Culverts.

For the corrugated pipe the same manner of installation was followed, except that in this case holes were cut through the pipe wall and the cells bolted on, using a cast-iron filler block corrugated on one side. The cell diaphragm in position was just flush with the ridges of the corrugations on the outside of the pipe. The openings were made watertight by caulking around the cells with Sarco compound. The location of the cells and plan of installation is shown in Photo No. 8 and Fig. 2.

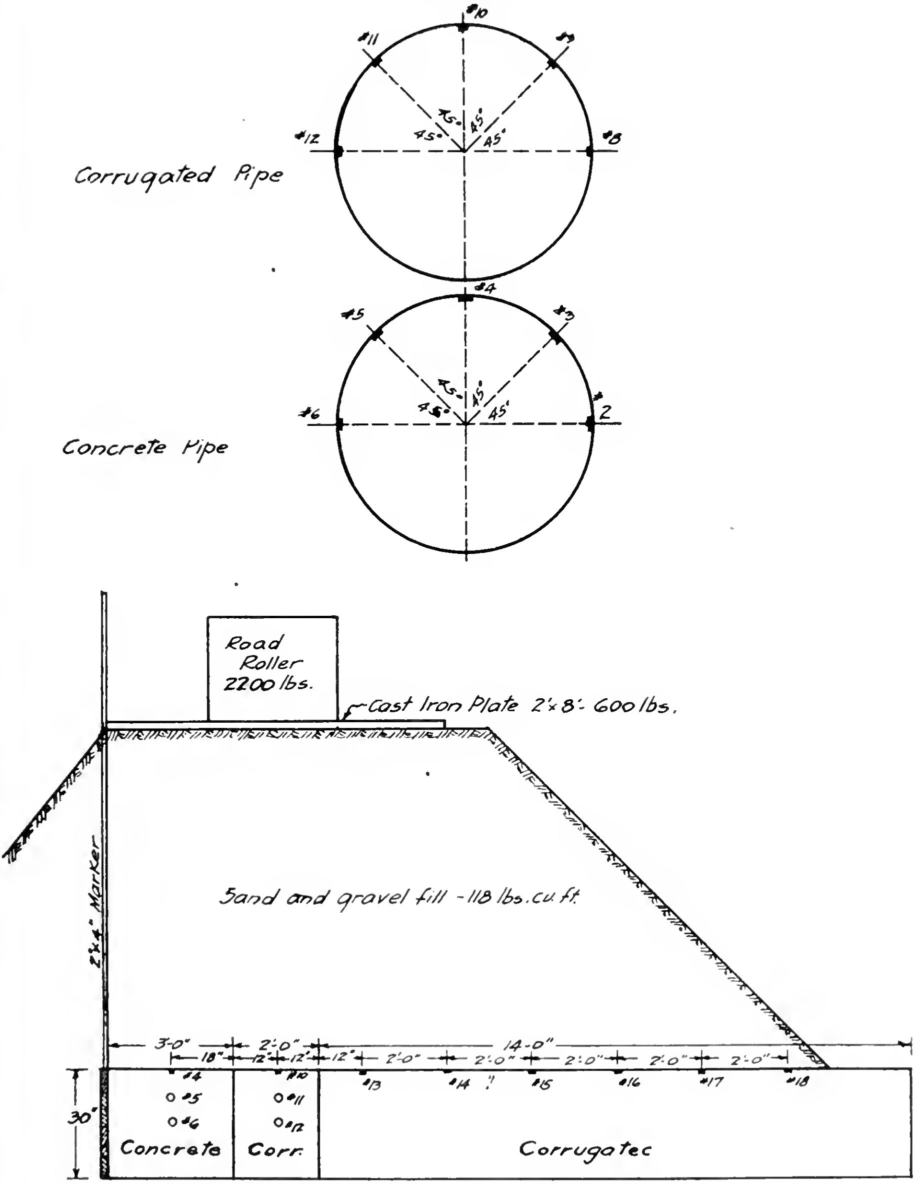


Fig. 2.—Layout of Test Culvert and Location of Cells. Preliminary Test No. 2.

The pipe was very carefully installed, being placed exactly level on an undisturbed natural bed of sand and gravel. The elevations of the cell diaphragms were noted in order to determine what part, if any, settlement might play in the results of the test.

The embankment material, samples of which were weighed, averaged 118 lb. per cu. ft. All of the pipe was bedded with 90 per cent (or 27 inches in this case) of the culvert projecting above the surface of the undisturbed natural bed. All of the pipe was tamped to the three-quarter points.

Photo No. 8

Preliminary Test No. 3. Method of Mounting Cells in Corrugated Pipe.

Two sets of readings were taken at each additional foot of cover up to 8 ft. One set was taken of the unloaded fill; another set was taken with the additional loading of a cast-iron plate 2 ft. by 8 ft., weighing about 600 lb., and placed directly over the concrete pipe and the 2 ft. section of corrugated pipe, on top of which plate was then placed a 2,200-lb. concrete road roller. The total load on the fill was thus increased by 175 lb. per sq. ft. over an area of 16 sq. ft.

The material in embankment was all placed by team with slip and compacted at each one-foot height by moving the 2,200-lb. roller once entirely across the fill. This rolling was done after each unloaded first set of readings was taken.

The pressure reading for each cell is shown in Table 2.

Dean Marston's investigations of culvert loads had shown that the fill load reaching a rigid culvert under 90 per cent projection condition was considerably in excess of the weight of the material directly over the culvert. In discussing his own work Marston says:

> "The theory assumes that the culvert itself is relatively unyielding as compared with the embankment material immediately alongside the culvert on each side and extending up to the level of the top of the culvert. Hence, the theory will not apply if the culvert is cracked or seriously deformed. If such cracking or serious distortion occurs, the consequent shortening of the vertical diameter lessens the vertical pressure, and the consequent enlarging of the horizontal diameter increases the side pressure."

The results of this test indicate that the reactions of the rigid and flexible pipe under fill load are fundamentally different.

In Preliminary Test No. 2 only a limited number of cells were used due to the small diameter of pipe, but the uniformity of results obtained left little doubt as to the value of the application of the cells to our work and that radial pressures at approximately any desired point could be determined. As a further assurance of this, Preliminary Test No. 3 along the same lines was conducted.

TABLE 2

Preliminary Test No. 2—Actual cell readings in pounds per sq. in.

Cell Numbers

UNLOADED FILL										
Fill Ht.	*2*	*3*	*4*	*5*	*6*	*8*	*9*	*10*	*11*	*12*
8′ 0″	0.95	3.55	5.50	3.70	0.65	1.40	2.00	2.55	2.40	....
7′ 0″	0.85	3.00	4.95	2.75	0.50	1.15	1.70	2.10	2.05	1.20
6′ 0″	0.80	2.55	4.25	2.30	0.40	1.00	1.50	2.00	1.95	1.00
5′ 0″	0.60	2.00	3.50	1.65	0.35	0.75	1.35	1.75	1.70	0.75
3′ 8″	0.50	1.55	3.25	1.35	0.33	0.73	1.25	1.65	1.55	0.73
3′ 0″	0.40	1.55	2.75	1.25	0.35	0.70	1.20	1.40	1.45	0.48
0′ 9″	0.45	0.90	0.75	0.55	0.35	0.30	0.60	0.75	0.45	0.35
LOADED FILL										
8′ 0″										
7′ 0″										
6′ 0″										
5′ 0″	0.60	2.05	3.55	1.65	0.40	0.80	1.50	1.80	1.85	0.80
3′ 8″	0.55	1.65	3.25	1.40	0.45	0.75	1.35	1.75	1.65	0.75
3′ 0″	0.35	1.48	3.40	1.25	0.33	0.75	1.15	1.55	1.55	0.55
0′ 9″	0.33	1.20	5.30	0.65	0.30	0.35	0.65	0.70	0.90	0.30

The cell numbers correspond to the numbers shown on Fig. 2.

PRELIMINARY TEST NO. 3

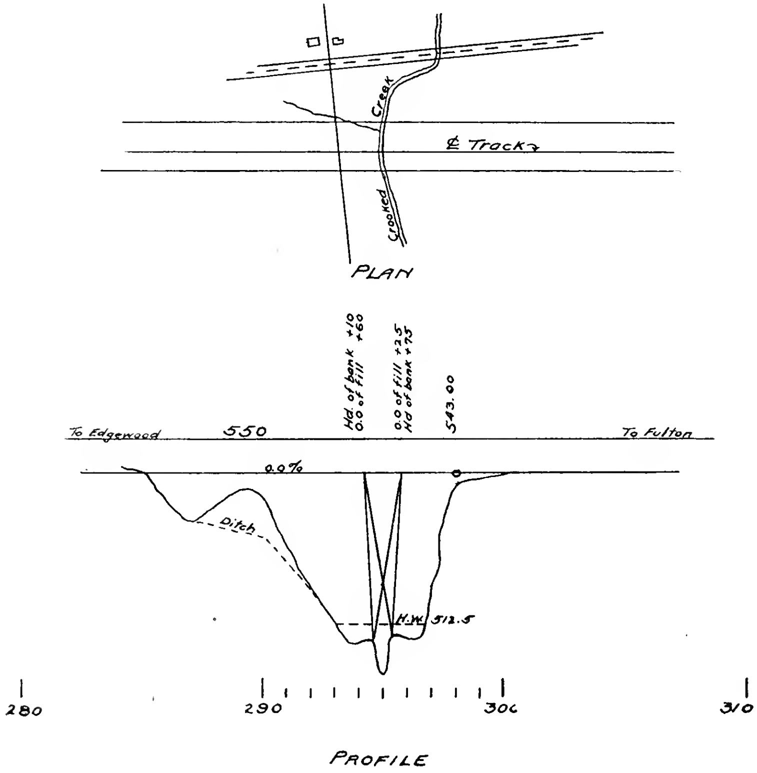
This test was made under exactly the same conditions as Test No. 2, except that 24-inch and 36-inch corrugated pipes were also included.

The results practically checked those obtained in Test No. 2, and will not be given here in detail.

It was now felt that the preliminary work had yielded sufficiently encouraging results to warrant the procedure with the principal, or Farina, Illinois, test.

FARINA, ILLINOIS, TEST

With the preliminary tests completed, and the necessary information and experience obtained therefrom, the Committee was ready to make tests under actual service condition. At the same time it was recognized that



Site of Farina Test
On Illinois Central RR.
Near Farina Illinois

FIG. 3

on construction work the control obtained in the laboratory would be difficult to secure. However, an effort was made to obtain conditions that would give reliable results in the field.

Location

Such conditions were found on the Illinois Central Railroad's new line in Southern Illinois. The point selected is Station 294, where this line crosses what is known as Crooked Creek about six miles east of Farina, Illinois. The fill at this point is about 38 ft. high. This site was ideal for a test of major proportions.

Culverts Tested

The test culverts comprised eight lines, as shown in Table 3.

Table 3

Farina Test—Location and description of culverts

Line No.		*Total Ht. Fill*	*Total fill over pipe*
1	42″ 12-ga. corrugated	8.8 ft. fill	6.0
2	42″ 12-ga. "	15.0 " "	12.2
3	24″ x 27″ concrete*	34.7 " "	32.2
4	24″ 14-ga. corrugated	34.8 " "	33.1
5	42″ 12-ga. "	35.8 " "	33.5
6	42″ Extra heavy cast-iron	37.2 " "	34.2
7	42″ 12-ga. corrugated	38.7 " "	34.9
8	48″ 10-ga. " †	37.9 " "	34.6

---

*Same type and construction as used on I.C. construction.
†Second sheets.

Fig. 3 shows a plan and profile of the line where Farina test is being conducted.

Apparatus

A large number of cells are necessary in a test of this magnitude to insure uniformity in case of slips, faults and variations in compaction of the fill that would be reflected in the readings of a single cell. Sixty-six cells were used. The method of location is shown in Fig. 4 and 5. The same precautions, to assure accuracy of reading, were taken as in Preliminary Test No. 3; mercury column to test accuracy of gage, etc.

Installation of Culverts

Extreme care was taken to see that all culverts regardless of type or diameter were installed under exactly similar conditions. This was essential if the results were to be comparable. The embankment material was tamped to three-fourths the height of the pipes and at least 14 in. out from the sides. This was done by hand. In some cases culverts were given a different amount of projection above the natural ground in order to determine how much this would affect the loading.

Rainfall data was secured to note what effect, if any, it had on the pressures in the fill. Table 4 gives this data. Elevations were taken on the top cell of each line so as to note settlement and its effect on the pressures. This settlement is given in Table 5. Deflections were read with an inside micrometer reading to three places.

Kind and Character of Filling Material

The material for approximately the first eight feet of filling consisted of a very loose-grained top soil. It was not possible to tamp this material very much as it was very fine and dry at the time of placing. Weighings showed little variation from 85 lb. per cu. ft. and this was therefore taken as representing the average weight in fill up to this height.

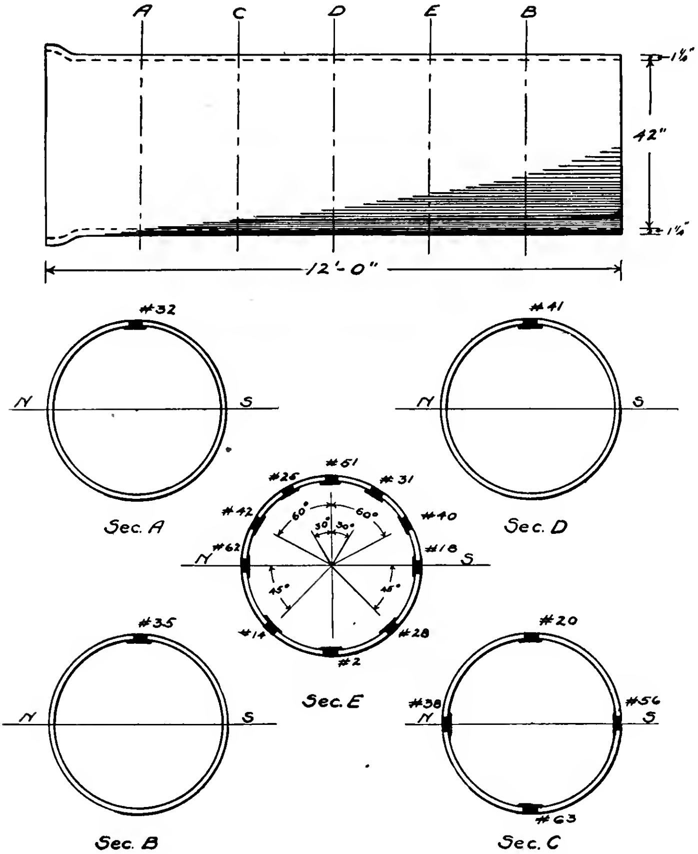
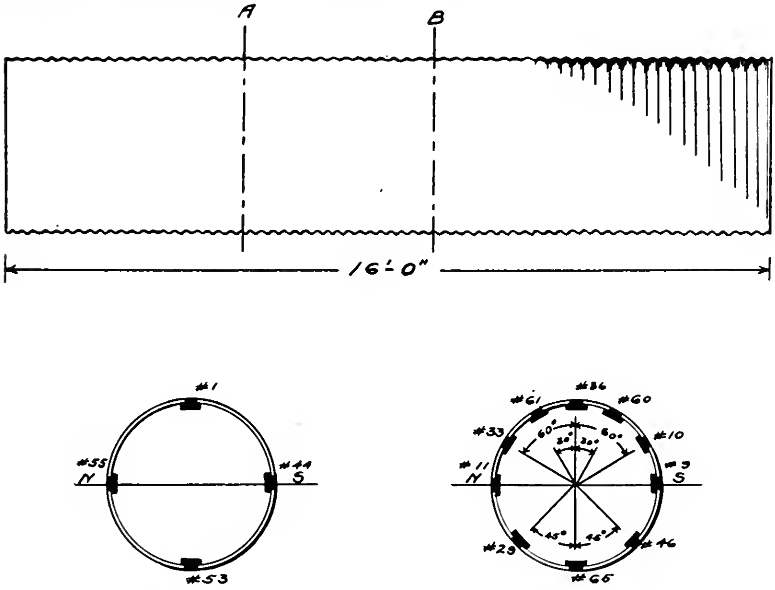


Fig. 4.—Location of Cells in Test Culvert. Line No. 6 42-In. Diameter Bent Iron.

Below the top soil the borrow pits yielded a dense and compact yellow clay. This material packed readily and was well consolidated in the fill by the wagons and teams. This part of the fill received considerable rainfall. The clay was so firmly packed that the samples for weighing were taken from the fill in solid blocks. The average weight of this clay was about 112 lb. per cu. ft.

Method of Making Fill

The contractors built the fill in lifts of two feet. After each two-foot layer was placed and leveled off, elevations were taken over each culvert and the pressures and deflections read.



Sec. A-West

Sec B-East

Fig. 5.—Location of Cells in Test Culvert. Line No. 7 42-In. Diameter Corrugated.

Table 4

Farina Test—Record of rainfall during construction.

Date	*Inches*
6/6/25	0.1
6/8	0.1
6/13	0.8
6/14	0.2
6/17	3.0
6/22	0.5
6/23	1.5
6/24	1.0
6/28	1.0
7/5	0.4
7/7	0.4
7/9	0.6
7/20	0.2
7/25	1.0
7/27	1.1

TABLE 5

Farina Test—Settlement of test culverts into foundation up to August 10, 1925.

Line No. 5	0.115 ft.
" " 6	0.29 "
" " 7	0.17 "
" " 8	0.18 "

The embankment was placed between June 2 and July 15, 1925. It must be recognized that the average earth fill is not composed of a perfectly homogeneous material. It is therefore to be expected that there will be occasional irregular variations in the unit pressures exerted on the pipes. This explains some apparent discrepancies in some of the readings. The effect of these is minimized by the use of the large number cells. The results in terms of general averages may be taken as representative.

Considering the amount of the projection of the pipes above the natural soil and the weight of the filling material it seems probable there will seldom be installations where the culvert will be subjected to more severe loading. For this reason the deflections shown may be taken as somewhat greater than may be expected under ordinary conditions.

Deflections

Curves showing the deflections of the culverts at the various depths of fill are shown on Charts 3, 4 and 5.

Chart 3 shows a comparison of the deflection of the 24-inch concrete with the 24-inch corrugated. The concrete pipe fractured longitudinally throughout its length before the fill was completed, without, however, any marked deflection. The corrugated pipe had deflected .8 of an inch at the completion of the fill.

Chart 4 compares the deflection of the 42-inch diameter 12-gage corrugated with the 42-inch cast-iron pipe. The maximum deflection of the former was 3.062 inches, and the latter 0.262 inches; both are still intact.

Chart 5 shows the deflections for the 42-inch diameter 12-gage and the 48-inch diameter 10-gage corrugated. At the completion of the fill, the former was 3.024 in., and the deflection curve conforms closely to the one for the same diameter and gage of culvert shown in Chart 4. The 48-inch shows a total deflection of 4.94 in.; both pipes are intact.

Pressures

Chart 6 shows the pressure readings on the 24-inch corrugated pipe. This chart should be compared with Chart 7 showing the pressure readings for the 24-inch concrete. In the case of the corrugated pipe, it should be noted that the side pressures fairly approximate the top pressure, while in the case of the concrete the side pressures ar only approximately 30 per cent of the top pressures. Also the top pressures on the corrugated culvert are

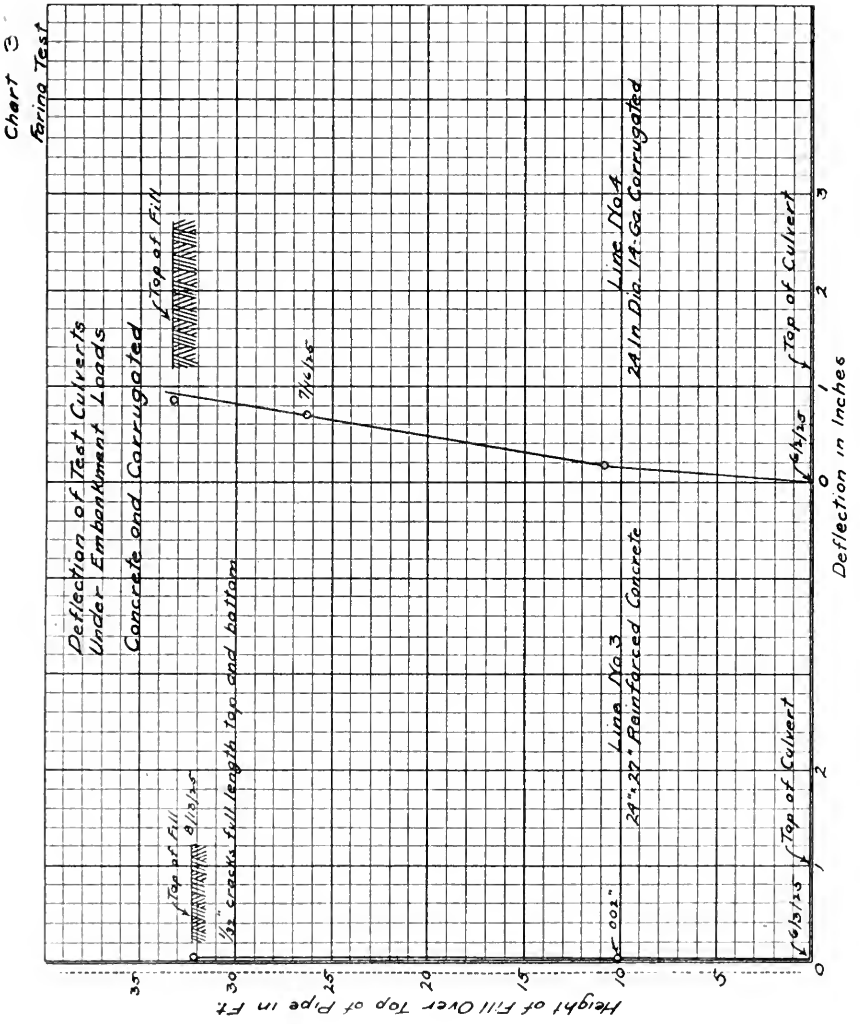


Chart ③
Farina Test
Deflection of Test Culverts
Under Embankment Loads
Concrete and Corrugated
Top of Fill
7/16/25
Line No 4
24 In Dia 14-Ga Corrugated
Top of Culvert
6/12/25
Top of Fill
8/10/25
1/32" cracks full length top and bottom
.002"
Line No 3
24"×27" Reinforced Concrete
Top of Culvert
6/3/25
3
2
1
0
1
2
Deflection in Inches
35
30
25
20
15
10
5
0
Height of Fill Over Top of Pipe in Ft.

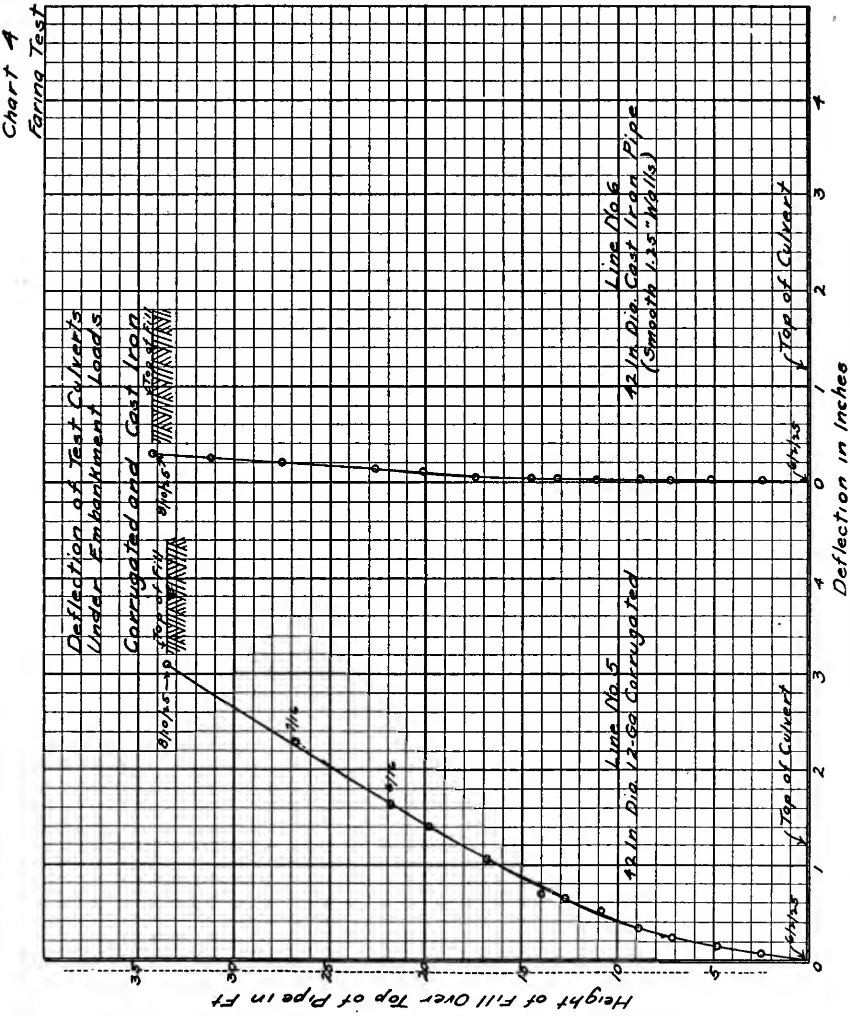


Chart 4
Facing Test
Deflection of Test Culverts
Under Embankment Loads
Corrugated and Cast Iron
Line No. 6
42 In Dia. Cast Iron Pipe
(Smooth 1.25" Walls)
Line No. 5
42 In Dia. 12-Ga. Corrugated
Top of Fill
8/10/25
6/1/25
Top of Culvert
7/16
Deflection in Inches
0
1
2
3
4
Height of Fill Over Top of Pipe in Ft
5
10
15
20
25
30
35

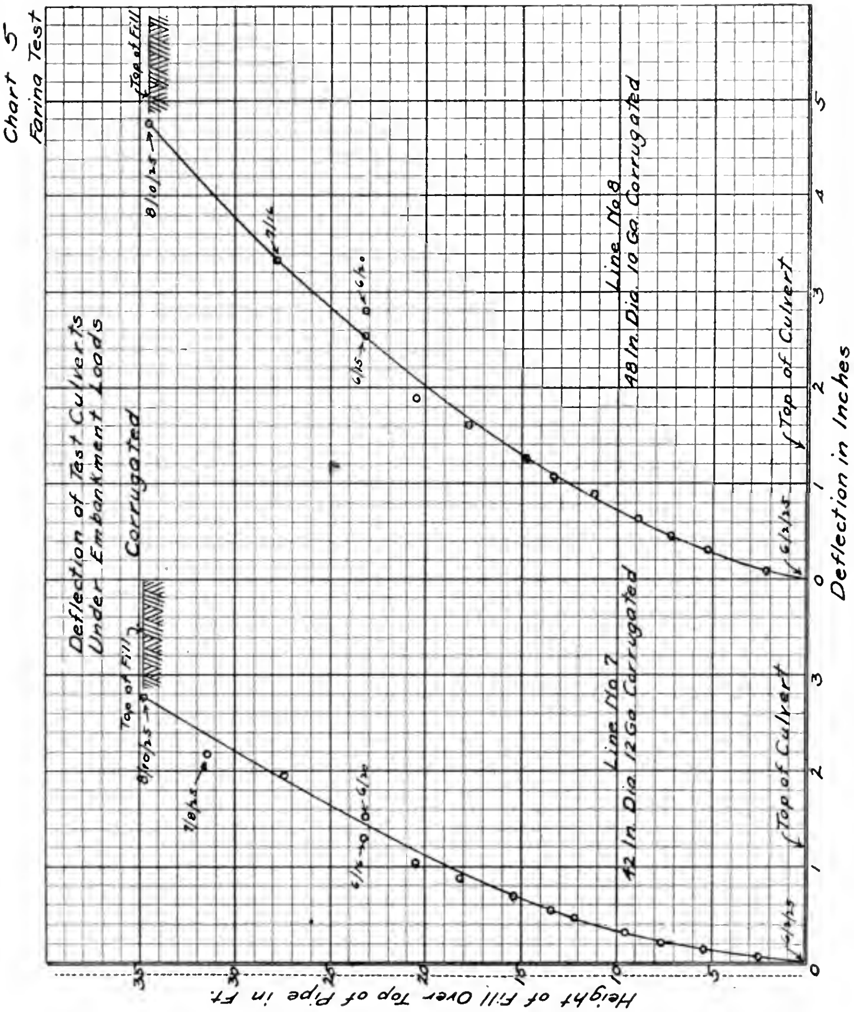


Chart 5
Farina Test
Deflection of Test Culverts
Under Embankment Loads
Corrugated
Top of Fill
Top of Fill
8/10/25
7/16
6/15
6/20
6/12/25
Line No. 8
48 In. Dia. 10 Ga. Corrugated
Top of Culvert
8/10/25
7/8/25
6/15
6/20
6/12/25
Line No. 7
42 In. Dia. 12 Ga. Corrugated
Top of Culvert
0
1
2
3
4
5
0
1
2
3
Deflection in Inches
0
5
10
15
20
25
30
35
Height of Fill Over Top of Pipe in Ft.

only about 39 per cent of the top pressures on the concrete, and the side pressures on the corrugated are about 145 per cent of those on the concrete.

Attention is drawn to the characteristic manner in which the rigid type supports the major portion of the load on its crown and the characteristic manner in which the flexible type distributes the load over its circumference.

Chart 8 shows the vertical and horizontal pressures as well as those at points 30 degrees off of vertical for the 42-inch 12-gage corrugated pipe. Pressures at the same points are shown for the 42-inch cast-iron pipe on Chart 7. A comparison of these charts will show the same general trend as in the case of the 24-inch pipes.

Chart 9 shows the pressures at points on the vertical 30 degrees off vertical and 60 degrees off vertical and horizontal for the 48-inch 10-gage corrugated. Because pressures were measured at more points on this pipe than any other, the results more completely illustrate the tendency of the pressures to equalize in the case of the corrugated pipe, and thus distribute the load over the circumference.

Chart 10 shows the approximate average vertical and horizontal pressures for both rigid and flexible types. For comparative purposes, there has been inserted a curve showing the approximate weight of a column of earth one inch square directly above the crown of the pipes. This curve was computed from the actual weight of the material which made up the fill. It will be noted that the vertical and horizontal pressures of the flexible type closely approximate each other, whereas, in the case of the rigid pipe, there is a considerable variation, at the 35-ft. level the horizontal pressure being only about 30 per cent of the vertical pressure. Now, considering the weight of the superimposed material, it will be noted that the vertical pressure on the flexible culvert is always less than the weight of the column above it, while the vertical pressure of the rigid type culvert is always more for heights above 10.5 ft. At the 35 ft. level, the vertical pressure on the flexible type is 54 per cent of the weight of the column of earth directly above. The vertical pressure of the rigid type at the same level is 158 per cent of the weight of the column of earth directly above.

INTERPRETATION OF RESULTS

All of the pipe except the concrete being intact as this report is being prepared, it is impossible to draw definite conclusions as to failure point in the case of corrugated pipe, or fracture point in the case of the cast-iron pipe for fills beyond 35 ft. Based on the information already obtained, further experiments will be made to determine the safe deflection and failure points of the corrugated metal culvert under various embankment loading conditions.

Charts 11, 12 and 13 show deflections for standard sizes and gages for fill conditions up to 35 ft. The 24-inch 14-gage, 42-inch 12-gage, and 48-inch 10-gage are actual curves derived from the Farina Test. The other curves are computed. The relative strength of the various sizes in different gages was determined by laboratory tests and verified mathematically. The complete mathematical investigations will be given in a later report.

Summary

Results so far show that under the conditions of the Farina Test:

(1) The intensity of vertical pressure measured by the top cells on the corrugated culverts is about one-third of the measured vertical pressure on the rigid type of culvert under the same condition of loading.

(2) The intensity of vertical pressure measured by the top cells of the corrugated culverts is about 54 per cent of the weight of the unit columns of the material above the cells.

(3) The intensity of vertical pressure measured by the top cells of the rigid culverts is about 158 per cent of the weight of the unit columns of the material above the cells.

(4) The intensity of pressure at the horizontal axis of the corrugated culvert is equal to or greater than the intensity of pressure at the vertical axis.

(5) The intensity of pressure at the horizontal axis of the rigid culvert is about one-third of the intensity of pressure at the vertical axis.

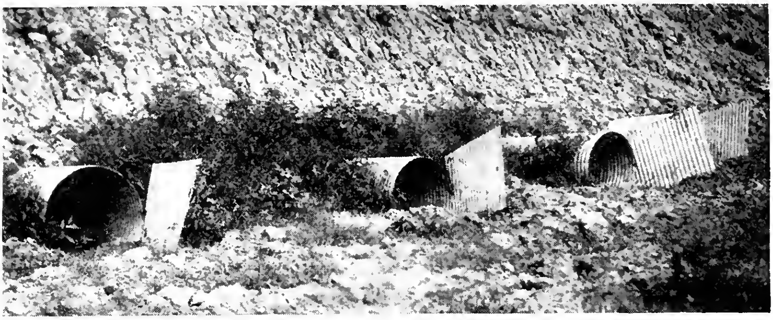
Observations are being continued at intervals of about 90 days. It is the intention to continue this for an indefinite period in order to determine what changes, if any, take place as the fill consolidates under traffic.

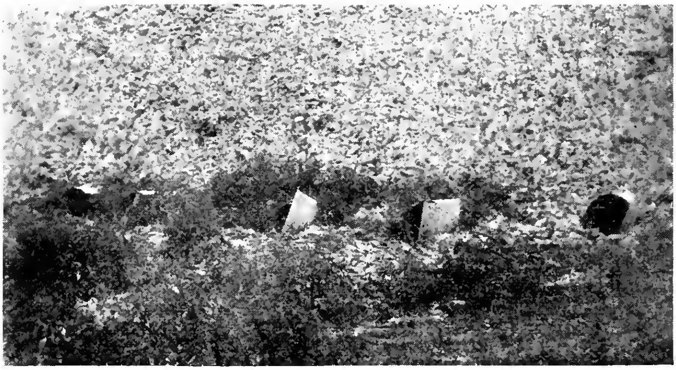
Records of readings on lines numbers one and two are being held until after the line is under traffic, when the Committee expects to make determination of the live loads transmitted for those fill heights.

A report on this work will be available for next year.

Acknowledgments

The Committee is indebted to the Armco Culvert and Flume Manufacturers' Association for the financing of the tests. It is desired to express appreciation of the co-operation by the Illinois Central Railroad in furnishing the site for the test as well as actual engineering assistance. The Committee is also indebted to Prof. A. N. Talbot, who, with his staff, has offered much constructive and valuable co-operation. Messrs. Goldbeck and Smith, of the U.S. Bureau of Public Roads, have given valuable guidance in the use of the soil pressure cells and in the actual planning of the tests.





PHOTOS No. 9 AND 10
Farina Test—View of Test Culverts.

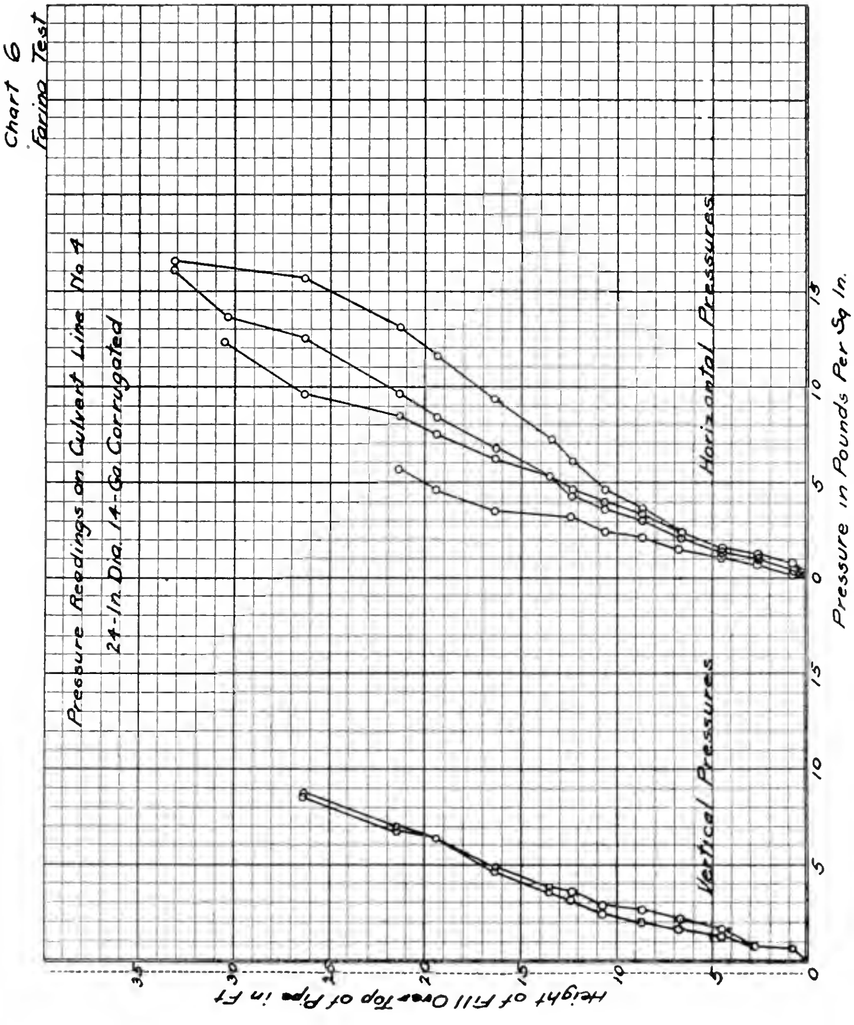
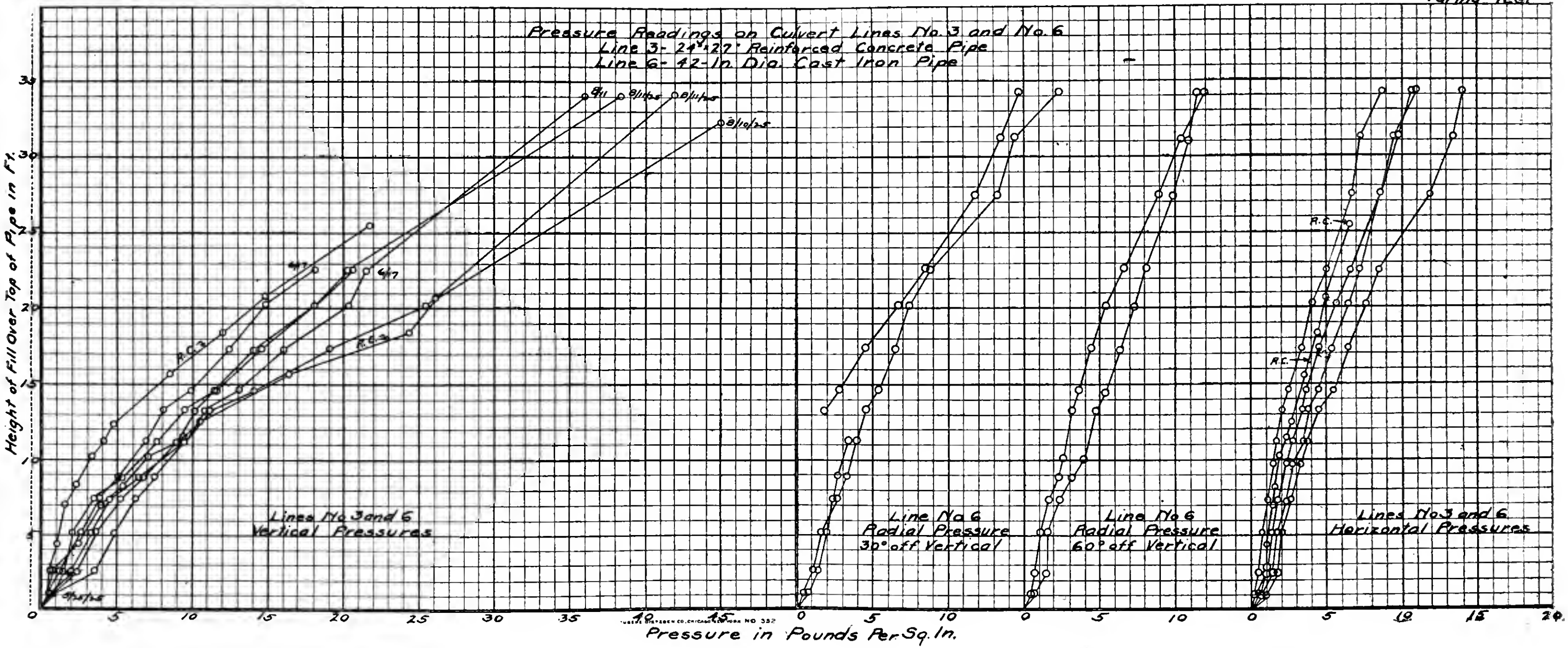


Chart 6
Farina Test
Pressure Readings on Culvert Line No 4
24-In. Dia. 14-Ga Corrugated
Horizontal Pressures
Vertical Pressures
0
5
10
15
0
5
10
15
Pressure in Pounds Per Sq In.
0
5
10
15
20
25
30
35
Height of Fill Over Top of Pipe in Ft

Chart 7
Facing Test



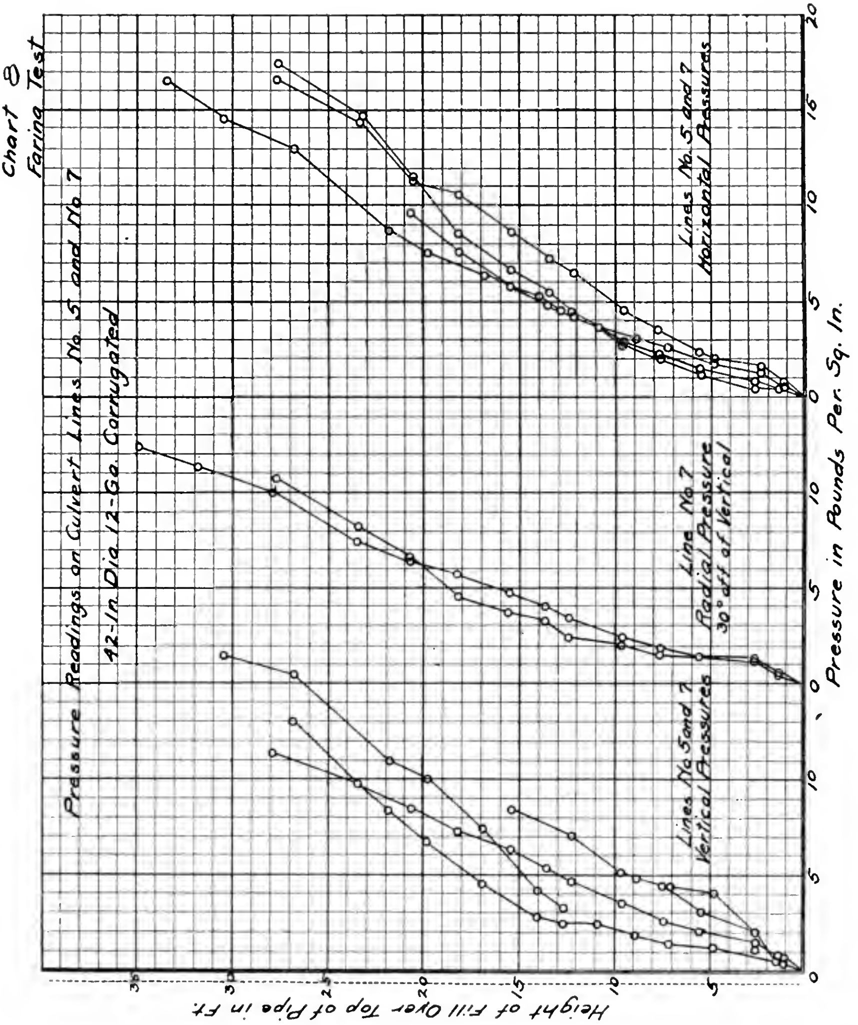


Chart 8
Farina Test
Pressure Readings on Culvert Lines No 5 and No 7
42-In Dia 12-Ga. Corrugated
Lines No. 5 and 7
Horizontal Pressures
Line No 7
Radial Pressure
30° off of Vertical
Lines No 5 and 7
Vertical Pressures
Pressure in Pounds Per Sq. In.
0
5
10
15
20
0
5
10
0
5
10
Height of Fill Over Top of Pipe in Ft.
0
5
10
15
20
25
30
35

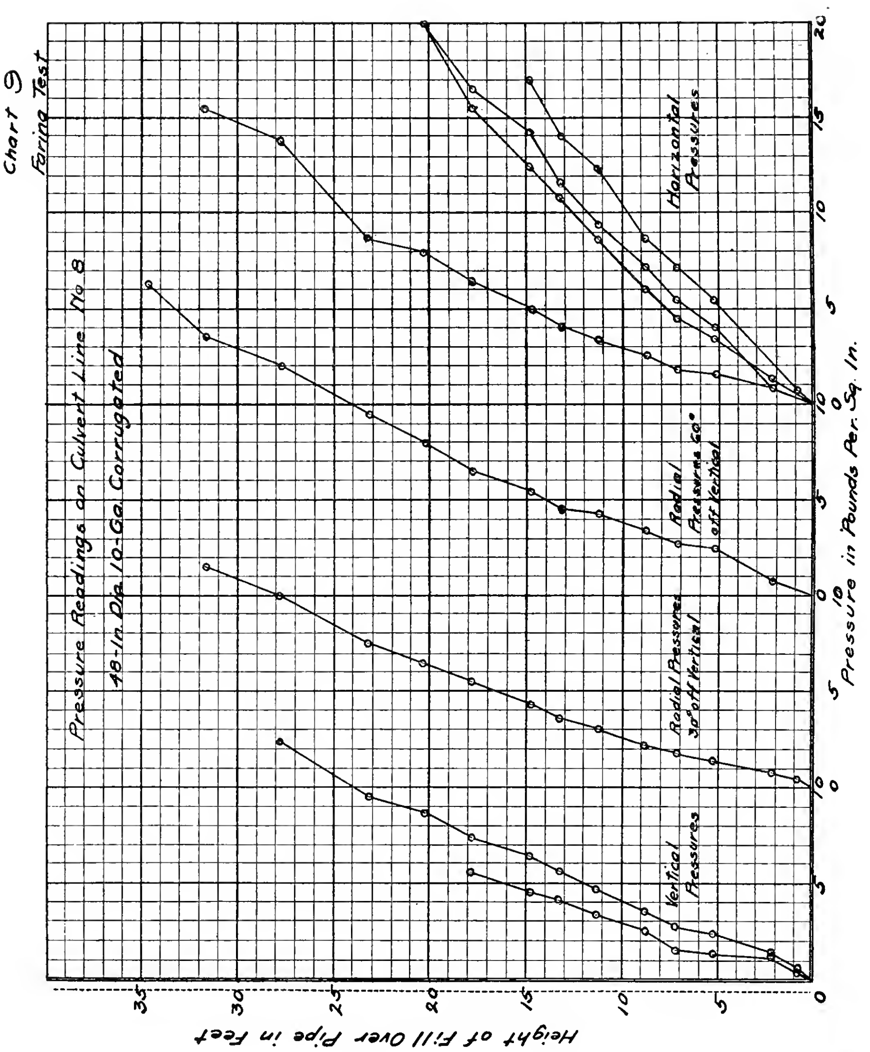


Chart 9
Foring Test
Pressure Readings on Culvert Line No 8
48-In Dia 10-Ga. Corrugated
Horizontal Pressures
Radial Pressures 60° off Vertical
Radial Pressures 30° off Vertical
Vertical Pressures
20
15
10
5
0
5
0
10
5
0
5
0
Pressure in Pounds Per Sq. In.
35
30
25
20
15
10
5
0
Height of Fill Over Pipe in Feet

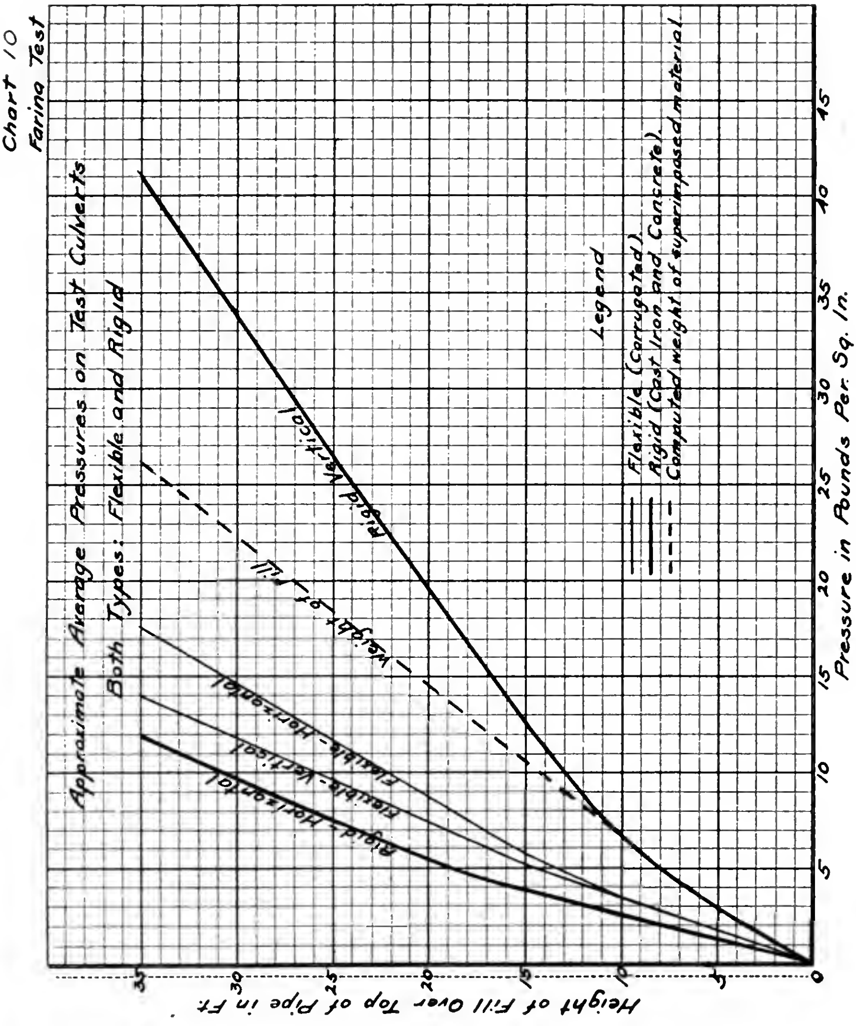
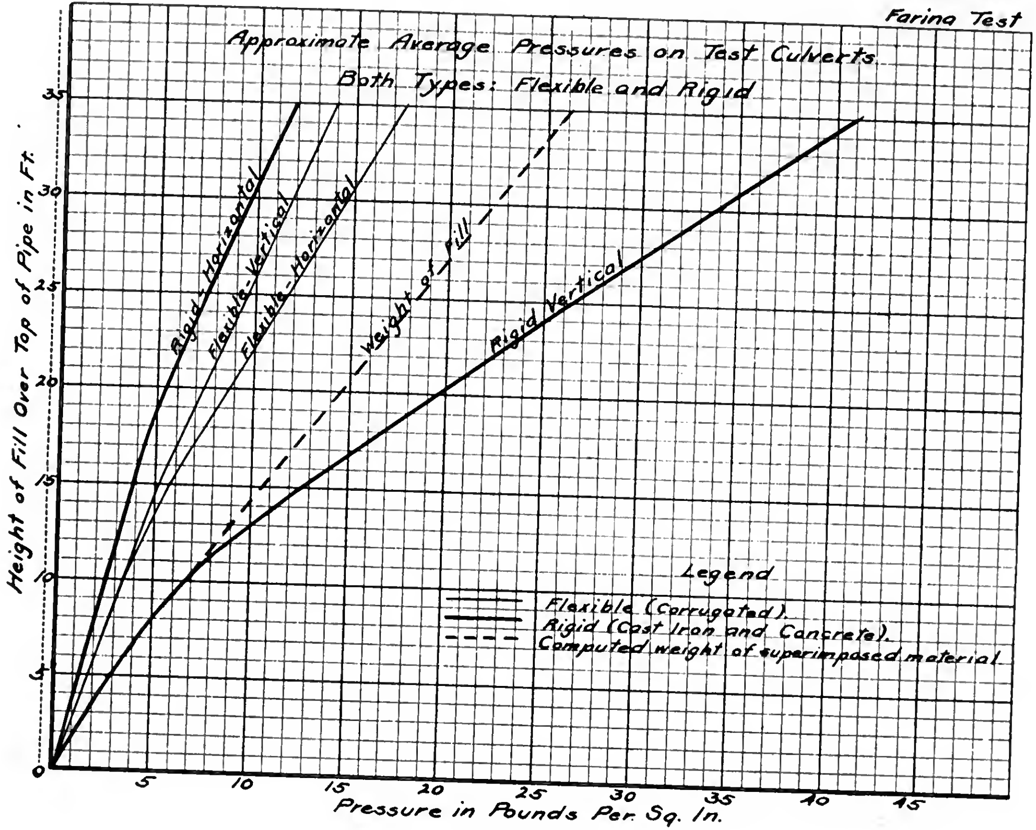


Chart 10
Farina Test
Approximate Average Pressures on Test Culverts
Both Types: Flexible and Rigid
Legend
Flexible (Corrugated).
Rigid (Cast Iron and Concrete).
Computed weight of superimposed material
Rigid Vertical
Weight of Fill
Flexible - Horizontal
Flexible - Vertical
Rigid - Horizontal
Pressure in Pounds Per Sq. In.
0
5
10
15
20
25
30
35
40
45
Height of Fill Over Top of Pipe in Ft.
0
5
10
15
20
25
30
35

Chart 10
Farina Test



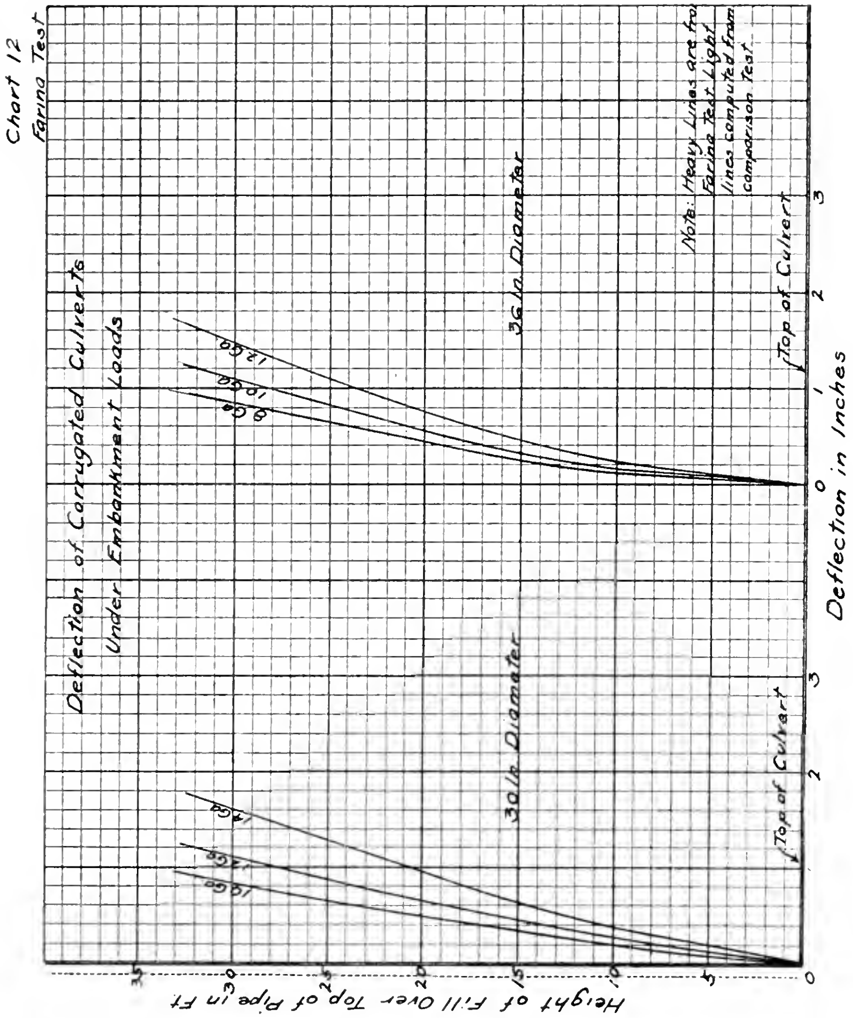


Chart 12
Farina Test
Deflection of Corrugated Culverts
Under Embankment Loads
36 In Diameter
12 Ga
10 Ga
8 Ga
30 In Diameter
14 Ga
12 Ga
10 Ga
Top of Culvert
Top of Culvert
Note: Heavy Lines are fro
Farina Test. Light
lines computed from
comparison Test
0
1
2
3
0
1
2
3
Deflection in Inches
0
5
10
15
20
25
30
35
Height of Fill Over Top of Pipe in Ft

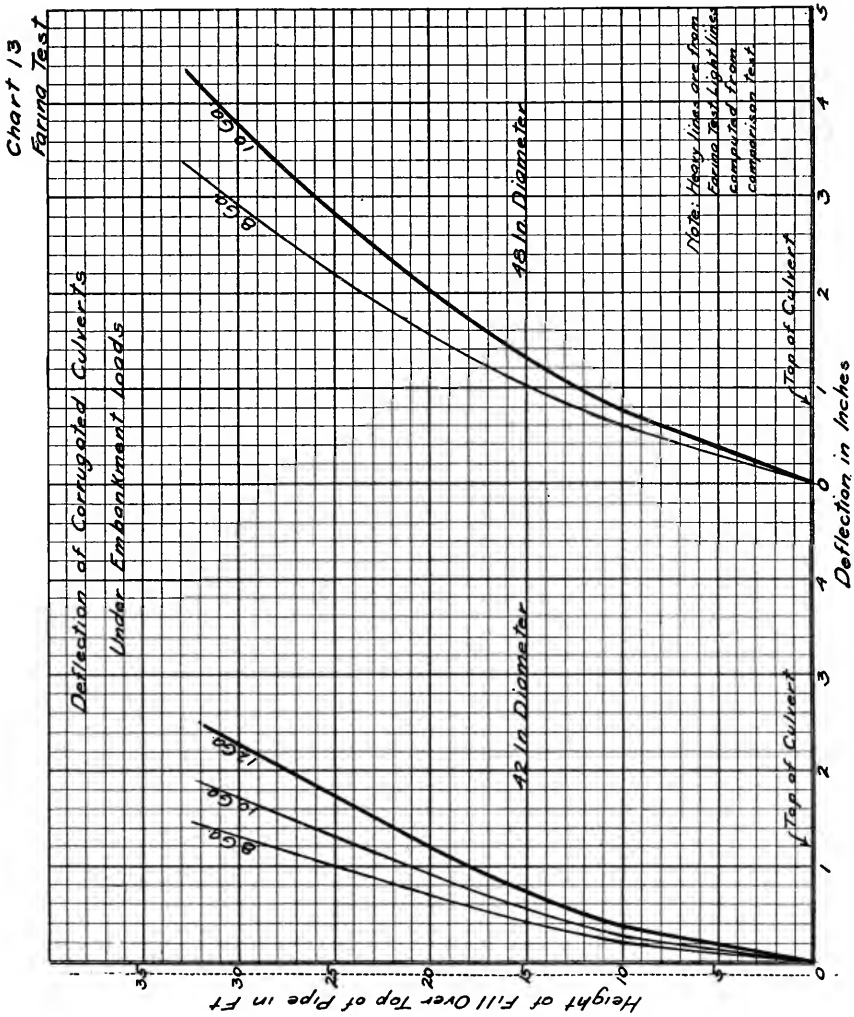


Chart 13
Farina Test
Deflection of Corrugated Culverts
Under Embankment Loads
48 In. Diameter
42 In. Diameter
10 Ga.
8 Ga.
12 Ga.
10 Ga.
8 Ga.
Note: Heavy lines are from Farina Test Light lines computed from comparison test
Top of Culvert
Top of Culvert
Deflection in Inches
0
1
2
3
4
5
0
1
2
3
4
Height of Fill Over Top of Pipe in Ft
0
5
10
15
20
25
30
35

REPORT OF COMMITTEE VII—WOODEN BRIDGES AND TRESTLES

Arthur Ridgway, *Chairman;*	J. B. Maddock, *Vice-Chairman;*
H. Austill,	D. F. Holtman,
O. C. Badger,	W. H. Hoyt,
Charles Chandler,	T. F. Laist,
C. R. Chevalier,	J. R. C. Macredie,
C. M. Chumley,	J. A. Newlin,
F. H. Cramer,	C. E. Paul,
W. J. Gooding,	G. W. Rear,
E. M. Grime,	D. W. Smith,
W. E. Hawley,	G. C. Tuthill,
F. M. Hawthorne,	J. T. Vitt,
C. S. Heritage,	S. L. Wonson,
C. J. Hogue,	S. R. Young,

Committee.

To the American Railway Engineering Association:

Your Committee respectfully presents herewith report covering the following subjects:

(1) Revision of Manual.

The report of the Sub-Committee on Revision of Manual will be found in Appendix A.

(2) Continue work of cooperation and collaboration with other organizations in simplification of grading rules and classification of timber and lumber for railway uses.

The Sub-Committee to which this subject was assigned has prepared the form of final report for consideration of the Association. This final draft will be found under Appendix B.

The subject was referred back to the Committee in the proceedings of last year, and intensive work has been done throughout the current year. A vast amount of study and investigation has been devoted to the subject, and no little time has been spent in attending conferences with other interested organizations and institutions in the national movement designed to simplify the use of the products of the whole lumber industry.

It is hoped that the Association will consider the report favorably, for they are doubtless the most comprehensive specifications of lumber and timber heretofore compiled.

(3) Value of treated timber in wooden bridges and trestles.

A progress report on this subject will be found in Appendix C. It is intended only as information, and the request is made that it be received as such.

On account of the additional work to be accomplished in the final report, the subject should be carried over for another year.

A

(4) Study and report on best methods of maintaining at a minimum consistent with economy the quantity and multiplicity of sizes of lumber and timber carried in railway stock.

Because of the necessity of assembling more data and the devotion of additional time in investigation and study by the Sub-Committee, no report is offered to the Association this year.

(5) Continue the study on classification of the uses of timber and lumber under American Railway Engineering Association specifications.

The final report on this subject was returned to the Association last year.

Because of the necessity of making this particular subject contingent upon Subject (2), specifications for lumber and timber, it had to be carried over from last year for the reason that the specifications were also returned to the Committee at the same time.

Since the final report is tendered for Subject (2) there is also offered a final report on this subject. Such report will be found in Appendix D.

(6) Outline of work for ensuing year:

The Sub-Committee to which this subject was assigned has no additional subjects to suggest for the ensuing year aside from those which must of necessity be carried over from this year's work.

The recommended suggestions for future work of the Committee are therefore as follows:

1. Revision of Manual.
2. Value of treated timber in wooden bridges and trestles.
3. Study and report on best methods of maintaining at a minimum consistent with economy the quantity and multiplicity of sizes of lumber and timber carried in railway stock.

Action Recommended

1. That the final report on Subject (2) in Appendix B, Exhibits A, B, and C, be adopted by the Association and printed in the Manual, withdrawing all material in conflict therewith. The material now in the Manual which would be withdrawn by this action extends from the bottom of page 303, beginning names for varieties of Structural Timber, to page 351; Specifications for Construction Oak, and also table of working stresses for timbers, on page 302.

2. That the final report on Subject (5) in Appendix D, Exhibit D, be adopted by the Association and printed in the Manual as a development of material appearing on pages 364 to 368, inclusive.

Respectfully submitted,

THE COMMITTEE ON WOODEN BRIDGES AND TRESTLES,
ARTHUR RIDGWAY, *Chairman.*

Appendix A

(1) REVISION OF MANUAL

H. Austill, Chairman, Sub-Committee; F. H. Cramer, F. M. Hawthorne, S. L. Wonson.

During the year your Committee continued its cooperation with the Committee on Rules and Organization in the work of revising the rules for the inspection of bridges.

Your Committee has further considered changes in definitions, names of varieties, classification terms, etc., now appearing in the Manual, which should be contemporaneous with the adoption of the proposed new specifications for timber, but it still feels that no change should be made in the above until after adoption of new specifications.

Your Committee therefore has no changes in the Manual to recommend at this time.

Due to the increasing size of the Manual and the difficulty of posting one's copy up to date, your Committee feels that an improvement in its form can be made by use of a binder and by printing in pamphlets the material which is adopted each year in a way that obsolete material may be removed and replaced by new.

Appendix B

(2) CONTINUE WORK OF COOPERATION AND COLLABORATION WITH OTHER ORGANIZATIONS IN SIMPLIFICATION OF GRADING RULES AND CLASSIFICATION OF TIMBER AND LUMBER FOR RAILWAY USES.

W. E. Hawley, Chairman, Sub-Committee; H. Austill, O. C. Badger, Charles Chandler, C. J. Hogue, D. F. Holtman, J. B. Maddock, J. A. Newlin, C. E. Paul, D. W. Smith, S. L. Wonson.

The instructions contained in the subject of this Committee's work have been carried out through the participation of the various members in the standardization program of the lumber industry under the leadership of the Central Committee on Lumber Standards, with the cooperation of the Department of Commerce and Department of Agriculture and also by attendance at the annual meeting of the American Society for Testing Materials, held at Atlantic City, June 23 to 26, 1925, where Committee D-7 of that society and this Sub-Committee held a joint meeting. Another joint meeting was held at Madison, Wisconsin, September 22.

Since the last meeting of the American Railway Engineering Association there has been held on May 1, 1925, another general conference of the lumber industry meeting in Washington, D. C., under the chairmanship of Secretary Herbert Hoover. At this conference American Lumber Standards for softwood were practically completed and these conclusions have been available to this Committee and closely followed. The following report is presented in full harmony with the intent of the American Lumber Standards.

In the section on structural timber the Committee has availed itself of the cooperation and latest developments of the Forest Products Laboratory at Madison, Wisconsin.

The Sub-Committee presents this report in full confidence that it is a more complete and better developed report than the one presented last year.

The report has been prepared with the view of withdrawal of material in the present Manual on this subject and the substitution of the new standards here given.

This Sub-Committee has collaborated with the Sub-Committee on Revision of Manual and the proposed revisions in the lumber divisions are offered to bring this section in line with the American Lumber Standards.

This Sub-Committee has also cooperated with the Sub-Committee on classification of the uses of timber and lumber under American Railway Engineering Association specifications and their report is based on the recommendations of this Committee.

"Names for Varieties of Structural Timber" and accompanying text on pages 303 and 304 is to be omitted and the following title and list below substituted therefor:

Exhibit A

COMMERCIAL NAMES FOR LUMBER AND TIMBER CUT FROM THE PRINCIPAL SPECIES OF SOFTWOODS.

The following standard commercial names for lumber and timber cut from species of softwood as listed under botanical names shall be used in the construction of contracts and other documents arising in transactions of purchase and sale of American Standard Lumber. Preferred commercial names are shown in boldface type.

Commercial Name	*Botanical Name*
	Cedars
Alaska Cedar	Chamæcyparis nootkatensis
Eastern Red Cedar	Juniperus virginiana
Incense Cedar	Libocedrus decurrens
Northern White Cedar	Thuja occidentalis
Port Orford Cedar	Chamæcyparis lawsoniana
Southern White Cedar	Chamæcyparis thyoides
Western Red Cedar	Thuja plicata
	Cypress
Southern Cypress	Taxodium distichum
Red Cypress	Taxodium distichum
Yellow Cypress	Taxodium distichum
White Cypress	Taxodium distichum
	Douglas Fir
Douglas Fir	Pseudotsuga taxifolia (Coast type)
Red Fir	Pseudotsuga taxifolia (Intermountain type)
	The True Firs
Alpine Fir	Abies lasiocarpa
Balsam Fir	Abies balsamea and Abies fraseri (Southern balsam fir)
Golden Fir	Abies magnifica
Noble Fir	Abies nobilis
Silver Fir	Abies amabilis
White Fir	Abies concolor and Abies grandis (lowland white fir)
	Hemlocks
Eastern Hemlock	Tsuga canadensis
Mountain Hemlock	Tsuga mertensiana
West Coast Hemlock	Tsuga heterophylla
	Larch
Western Larch	Larix occidentalis

Commercial Name	*Botanical Name*
	Pines
Arkansas Soft Pine	Pines echinata and taeda
California White Pine	Pinus ponderosa and Pinus jeffreyi (Jeffrey pine)
Idaho White Pine	Pinus monticola
Jack Pine	Pinus divaricata
Loblolly Pine	Pinus taeda
Lodgepole Pine	Pinus contorta
Longleaf Pine	Pinus palustris
North Carolina Pine	Pinus taeda and echinata, and Pinus Virginiana (Virginia Pine)
Northern White Pine	Pinus strobus
Norway Pine	Pinus resinosa
Pond Pine	Pinus serotina
Pondosa Pine	Pinus ponderosa
Shortleaf Pine	Pinus echinata
Slash Pine	Pinus caribaea
Southern Pine or Southern Yellow Pine	Pinus taeda, palustris, serotina, echinata, and caribaea, and Pinus rigida (pitch pine) and Pinus glabra (spruce pine)
Sugar Pine	Pinus lambertiana
	Redwood
Redwood	Sequoia sempervirens
	Spruces
Eastern Spruce	Picea mariana (black spruce), Picea rubra (red spruce), and Picea glauca (white spruce)
Engelmann Spruce	Picea engelmanni and Picea parryana (blue spruce)
Sitka Spruce	Picea sitchensis
	Tamarack
Tamarack	Larix laricina

USE-CLASSIFICATION

Lumber is the product of the saw and planing mill not further manufactured than by sawing, resawing, and passing lengthwise through a standard planing machine, crosscut to length, and matched.

Lumber is classified as (a) yard lumber, (b) structural timbers, and (c) shop or factory lumber. Different grading rules apply to each class of lumber.

Yard lumber is lumber that is less than six (6) inches in thickness and is intended for general building purposes. The grading of yard lumber is based upon the use of the entire piece.

Structural timber is lumber that is six (6) inches or over in thickness and width. The grading of structural timbers is based upon the strength of the piece and the use of the entire piece.

Shop or factory lumber is lumber intended to be cut up for use in further manufacture. It is graded on the basis of the percentage of the area which will produce a limited number of cuttings of a given minimum size and quality.

SIZE CLASSIFICATION

Strips are yard lumber less than two (2) inches thick and under eight (8) inches wide.

Boards are yard lumber less than two (2) inches thick, eight (8) inches or over in width.

Dimension includes all yard lumber except boards, strips and timbers, that is, yard lumber two (2) inches and under six (6) inches thick, and of any width.

Planks are yard lumber two (2) inches and under four (4) inches thick and eight (8) inches and over wide.

Scantlings are yard lumber two (2) inches and under six (6) inches thick and under eight (8) inches wide.

Heavy joists are yard lumber four (4) inches and under six (6) inches thick and eight (8) inches or over wide.

MANUFACTURING CLASSIFICATION

Manufactured lumber is classified as rough, surfaced, and worked.

Rough lumber is undressed lumber as it comes from the saw.

Surfaced lumber is lumber that is dressed by running through a planer. It may be surfaced on one side (S1S), two sides (S2S), one edge (S1E), two edges (S2E), or a combination of sides and edges (S1S1E) (S2S1E) (S1S2E) or (S4S).

Worked lumber is lumber which has been run through a matching machine, sticker or molder. Worked lumber may be matched, shiplapped or patterned.

Matched lumber is lumber that is edge dressed and shaped to make a close tongue and groove joint at the edges or ends when laid edge to edge or end to end.

Shiplapped lumber is lumber that is edge dressed to make a close rabbetted or lapped joint when laid edge to edge.

Patterned lumber is worked lumber that is shaped to a patterned or moulded form.

DEFINITIONS OF MAXIMUM DEFECTS AND BLEMISHES

The following definitions vary slightly from the definitions of the American Lumber Standards. Definitions of regional lumber associations also vary slightly from American Lumber Standards. This should be considered in making contracts.

The terms "Defect" and "Blemish" as applied to wood usually imply the idea of imperfections. These are not always detrimental.

Defect.—Any irregularity or want occurring in or on wood that may lower some of its strength, durability or utility values.

Blemish.—Any mark or formation of wood structure, not classified as a defect, marring the appearance of the wood.

The presence of a defect or blemish may or may not be detrimental to the value of the material, depending upon the character of the defect or blemish and the use of the material.

Bark Pocket

Bark Pocket.—A patch of bark partially or wholly enclosed in the wood. In size it is classified the same as pitch pockets.

Bird's-eye

"Bird's-Eye."—A small central spot with the wood fibers arranged around it in the form of an ellipse, so as to give the appearance of an eye. "Bird's-Eye," unless unsound or hollow, shall not be considered a defect.

Checks

Check.—A lengthwise separation of the wood, which occurs usually across the rings of annual growth.

Surface Check.—A check occurring on the surface of the piece.

Small Surface Check.—A perceptible opening not over four (4) inches long.

Medium Surface Check.—A check not over $\frac{1}{32}$ inch wide and over four (4) but not more than ten (10) inches long.

Large Surface Check.—A check over $\frac{1}{32}$ inch wide and over ten (10) inches long.

End Check.—Check occurring on an end of a piece.

Through Check.—Check extending from one surface through the piece to the opposite surface or to an adjoining surface.

Heart Check.—Check starting at the pith and extending toward but not to the surface of a piece.

Honeycombing.—Checks occurring in the interior of a piece, often not visible on the surface. On a cross-section they usually appear as slits, or as open pockets whose width may appear very large in proportion to the radial length.

Cross Breaks

Cross Break.—A separation of the wood cells across the grain, such as may be due to tension resulting from unequal shrinkage or mechanical stresses.

Cross Grain

Cross Grain.—Wood in which the cells or fibers do not run parallel with the axis, or sides, of a piece. It may be classified as spiral, diagonal, wavy, dip, curly and interlocked grain. The slope of the grain can be determined by observing the direction of surface checks, resin ducts, pores of the wood, annual layers of growth, etc. A drop of stained liquid, such as ink, tends to elongate in the direction of the grain when placed on a smooth surface of the piece.

Spiral Grained.—Wood in which the fibers take a more or less winding or spiral course, such as occurs in a twisted tree. It may be detected on the flat grain (plain sawed or tangential) surface.

Diagonal Grained.—Wood in which the fibers extend at an angle (i. e., diagonally) across a piece as a result of sawing at an angle across the annual layers of growth. It may appear on either the radial or tangential surface.

Wavy Grained.—Wood in which the fibers take the form of waves or undulations as indicated by the wavy surface of the split piece. It may appear on either the radial or tangential surfaces.

Dip Grained.—Wood which has one wave or undulation of the fibers such as occurs around knots, pitch pockets, etc.

Curly Grained.—Wood in which the fibers are distorted so that they take a curled direction as in "Bird's-Eye Wood." These patches may vary up to several inches in diameter.

Interlocked Grain.—Wood which shows spiral grain in one direction for a number of years and then the slope of the grain in the succeeding annual layers of growth turns in a reverse direction around the tree, then later reverses back, etc.

Slight Cross Grain.—Wood in which slope of the grain is not over one (1) inch in a length of fifteen (15) inches.

Medium Cross Grain.—Wood in which slope of the grain is over one (1) inch in a length of fifteen (15) inches but not more than one (1) inch in a length of ten (10) inches.

Steep Cross Grain.—Wood in which slope of the grain is over 1 inch in a length of 10 inches.

Decay

Decay.—A disintegration of wood substance due to the action of wood-destroying fungi. The words "dote" and "rot" mean the same as decay.

Incipient Decay.—An early stage of decay in which the disintegration has not proceeded far enough to soften or otherwise change the hardness of the wood perceptibly. It is usually accompanied by a slight discoloration bleaching of the wood.

Firm Red Heart.—A stage of incipient decay characterized by a reddish color produced in the heartwood, which does not unfit the wood for the majority of yard purposes.

Water-Soak (or Stain).—A term applied to a generally water-soaked area in heartwood, which is usually interpreted as the incipient stage of certain wood rots.

Advanced (or typical) Decay.—The older stage of decay in which the disintegration is readily recognized because the wood has become punky, soft and spongy, stringy, ringshaked, pitted or crumbly. Decided discoloration or bleaching of the rotted wood is often apparent.

Pocket Rot.—Typical decay which appears in the form of a hole, pocket, or area of soft rot, usually surrounded by apparently sound wood.

Gum Spots and Streaks

Gum Spot or Streak.—An accumulation of gum-like substance occurring as a small patch or streak in a piece. They may occur in conjunction with a bird peck, or other injury to the growing wood. In size they are classified the same as pitch pockets or pitch streaks.

Holes

Holes in wood may extend partially or entirely through the piece and be from any cause.

When holes are permitted, the average of the maximum and minimum diameters measured at right angles to the direction of the hole shall be used in measuring the size, unless otherwise stated.

Pin worm hole—One not over 1/16 inch in diameter.

Medium worm hole—One over 1/16 but not more than ¼ inch in diameter.

Large worm hole—One over ¼ inch in diameter.

Imperfect Manufacture

Imperfect manufacture includes all defects or blemishes which are produced in manufacturing, such as chipped grain, loosened grain, raised grain, torn grain, skips in dressing, hit and miss, variation in sawing, miscut lumber, machine burn, machine gouge, mismatching and insufficient tongue or groove.

Chipped Grain.—A part of the surface chipped or broken out in very short particles below the line of cut. It should not be classed as torn grain and, as usually found, shall not be considered a defect, unless it is present in excess of 25 per cent of the area.

Loosened Grain.—A small portion of the wood which has become loosened but not displaced. It occurs on the heartside of the piece and is a serious defect, especially in flooring.

Raised Grain.—A roughened condition of the surface of dressed lumber in which the hard summerwood is raised above the softer springwood, but not torn loose from it.

Torn Grain.—A part of the wood which is torn out in dressing, and in depth is of four distinct characters; slight, medium, heavy and deep.

Slight Torn Grain.—Not more than 1/32 inch in depth.

Medium Torn Grain.—More than 1/32 but not more than 1/16 inch in depth.

Heavy Torn Grain.—More than 1/16 but not more than ⅛ inch in depth.

Deep Torn Grain.—More than ⅛ inch in depth.

Skip.—An area on a piece that failed to surface.

Slight Skip.—One that failed to surface smoothly, whose area does not exceed the product of the width of the piece in inches multiplied by six (6).

Heavy Skip.—One that the planer knife did not touch.

Hit and Miss.—A series of skipped spots with surfaced areas between, or with skips the entire length when not over 1/16 inch in depth.

Variation in Sawing.—A deviation from the line of cut.

Slight Variation.—Not more than 1/16 inch in one-inch material, ⅛ inch in 2-inch, 3/16 in 3 to 7-inch, and ¼ inch in 8 inches and up.

Miscut Lumber.—That which has a greater variation in thickness or width at different places on the piece than specified for variation in sawing.

Machine Burn.—A darkening or charring of the wood due to overheating by the machine knives.

Machine Gouge.—A groove across a piece due to the machine cutting below the desired line of cut.

Mismatched Material.—Worked material that does not fit tightly at all points of contact between adjoining pieces, or in which the surfaces of adjoining pieces are not in the same plane.

Slight Mismatch.—A surface variation not more than $\frac{1}{64}$ inch.

Medium Mismatch.—A surface variation more than $\frac{1}{64}$ but not more than $\frac{1}{32}$ inch.

Heavy Mismatch.—A surface variation more than $\frac{1}{32}$ inch.

Knots

Knot.—A portion of branch or limb which has become incorporated in the body of the tree. Knots are classified according to size, form, quality and occurrence. They are measured on the surface of the piece. The average of the maximum and minimum diameters shall be used in measuring the size of knots, unless otherwise stated.

Size

Pin Knot.—One not more than ½ inch in diameter.

Small Knot.—One more than ½ inch but not more than ¾ inch in diameter.

Medium Knot.—One more than ¾ inch but not more than 1½ inches in diameter.

Large Knot.—One more than 1½ inches in diameter.

Form

Round Knot.—One oval or circular in form.

Spike Knot.—A branch or limb sawed in a lengthwise direction.

Quality

Sound Knot.—One solid across its face, as hard as the surrounding wood, and showing no indications of decay. It may vary in color from red to black.

Unsound Knot.—One solid across its face but containing incipient decay.

Decayed Knot.—One softer than the surrounding wood and containing advanced decay.

Tight Knot.—One so fixed by growth or position that it will firmly retain its place in the piece.

Intergrown Knot.—One whose rings of annual growth are completely intergrown with those of the surrounding wood.

Watertight Knot.—One whose rings of annual growth are completely intergrown with those of the surrounding wood on one surface of the piece, and which is sound on that surface.

Encased Knot.—One whose rings of annual growth are not intergrown and homogeneous with those of the surrounding wood. The encasement may be partial or complete; or pitch or bark.

LOOSE KNOT.—One not held firmly in place by growth or position and which cannot be relied upon to remain in place in the board.

PITH KNOT.—A sound knot with a pith hole not more than ¼ inch in diameter.

HOLLOW KNOT.—An apparently sound knot with a relatively large hole in it.

Occurrence

SINGLE KNOT.—One occurring by itself with the fibers of the wood in which it occurs deflected around it.

KNOT CLUSTER.—Two or more knots grouped together as a unit with the fibers of the wood deflected around the entire unit. A group of single knots is not a knot cluster.

BRANCH KNOTS.—Two or more knots branching from a common center.

Pitch

PITCH.—A poorly defined accumulation of resin in the wood cells in a more or less irregular patch.

LIGHT PITCH.—Lightly evident presence of pitch.

MEDIUM PITCH.—Slightly more evident trace of pitch than the light pitch.

HEAVY PITCH.—Very evident presence of pitch showing by its color and consistency.

MASSED PITCH.—A clearly defined accumulation of solid pitch in a body by itself in a piece of lumber.

Pitch Pockets

PITCH POCKET.—A well defined opening between rings of annual growth usually containing, or which has contained, more or less pitch, either solid or liquid. Bark also may be present in the pocket.

VERY SMALL PITCH POCKET.—One not more than ⅛ inch in width and not over two (2) inches in length.

SMALL PITCH POCKET.—One not more than ⅛ inch in width and not more than 4 inches in length, or not more than ¼ inch in width and not more than 2 inches in length.

MEDIUM PITCH POCKET.—One not more than ⅛ inch in width and not more than 8 inches in length, or not more than ⅜ inch in width and not more than 4 inches in length.

LARGE PITCH POCKET.—One whose width or length exceeds the maximum stated as permissible for a medium pitch pocket.

CLOSED PITCH POCKET.—One that does not show an opening on both sides of the piece.

Pitch Seam

PITCH SEAM.—A shake or check which is filled with pitch.

Pitch Streaks

PITCH STREAK.—A well-defined accumulation of pitch in more or less regular streak.

SMALL PITCH STREAK.—One not more than 1/12 the width by 1/6 the length of the surface on which it occurs.

MEDIUM PITCH STREAK.—One more than 1/12 but not more than 1/6 the width, by over 1/6 but not more than 1/3 the length of the surface on which it occurs.

LARGE PITCH STREAK.—One more than 1/6 the width by 1/3 the length of the surface on which it occurs.

Pith

PITH.—The small soft core occurring in the structural center of the log. The wood immediately surrounding the pith often contains small checks, shake, or numerous pin knots, and is discolored; any such combination of defects and blemishes is known as heart center.

Pith Fleck

PITH FLECK.—A narrow streak resembling pith, usually brownish, up to several inches in length on the surface of a piece resulting from burrowing of larvæ in the growing tissue of the tree.

Shake

SHAKE.—A lengthwise separation of the wood, which occurs usually between and parallel to the rings of annual growth.

FINE SHAKE.—One with a barely perceptible opening.

SLIGHT SHAKE.—One with more than a perceptible opening but not more than 1/32 inch in width.

MEDIUM SHAKE.—One with an opening more than 1/32 but not more than 1/8 inch width.

OPEN SHAKE.—One with an opening more than 1/8 inch wide.

THROUGH SHAKE.—One extending from one surface through the piece to the opposite surface or to an adjoining surface.

Splits

SPLIT.—A lengthwise separation of the wood, due to the tearing apart of the wood cells.

SHORT SPLIT.—One whose length does not exceed either the width of a piece or 1/6 its length.

MEDIUM SPLIT.—One whose length exceeds the width of a piece, but does not exceed 1/6 its length.

LONG SPLIT.—One whose length exceeds 1/6 the length of a piece.

Stain (or Discoloration)

STAIN.—Discoloration, occurring on or in lumber of any color other than the natural color of the piece on which it appears. It is classified as light, medium and heavy.

LIGHT STAIN.—A slight difference in color which will not materially impair the appearance of the piece if given a natural finish.

MEDIUM STAIN.—A pronounced difference in color which, although it does not obscure the grain of the wood, would customarily be objectionable in a natural but not in a painted finish.

HEAVY STAIN.—A difference in color so pronounced as practically to obscure the grain of the wood.

Wane

WANE.—Bark, or lack of wood, from any cause, on the edge or corner of a piece.

SLIGHT WANE.—Not more than ¼ inch wide on the surface on which it appears, for 1/6 the length and ¼ the thickness of the piece.

MEDIUM WANE.—More than ¼ inch but not more than ½ inch wide on the surface on which it appears, for 1/6 the length and ¼ the thickness of the piece.

LARGE WANE.—More than ½ inch wide on the surface on which it appears, and/or over 1/6 the length and ¼ the thickness of the piece.

Warp

WARP.—Any variation from a true or plane surface. It includes bow, crook, cup, or any combination thereof.

BOW.—Deviation flatwise from a straight line drawn from end to end of a piece, measured at the point of greatest distance from the straight line.

CROOK.—Deviation edgewise from a straight line drawn from end to end of a piece, measured at the point of greatest distance from the straight line. It is known as slight, small, medium and large.

Based on a piece 4 inches wide and 16 feet long, the distances for the different degrees of crook shall be for:

Slight crook, a maximum of 1 inch.
Small crook, a maximum of 1½ inches.
Medium crook, a maximum of 3 inches.
Larger crook, more than 3 inches.

For wider piece it shall be ⅛ inch less for each additional 2 inches of width. Shorter or longer piece may have the same curvature.

CUP.—A curve in a piece across the grain or width of a piece. It is measured at the point of greatest deviation from a straight line drawn from edge to edge of a piece. It is known as slight, medium and deep.

Based on a piece 12 inches wide, the distances for the different degrees of cup shall be for:

Slight cup, a maximum of ¼ inch.
Medium cup, a maximum of ⅜ inch.
Deep cup, a maximum of ½ inch.

Narrower or wider pieces may have the same curvature.

STANDARD LUMBER ABBREVIATIONS

The following standard lumber abbreviations when used in the construction of contracts and other documents arising in transactions of purchase and sale of American standard lumber shall be construed as herein provided:

AD	Air-dried
a. l.	All lengths
av.	Average
av.w.	Average width
av.l.	Average length
a.w.	All widths
B1S	Beaded one side

B2S	Beaded two sides
BBS	Box bark strips
bd.	Board
bd.ft.	Board foot; i. e., an area of one square foot by one inch thick.
bdl.	Bundle
bdl. bk.s.	Bundled bark strips
Bev.	Bevelled
B/L	Bill of Lading
b.m.	Board (foot) measure
Btr.	Better
CB1S&E	Edge and center bead one side; i. e., surfaced one or two sides and with a longitudinal edge and center bead on a surfaced face.
CB2S&E	Edge and center bead two sides; i. e., all four sides surfaced and with a longitudinal edge and center bead on the two faces.
c. & f.	(named port) Cost and freight to named port. Term used when the seller is ready to go farther than the delivery of his goods upon a vessel and is willing to pay transportation to another port.
c.i.f.	(named port) Cost, insurance, and freight to a named port. Term used when the seller desires to quote a price covering the cost of the goods, the marine insurance on the goods, and all transportation charges to the point of delivery.
c.i.f.e.	(named port) Cost, insurance, freight and exchange to a named port. This is the same as c.i.f. with the additional provision that the seller guarantees the buyer against loss due to a decline in the rate of exchange.
Clg.	Ceiling
Clr.	Clear
CM	Center matched; i. e., the tongue and groove joints are worked along the center or the edges of the piece.
Com.	Common
Coop.	Cooperage (stock)
Csg.	Casing
Ctg.	Crating
cu.ft.	Cubic foot
Cust.	Custom (sawed)
CV1S&E	Edge and center V one side; i. e., surfaced one or two sides and with a longitudinal edge and center V-shaped groove on a surfaced face.
CV2D&E	Edge and center V two sides; i. e., all four sides surfaced and with a longitudinal edge and center V-shaped groove on the two faces.
D&CM	Dressed (one or two sides) and center matched.
D&H	Dressed and headed; i. e., dressed one or two sides and worked to tongue and groove joints on both the edge and the ends.
D&M	Dressed and matched; i. e., dressed one or two sides and tongued and grooved on the edges. The match may be center or standard.
D&SM	Dressed (one or two sides) and standard matched.
D2S&CM	Dressed two sides and center matched.
D2S&M	Dressed two sides and (center or standard) matched.
D2S&SM	Dressed two sides and standard matched.
Dim.	Dimension

D.S.	Drop siding
E.	Edge
ECM	Ends center matched
EM	End matched—either center or standard
ESM	Ends standard matched
exp.	Export (lumber or timber)
FAS	Firsts and Seconds—a combined grade of the two upper grades of hardwoods.
f.a.s. vessel	(named port) Free alongside vessel at a named port. Term used when the seller desires to quote a price covering delivery of the goods alongside a vessel and within reach of its loading tackle.
f.bk.	Flat back
fcty.	Factory (lumber)
F.G.	Flat grain
Flg.	Flooring
f.o.b.	(named shipment point) Free on board at a named shipping point. Term used when the price quoted applies only to an inland shipping point and the seller merely undertakes to load the goods on or in cars or lighters furnished by the railroad company serving the industry, or most conveniently located to the industry, without other designation as to routing.
f.o.b.	(named point) Freight prepaid to (named point). Free on board at a named point and freight prepaid to a named point. Term used when the seller quotes a price including transportation charges to a given point without assuming responsibility for the goods after obtaining a clean bill of lading at point of origin.
f.o.b.	(named point) Freight allowed to (named point). Free on board at a named point and freight allowed to a named point. Term used where the seller wishes to quote a price from which the buyer may deduct the cost of transportation to the point of destination, without the seller assuming responsibility for the goods after obtaining a clean bill of lading at the point of origin.
f.o.b. cars	(named destination point) Free on board cars at a named destination point. Term used when the seller desires to quote a price covering the transportation of the goods to a given point, assuming responsibility for loss and/or damage up to that point.
f.o.b. cars	(named point) Free on board cars at a named point less carload lots. Term used when the goods on which a price is quoted to a given point, constitutes less than a carload lot.
f.o.b.	(named port) Lighterage free. Free on board at a named port with lighterage free. Term used when seller desires to quote a price which will include the expense of transportation of the goods by rail to the seaboard, including lighterage.
f.o.b. vessel	(named port) Free on board vessel at a named port. Term used when the seller desires to quote a price covering all expenses up to and including delivery of the goods upon a vessel at a named port.
f.o.k.	Free of knots.
f.o.w.	First open water.
Frm.	Framing.

ft.	Foot or feet. Also one accent ('). See symbols.
ft. b.m.	Feet board measure.
ft. s.m.	Feet surface measure.
Furn.	Furniture (stock).
G.R.	Grooved roofing.
H.bk.	Hollow back.
Hdl.	Handle (stock).
hdwd.	Hardwood.
Hrt.	Heart.
Hrtwd.	Heartwood.
1s&2s	One and Twos—a combined grade of the hardwood grades of firsts and seconds.
Impl.	Implement (stock).
in.	Inch or inches. Also two accent marks ("). See symbols.
KD	Kiln-dried.
k.d.	Knocked down.
lbr.	Lumber.
l.c.l.	Less carload lots.
lgth.	Length.
lgr.	Longer.
lin. ft.	Linear foot; i. e., 12 inches.
LR	Log run.
LR,MCO	Log run, mill culls cut.
Lth.	Lath.
M.	Thousand.
M. b.m.	Thousand (feet) board measure.
MCO	Mill culls out.
Merch.	Merchantable.
m. l.	Mixed lengths.
Mldg.	Moulding.
MR	Mill run.
M.s.m.	Thousand (feet) surface measure.
m.w.	Mixed widths.
No.	Number.
Ord.	Order.
P.	Planed.
Pat.	Pattern.
Pky.	Pecky.
Pln.	Plain, as plain sawed.
Pn.	Partition.
Prod.	Production.
Qtd.	Quartered—when referring to hardwoods.
rdm.	Random.
res.	Resawed.
Rfg.	Roofing.
Rfrs.	Roofers.
rip.	Ripped.
r.l.	Random lengths.
rnd.	Round.
R. Sdg.	Rustic siding.
r.w.	Random widths.
S&E	Surfaced one side and one edge.
S1E	Surfaced one edge.
S2E	Surfaced two edges.
S1S	Surfaced one side.
S2S	Surfaced two sides.
S1S1E	Surfaced one side and one edge.
S2S1E	Surfaced two sides and one edge.

S1S2E	Surfaced one side and two edges.
S4S	Surfaced four sides.
S4SCS	Surfaced four sides with a calking seam on each edge.
S&CM	Surfaced (one or two sides) and center matched.
S&M	Surfaced and matched; i. e., surfaced one or two sides and tongued and grooved on the edges. The match may be center or standard.
S&SM	Surfaced (one or two sides) and standard matched.
S2S&CM	Surfaced two sides and center matched.
S2S&M	Surfaced two sides and (center or standard), matched.
S2S&SM	Surfaced two sides and standard matched.
Sap.	Sapwood.
SB	Standard bead.
Sd.	Seasoned.
Sdg.	Siding.
Sel.	Select.
S. E. Sdg.	Square edge siding.
s.f.	Surface foot; i e.., an area of one square foot.
Sftwd.	Softwood.
Sh. D.	Shipping dry.
Ship.	Shipment or shipments.
Shlp.	Shiplap.
s. m.	Surface measure.
SM	Standard matched.
smkd.	Smoked (dried).
smk.stnd.	Smoke stained.
s.n.d.	Sap no defect.
snd.	Sound.
sq.	Square.
Sq.E&S	Square edged and sound.
sqrs.	Squares.
Std.	Standard.
stnd.	Stained.
stk.	Stock.
stp.	Stepping.
S.W.	Sound wormy.
Symbols:	″—inch or inches, as 12″. ′—foot or feet, as 12′. ×—by, as 6 × 8 timber. 4/4, 5/4, 6/4, 8/4, etc. = 1 inch, 1¼ inches, 1½ inches, 2 inches, etc., when referring to the size of lumber.
T&G	Tongued and grooved.
TB&S	Top bottom, and sides.
Tbrs.	Timbers.
V1S	V one side; i. e., a longitudinal V-shaped groove on one face of a piece of lumber.
V2S	V two sides; i. e., a longitudinal V-shaped groove on two faces of a piece of lumber.
V.G.	Vertical grain.
w.a.l.	Wider, all lengths.
Wth.	Width.
wdr.	Wider.
Wgn.	Wagon (stock).
wt.	Weight.

AMERICAN LUMBER STANDARDS FOR SOFTWOOD LUMBER

Classification

1. For the purposes of simplification of sizes and grades, and of equalizing, among species used for similar general purposes, the grades of a similar name, lumber shall be classified by principal uses into (a) yard lumber, (b) structural timbers, (c) shop or factory lumber.

Note.—See definitions for further details of various kinds of lumber.

Yard Lumber

2. The term "yard lumber" as here used means lumber that is manufactured and classified into those sizes, shapes, and qualities required for ordinary construction and general purpose uses. Heavy timbers for structural purposes, softwood factory lumber, hardwood factory lumber, and other special-use materials are not considered yard stock.

GRADE STANDARDS

Grades

3. On the basis of quality, yard lumber is divided into two main divisions: (a) Select lumber, and (b) Common lumber.

These are again divided into two classes—

Select lumber into
- (1) that suitable for natural finishes and
- (2) that suitable for paint finishes;

Common lumber into
- (1) that which can be used without waste and
- (2) that which permits some waste. Each of these four classes is further divided into quality classes or grades.

SELECT LUMBER

Select Lumber

4. Lumber which is generally clear, containing defects limited both as to size and number and which is smoothly finished and suitable for use as a whole for finishing purposes or other uses in which large, clear pieces are required, shall be considered Select Lumber.

5. Two classes shall be recognized. The first shall be suitable for natural finishes. The second class permits similar defects, and, in addition, blemishes of somewhat greater extent than those of the first class, but of a type which can be covered by paint.

Grade names are A, B, C, and D.

COMMON LUMBER

Common Lumber

6. Lumber containing numerous defects and blemishes which preclude it from use for finishing purposes, but which is suitable for general utility and construction purposes shall be considered Common lumber.

7. Two general classes shall be recognized. The first shall be suitable for use as a whole for purposes in which surface covering or strength is

required. Defects and blemishes permitted in this class must be sound. The second class permits very coarse defects which may cause waste in the use of the piece.

Grade Names: No. 1 Common, No. 2 Common, No. 3 Common, No. 4 Common, and No. 5 Common.

Dimension Grade Names: No. 1 Common, No. 2 Common, and No. 3 Common.

BASIC GRADE CLASSIFICATION FOR YARD LUMBER

8.

- Total products of a typical log arranged in series according to quality as determined by appearance.
  - Select Lumber of Good Appearance and finishing qualities
    - Suitable for natural finishes
      - Grade A—Practically free from defects.
      - Grade B—Allows a few small defects or blemishes.
    - Suitable for paint finishes
      - Grade C—Allows a limited number of small defects or blemishes that can be covered with paint.
      - Grade D—Allows any number of defects or blemishes which do not detract from a finish appearance, especially when painted.
  - Common Lumber containing defects or blemishes which detract from a finish appearance but which is suitable for general utility and construction purposes
    - Lumber suitable for use without waste
      - No. 1 Common—Sound and tight knotted stock. Size of defects and blemishes limited. May be considered water-tight lumber.
      - No. 2 Common—Allows large and coarse defects. May be considered grain-tight lumber.
    - Lumber permitting waste
      - No. 3 Common—Allows larger and coarser defects than No. 2 and occasional knot holes.
      - No. 4 Common—Low quality lumber admitting the coarsest defects such as rot and holes.
      - No. 5 Common—Must hold together under ordinary handling.

Refer to Regional Associations

9. With the above as a basis the various regional lumber manufacturer's associations have published grading rules in detail for their products and reference should be made to these rules in interpreting the practical application of these divisions of lumber into quality classes.

10. As in the case of definitions, some of the provisions vary slightly from the American Lumber Standards and the particular rules under which shipment is to be made should be considered in making contracts.

GENERAL PROVISIONS

Variation in Grading and Inspection

11. The grading of lumber cannot be considered an exact science, because it is based on a visual inspection of each piece and on the judgment of the grader. The provisions of these specifications, however, are sufficiently explicit to establish 5 per cent below grade as a reasonable variation between graders.

Better Face

12. Except in dimension, the grade of yard lumber, rough or surfaced two sides, shall be determined from the better or face side of the piece,

Surfaced Face

and lumber which is surfaced one side only shall be graded from the surfaced side.

Poorest Piece

13. The rules for yard lumber prescribe the number and extent of defects and blemishes in the poorest pieces admissible in each grade.

Area of Piece

14. The number of defects and blemishes permitted varies as the area of the piece to be graded increases or diminishes in respect to the standard size specified, but the size of the defects must not exceed that allowed by the grading rules.

Combinations of Defects

15. When defects or blemishes or combinations thereof, not described in these grading rules are encountered, they will be considered as equivalent to known defects according to their damaging effect upon the piece in the grade under consideration.

Vertical Grain

16. Material shall be considered vertical grain when the rings (so-called grain) form an angle of 45 degrees or more with the surface of the piece. When the angle becomes less than 45 degrees at any point, the material shall be known as flat (slash) grain.

Mixed Grades

17. Mixed grades other than the two highest recognized grades for each species, not specifying the proportion of each grade, are not American Lumber Standard grades.

SIZE STANDARDS

18. The thickness and width of finished lumber, S1S or S2S and/or S1E or S2E, shall be in accordance with following tables:

Finish, Common Boards and Strips, and Dimension

(The thicknesses apply to all widths and the widths to all thicknesses)

Product	*Size, board measure*		*Dressed dimension at standard commercially dry shipping weight*		
	Thickness Inches	*Width Inches*	*Thickness Inches*	*Thickness extra standard Inches*	*Width Inches*
Finish					
		3	5/16		2⅝
		4	7/16		3⅝
		5	9/16		4⅝
		6	11/16		5⅝
	1	7	25/32	26/32	6⅝
	1¼	8	1 1/16		7½
	1½	9	1 5/16		8½
	1¾	10	1 7/16		9½
	2	11	1⅝		10½
	2½	12	2⅛		11½
	3		2⅝		
Common Boards and Strips					
	1	3	25/32	26/32	2⅝
	1¼	4	1 1/16		3⅝
	1½	5	1 5/16		4⅝
		6			5⅝
		7			6⅝
		8			7½
		9			8½
		10			9½
		11			10½
		12			11½
Dimension					
	2	2	1⅝	1-6/8	1⅝
	2½	4	2⅛		3⅝
	3	6	2⅝		5⅝
	4	8	3⅝		7½
	over 4	10	off ⅜		9½
		12			11½

Siding, Flooring, Ceiling, Partition, Shiplap, and Dressed and Matched 19.

(The thicknesses apply to all widths and the widths to all thicknesses)

Product	*Size, board measure*		*Dressed dimension at standard commercially dry shipping weight*	
	Thickness Inches	*Width Inches*	*Thickness Inches*	*Width Inches*
Bevel Siding				
		4	7/16 (minimum) x 3/16	3½
		5	10/16 x 3/16	4½
		6		5½
Rustic and drop siding				
		4	9/16	(1) 3⅛
		5	¾	(1) 4⅛
		6		(1) 5⅛
		8		(1) 7⅛
Flooring				
		2	5/16	1½
		3	7/16	2⅜
		4	9/16	3¼
		5	25/32	4¼
	1	6		5¼
	1¼		1 1/16	
	1½		1 5/16	
Ceiling				
		3	5/16	2⅜
		4	7/16	3¼
		5	9/16	4¼
		6	11/16	5¼
Partition				
		3	¾	2⅜
		4		3¼
		5		4¼
		6		5¼
Shiplap				
	1	4	25/32	3⅛
		6		5⅛
		8		7⅛
		10		9⅛
		12		11⅛
Dressed and Matched				
	1	4	25/32	3¼
	1¼	6	1 1/16	5¼
	1½	8	1 5/16	7¼
		10		9¼
		12		11¼

(1) Shiplapped; face widths, D&M, ⅛ inch wider than shiplapped.

The over-all widths of patterned material, 1, 1¼ and 1½ inches thick may be computed on the basis that the tongue shall be ¼ inch wide in the tongued and grooved lumber, and the lap ⅜ inch wide in shiplapped lumber.

Factory Flooring, Heavy Roofing, Decking and Sheet Piling

20.

(The thicknesses apply to all widths and the widths to all thicknesses)

Size, board measure		*Dressed dimension at standard commercially dry shipping weight*			
			Face Width		
Thickness Inches	*Width Inches*	*Thickness Inches*	*D&M Inches*	*Shiplapped Inches*	*Grooved for splines Inches*
2	4	1⅝	3⅛	3	3½
2½	6	2⅛	5⅛	5	5½
3	8	2⅝	7⅛	7	7½
4	10	3⅝	9⅛	9	9½
	12		11⅛	11	11½

The over-all widths of patterned material 2 inches and thicker may be computed on the basis that the tongue shall be ⅜ inch wide in tongued and grooved lumber, and the lap ½ inch wide in shiplapped lumber.

ROUGH DRY SIZES

Thickness Standard Board

Extra Standard Board

21. The standard rough dry thickness of the standard board shall be not less than 29/32 with an allowance of 20 per cent of the shipment, which may be not less than 28/32 inch, and the standard rough dry thickness of the extra standard board shall be not less than 30/32 inch with an allowance of 10 per cent of the shipment, which may be not less than 29/32 inch.

Thick Boards

22. The standard rough dry thickness of finish, common boards, and dimension of standard sizes 1¼ inches and thicker, board measure, shall not be less than ⅛ inch thicker than the corresponding standard finished dry thickness, with an allowance of 20 per cent of the shipment, which may not be less than 3/32 inch thicker than the corresponding standard finished dry thickness.

Widths

23. The widths of finish, common boards, and dimension, rough and commercially dry, 7 inches and narrower, shall be not more than ¼ inch less than the nominal widths, and the width 8 to 12 inches board measure shall be not more than ⅜ inch less than nominal widths.

LENGTHS

Lengths

24. With the exception of the following enumerated odd lengths, no odd lengths are considered standard in yard lumber.

2 by 4 inches, 6 and 8 inches—9 and 11 feet.
2 by 8 inches, and 10 inches—13 feet.
2 by 10 inches—15 feet
8 by 8 inches, 10 by 10 inches, 10 by 12 inches, 12 by 12 inches, 14 by 14 inches, 16 by 16 inches, 18 by 18 inches—11 and 13 feet.
6 by 16 inches, 6 by 18 inches, 8 by 16 inches, 8 by 18 inches—15 and 17 feet.
*7 by 16 inches, 9 by 16 inches, 9 by 18 inches—15 and 17 feet.

---

*Not mentioned in American Lumber Standards, but necessary in railroad use.

WORKINGS

Flooring

25. The standard working of flooring, 4 inches or under in width shall be S2S, SM, scratched back.

End Trimming

26. Unless otherwise stated in the contract of purchase, yard lumber shall be double end-trimmed with a tolerance of not to exceed 3 inches in excess of nominal length.

DESCRIPTION, MEASUREMENT AND TALLY

Tally Standard and Special

27. The thicknesses and widths of yard lumber as specified in Sections 18, 19, 20, 21, 22 and 23 shall be considered standard. All other sizes shall be considered special.

Description

28. Yard lumber of standard and extra standard size shall be described by those standard dimensions.

Thin Lumber

29. Lumber of standard and extra standard size shall be tallied board measure. On lumber of standard thickness less than 1 inch (board measure), the board-foot measurement shall be based on the surface dimensions.

Tally of Dressed Lumber

30. The board measurement of dressed lumber of standard and extra standard size shall be based upon the corresponding standard dimensions of rough green lumber.

Special Size

31. Lumber finished to special size shall be counted (tallied) as of the standard rough size necessarily used in its manufacture.

Stock Sizes

32. Material shipped on stock sizes shall be tallied by the number of pieces of each size and length in the shipment.

33. In shipments measured on board measure a piece tally in board feet shall be made.

Fractions of Board Foot

34. In material measured with a board rule on actual widths, pieces measuring to the even half foot shall be alternately counted as of the next higher and lower foot count, fractions below the one-half foot shall be dropped, fractions above the one-half foot shall be counted as of the next higher foot.

SHIPPING PROVISIONS

Invoice Dimensions of Non-Standard Lumber

35. The actual thickness and width of lumber shipped when not of standard or extra standard size shall be indicated on invoice.

Uneven Sawing

36. In shipments of rough boards and finish, pieces one-half inch or more above the count thickness, such as may be produced by uneven sawing, may, at the option of the buyer, be rejected, or accepted as of the next lower grade.

Average Length

37. The average length of a shipment of lumber shall be computed by dividing the total length in feet by the total number of pieces in a shipment.

Bundling

38. Each length of bundle stock shall be bundled separately.

SHINGLES

GRADES

Grades

39. The basic grades of shingles shall be A, B, C, and D.

SIZES

Sizes

40. Sixteen-inch 6/2 shingles and 18-inch 5/2 shingles shall be eliminated.

41. Dimension shingles shall be sold full net count, no dimension shingle to be less than ⅛ inch scant of the specified width when dried.

SHIPPING PROVISIONS

Dryness and Shipping Weight

42. The kiln-dried weight of shingles shall be not more than 10 per cent under the present association shipping weights.

Openings

43. The openings shall not exceed an average of 1 inch to the course in random width shingles.

STANDARD GRADES OF RED CEDAR SHINGLES

Random Widths

A

To be strictly clear, edge grain, and free from sap. Random widths.

24″ Shingles 4/2″

44. No shingle to be narrower than 4 inches. To be packed 14/14 courses to bunch; 9 bunches to "M"; 4 bunches to "square" 7½ inches exposure, 3 bunches to square 10 inches exposure. Bunches must measure 7 inches across butts when green, 6¾ inches when dry.

18″ Shingles 5/2¼″

45. No shingles to be narrower than 3 inches. If packed by "M" must count 20/20 courses to bunch, 5 bunches to "M." Bunches must measure 9

inches across butt when green, 8¾ inches when dry. If packed by the "square" must count 18/18 courses to bunch, 4 bunches to square. Bunches must measure 8⅛ inches across butts when green, 7⅞ inches when dry.

16" Shingles 5/2"

46. No shingle to be narrower than 3 inches. If packed by "M" must count 25/25 courses to bunch, 4 bunches to "M." Bunches must measure 10 inches across butts when green, 9¾ inches when dry. If packed by the "square" must count 20/20 courses to bunch, 4 bunches to square, or 5 to "M." Bunches must measure 8 inches across butts when green, 7¾ inches when dry.

B

47. To be strictly clear. Not less than 50 per cent edge grain, with not to exceed ½ inch sap on any portion of the 5 inches measured from the butt, on one edge only.

24" Shingles 4/2"

48. None.

18" Shingles 5/2¼"

49. No shingle to be narrower than 3 inches. If packed by "M" must count 20/20 courses to bunch, 5 bunches to "M." Bunches must measure 9 inches across butts when green, 8¾ inches when dry. If packed by the "square" must count 18/18 courses to bunch, 4 bunches to square. Bunches must measure 8⅛ inches across butts when green, 7⅞ inches when dry.

16" Shingles 5/2"

50. No shingle to be narrower than 3 inches. If packed by "M" must count 25/25 courses to bunch, 4 bunches to "M." Bunches must measure 10 inches across butts when green, 9¾ inches when dry. If packed by "square" must count 20/20 courses to bunch, 4 bunches to square, or 5 to "M." Bunches must measure 8 inches across butts when green, 7¾ inches when dry.

C

51. Ten-inch clear butts and better for 16 and 18-inch shingles and 16-inch clear butts and better for 24-inch shingles not permitted in higher grades. Sap permitted.

24" Shingles 4/2"

52. No shingle to be narrower than 3 inches. To be packed 14/14 courses to bunch; 9 bunches to "M"; 4 bunches to "square" 7½ inches exposure, 3 bunches to "square" 10 inches exposure. Bunches must measure 6¾ inches across butts when green, 6½ inches when dry.

18" Shingles 5/2¼"

53. No shingle to be narrower than 2½ inches. If packed by "M" must count 20/20 courses to bunch, 5 bunches to "M." Bunches must measure 8¾ inches across butts when green, 8½ inches when dry. If packed by the "square" must count 18/18 courses to bunch, 4 bunches to square. Bunches must measure 7⅞ inches across butts when green, 7⅝ inches when dry.

16″ Shingles 5/2″

54. No shingle to be narrower than 2½ inches. If packed by "M" must count 25/25 courses to bunch, 4 bunches to "M." Bunches must measure 9¾ inches across butts when green, 9½ inches when dry. If packed by the "square" must count 20/20 courses to bunch, 4 bunches to square, or 5 to "M." Bunches must measure 7¾ inches across butts when green, 7½ inches when dry.

D

55. Six-inch clear butts for 16 and 18-inch shingles, 10-inch clear butts for 24-inch shingles. Sap permitted.

24″ Shingles 4/2″

No shingle to be narrower than 2 inches. Permits shims and feather tips 20 inches long. To be packed 14/14 courses to bunch; 9 bunches to "M"; 4 bunches to "square" 7½ inches exposure, 3 bunches to "square" 10 inches exposure. Bunches must measure 6¾ inches across butts when green, 6½ inches when dry.

18″ Shingles 5/2¼″

56. No shingle to be narrower than 2 inches. Permits shims and feather tips 16 inches long. If packed by "M" must count 20/20 courses to bunch, 5 bunches to "M." Bunches must measure 8¾ inches across butts when green, 8½ inches when dry. If packed by the "square" must count 18/18 courses to bunch, 4 bunches to square. Bunches must measure 7⅞ inches across butts when green, 7⅝ inches when dry.

16″ Shingles 5/2″

57. No shingle to be narrower than 2 inches. Permits shims and feather tips 14 inches long. If packed by "M" must count 25/25 courses to bunch, 4 bunches to "M." Bunches must measure 9½ inches across butts when green, 9¼ inches when dry. If packed by the "square" must count 20/20 courses to bunch, 4 bunches to square, or 5 to "M." Bunches must measure 7½ inches across butts when green, 7¼ inches when dry.

GENERAL RULES

58. All A and B grade shingles must be parallel (a 16 or 18-inch A or B shingle not over ¼ inch off parallel or a 24-inch A shingle not over ⅜ inch off parallel shall be considered parallel), uniform in thickness, and well manufactured. This means shims and feather tips are not permitted; smoothness of faces and butts must be first-class. Badly cross-grained shingles not permitted.

59. No full flat-grain shingle wider than 10 inches permitted in grade B, and no shingle wider than 14 inches permitted in A and B grades; 1 inch over and under in length is permitted in 10 per cent. Shingles cut from equalized blocks may be ¼ inch less than the standard length. C grade admits slight irregularities in thickness. A shingle in C grade, not over ⅜ inch off parallel, shall be considered parallel.

60. When reference is made to edge grain, percentage of edge grain shall be determined by the proportion of actual linear measurement of edge grain to full linear measurement of shingles. In 16 and 18 inch A and B

grades not more than 10 per cent of any shipment may be less than 4 inches in width.

61. All shingles to be packed in straight courses in regulation frames 20 inches in width with band sticks not less than 19½ inches long. Openings shall not exceed an average of 1 inch to the course in random width shingles. Discrepancy in inspection in any grade shall not exceed 4 per cent.

SOFTWOOD FACTORY AND SHOP LUMBER

(Cypress and Redwood not Included)

GENERAL PROVISIONS

Grade by Cuttings

62. The grade of factory lumber shall be determined by the percentage of the area of each board or plank available in cuttings of specified sizes and qualities.

63. When lumber is crooked, bowed, cupped or twisted, the cuttings must be so laid out as to be flat and straight along the edges.

Measurement—Fractions

64. Board measurement shall be used in measuring factory lumber. When measured with a board rule, pieces measuring to the even half foot shall be alternately counted as of the next higher and the next lower surface foot; fractions below the half foot shall be dropped, and fractions above the half foot shall be counted as of the next higher foot.

Thicker Than 1″

65. To determine the board foot contents of material thicker than 1 inch the surface measure should be multiplied by the nominal thickness in inches and fractions of an inch.

Based Upon Rough Green

66. The board measurement of dressed factory lumber of standard and extra-standard size shall be based upon the corresponding standard dimension of rough green lumber.

SIZES

Dressed Thicknesses

Thicknesses

67. The following thicknesses of factory lumber shall be considered standard. All other thicknesses shall be considered special.

Finished thicknesses, S1S or S2S at commercially dry shipping weight

Size Board Measure Inches	*Standard Inches*	*Extra Standard Inches*
1	$\frac{25}{32}$	26/32
1¼	$1\frac{5}{32}$	
1½	$1\frac{13}{32}$	
2	1-26/32	
2¼	2⅛	
2½	2⅜	
3	2-6/8	
4	3-6/8	

WIDTHS

Widths

68. Standard widths shall be five inches and over; factory lumber is usually shipped in random lengths, though specified widths may be shipped. Five-inch widths must be full size in the rough dry condition.

LENGTHS

Lengths

69. Standard lengths shall be six feet and over in multiples of one foot.

FACTORY PLANK

Grade

70. The grade of softwood factory boards or plank shall be determined from the poor face, although the quality of both sides of each cutting must be considered.

Door Cuttings

71. In determining the percentage of door cuttings, consideration must be given to the fact that planks are to be ripped full length before cross-cutting, in such manner as will yield the highest grade and largest percentage of door cuttings, except in such cases where planks will yield a higher value by first being cross-cut for rails. In instances where stock is cross-cut for rails and some of the stock so obtained contains stiles or muntins or top rails, which can be obtained by ripping this cross-cut stock, the door cuttings so obtained may be figured in when determining percentages.

GRADE CLASSIFICATIONS FOR SOFTWOOD FACTORY PLANK

72.

Factory Plank Factory lumber graded with reference to its use for doors, sash and other cuttings.	Factory Clears Upper grades of factory plank containing a high percentage of best quality cuttings.	No. 1 and 2 Clear Factory—Lumber practically clear in wide sizes, to contain not less than 85 per cent of No. 1 door cuttings; not including pieces with over 2 muntins, or muntins only. No. 3 Clear Factory—Lumber containing not less than 70 per cent of No. 1 door cuttings; not including pieces with over 2 muntins, or muntins only.
	Shop Lower grades of factory plank yielding smaller percentages in smaller and lower quality cuttings.	No. 1 Shop—Lumber of high quality factory grade containing not less than 50 per cent of No. 1 door cuttings; allowing, if necessary, one No. 2 stile in any piece, but no pieces with over two muntins, or muntins only. No. 2 Shop—Lumber containing not less than 25 per cent of No. 1 door cuttings, or 40 per cent of No. 2 door cuttings, or 33⅓ per cent of mixed door cuttings. No. 3 Shop—Lumber of a shop type below the grade of No. 2 Shop and better than box lumber.

QUALITY OF CUTTINGS

Cuttings No. 1 and 2

73. In determining the grades of Factory Plank, two grades of cuttings shall be recognized. These shall be known as No. 1 and No. 2 Cuttings and shall conform to the following rules.

Defects

74. No. 1 Cuttings shall be free from defects on both sides. No restrictions shall be made upon bright sapwood.

75. No. 2 Cuttings shall admit any one of the following defects:

76. Light blue stain on one side, not larger in extent than one-half the area of the side.

77. Medium brown kiln or heart stain covering half the surface on one face, or a greater area of lighter stain, or a proportionate amount on two sides.

78. A small sound and tight knot which does not exceed ⅝ of an inch in diameter.

79. A small pitch pocket not over ⅛ of an inch wide nor over 2 inches long in West Coast woods and not over ⅛ of an inch wide nor over 1 inch long in Idaho White Pine, Pondosa Pine, California White Pine and Sugar Pine.

80. One or more small season checks whose combined length does not exceed 8 inches.

81. Light pitch or small pitch streaks that do not form a pronounced defect.

82. Slightly torn grain on one side.

SIZES OF CUTTINGS

Size of Stiles

83. Stiles shall be 5 inches and 6 inches wide by 6 feet 8 inches to 7 feet 6 inches long. They may be either No. 1 or No. 2 in quality.

Bottom Rails

84. Bottom rails shall be 9 inches and 10 inches wide by 2 feet 4 inches to 3 feet long. They may be either No. 1 or No. 2 in quality.

Muntins

85. Muntins shall be 5 inches and 6 inches wide by 3 feet 6 inches to 4 feet long. They may be either No. 1 or No. 2 in quality.

Top Rails

86. Top rails shall be 5 inches and 6 inches wide by 2 feet 4 inches to 3 feet long. They must be of No. 1 Cutting quality but shall be considered as No. 2 Cuttings.

Sash Cuttings

87. Sash Cuttings shall be 2½ inches and 3½ inches in width by 28 inches and over in length.

Cuttings and Area Use

88. In computing the area of cuttings in each piece of Factory Plank the sizes listed below shall be used. After each cutting size is shown the exact surface area in square feet. For convenience in computing, the figures shown on the right, representing the area to the nearest ¼ square foot, shall be used.

Size of cutting in board or plank	*Actual Area in Sq. Ft.*	*Nominal Area to be used in application of grading rules*
	STILES	
5″x6′8″	2.78	3
5″x6′10″	2.85	
5″x7′0″	2.92	
5″x7′2″	2.99	
5″x7′4″	3.06	
5″x7′6″	3.13	
6″x6′8″	3.33	3¼
6″x6′10″	3.42	3½
6″x7′0″	3.50	
6″x7′2″	3.58	
	BOTTOM RAILS	
9″x2′4″	1.75	1¾
9″x2′6″	1.875	
9″x2′8″	2.0	2
9″x2′10″	2.125	
9″x3′0″	2.25	2¼
10″x2′4″	1.95	2
10″x2′6″	2.08	
10″x2′8″	2.22	2¼
10″x2′10″	2.36	
10″x3′0″	2.50	2½
	MUNTINS	
5″x3′6″	1.46	1½
5″x3′8″	1.53	
5″x3′10″	1.60	
5″x4′0″	1.67	1¾
6″x3′6″	1.75	
6″x3′8″	1.83	
6″x3′10″	1.92	2
6″x4′0″	2.0	
	TOP RAILS	
5″x2′4″	.97	1
5″x2′6″	1.04	
5″x2′8″	1.11	
5″x2′10″	1.18	1¼
5″x3′0″	1.25	
6″x2′4″	1.17	
6″x2′6″	1.25	
6″x2′8″	1.33	
6″x2′10″	1.42	1½
6″x3′0″	1.50	

LUMBER INSPECTION PROVISIONS AND SERVICE

Use Shipping Form

89. Lumber must be inspected, accepted or rejected, on grade in the form in which it is shipped. Any subsequent change in manufacture, mill work, or dry kilning will prohibit an inspection for the adjustment of claims except with the consent of all parties interested.

Inspection Availability

90. Official lumber association inspection service for the inspecting of lumber sold as of standard or extra standard size, and standard grade, shall be available to non-members of associations, upon request and at a reasonable charge.

Re-Inspection

91. In case of complaint on account of the grade or tally of any shipment of standard or extra standard size or standard grade, official lumber association re-inspection shall be available.

Special Grades

92. Official lumber association inspection shall not be required to be furnished for the inspection of "special" grades of lumber (that is, not recognized in published grading rules), and inspection service for "special" grades shall be furnished only when the exact specifications of such grades in writing are furnished to the inspector.

Certificate

93. Where buyers demand, and will pay the cost thereof, a certificate made by a certified lumber association inspector shall be furnished with each shipment so arranged for.

Complaint and Re-inspection

94. Upon receipt of complaint from the purchaser the seller shall immediately request the association under whose rules shipment has been made to provide official re-inspection or re-measurement, as the case may be, according to its inspection rules in effect at the time of execution of contract; and the purchaser shall lend all reasonable assistance to facilitate the re-inspection or re-measurement.

Expense of Inspections

95. The expense of such re-inspection or re-measurement may be divided between the buyer and seller, or may be borne by either, according to agreement between them, but the person calling for the re-inspection shall be responsible to the association for the costs thereof.

Complaint on Grade Only

96. In cases of complaint regarding grade but not involving measurement (tally), the buyer is required to accept that portion of a shipment of lumber of standard grade or standard or extra standard size, which is up

to grade or of standard or extra standard size, as the case may be, holding intact that portion thereof, the grade or size of which is in dispute for official lumber association inspection, that the action on the part of the buyer in accepting and using such portion of the shipment shall not be construed as his acceptance of the entire shipment; further, that the buyer shall pay in accordance with the terms of sale for that portion which he accepts, but that acceptance by the buyer of a part of a shipment does not prejudice his just claims on account of any unused material that is alleged by him to be below standard grade or not of standard or extra-standard size.

Shipment to be Held Not Exceeding 60 Days

97. The complainant buyer shall hold disputed material intact, properly protected, for not exceeding 60 days, and shall file complaint with seller within 10 days from receipt of shipment.

Variation of Inspections

98. A shipment shall be considered as of the grade invoiced if, upon official association re-inspection under the grading and inspection rules under which the lumber has been graded and sold, 95 per cent thereof or more is found to be of said grade, the material below said grade to be accepted by the buyers as of its actual grade. Where the de-grades are in excess of 5 per cent of the shipment, or where the de-grades are found upon official re-inspection to be more than one grade lower than the grade invoiced, the de-grades shall be the property of the seller. These provisions shall not apply in the case of specially worked lumber.

Qualified Inspectors

99. All grading shall be done by properly supervised and qualified graders or inspectors.

Contract Clause

100. It is recommended that sales contracts incorporate in substance the following clause:

"Shipment under this contract shall be in accordance with the American Lumber Standards as modified and adopted by the American Railway Engineering Association."

Exemption

101. In case of shipments made or received under such contracts exemption from any provision thereof shall be by special agreement and the burden of proof thereof shall be upon person claiming exemption.

Exhibit B

STRUCTURAL GRADES OF LUMBER AND TIMBER AND THE METHOD OF THEIR DERIVATION

Purpose

1. The purpose of structural grades is to offer means for selecting structural material for strength, and for uniformity in strength, in order that appropriate working stresses may be assigned for its use.

Factors of Strength

2. The most important factors which influence the strength of structural material are the size, number and location of defects, and the extent of exposure to moisture during use. These factors must all be considered in design or grading if the maximum utilization is to be obtained from the material used.

Structural Grades and Strength

3. Structural grades control defects by limiting their size and location in accordance with their effect upon strength. Working stresses for each species are recommended by the Forest Products Laboratory, United States Forest Service, and take into consideration the allowable defects, the moisture content as determined by conditions of use, and, in the case of southern yellow pine and Douglas fir, rate of growth and percentage of summerwood.

Moisture

4. Moisture affects the strength of structural timbers both directly and indirectly. The direct effect of loss of moisture is the stiffening and strengthening of the wood fibers. This increase in strength, however, is accompanied by checking, splitting, warping and twisting, as a consequence, some of the strength due to drying is lost. Timbers are also subject, during use, to varying conditions of moisture, from the dry location of a heated building, to the continually wet condition of some pier and dock timbers. All of these conditions are taken into account in recommending working stresses under different conditions of use.

Size Effects

5. In dimension four inches and less in thickness the development of defects during seasoning does not offset the increase in strength from drying as much as in larger sizes, and in these sizes used in dry locations, higher working stresses in extreme fiber in bending can be recommended than in pieces of larger size having proportionately equivalent defects.

Defects

6. The principal defects which must be limited in structural grades are: Knots, Shakes and Checks, and Angle of Grain.

Influence of Knots

7. The influence of a knot is determined by its location in a beam and the area of its projection on the cross-section of the piece, the method of measurement being such as to give the best approximation of this influence. Knots in posts and heavy beams, which are likely to show only on one face or to run diagonally through the piece, reduce the strength in practically direct proportion to their size as measured. In dimension sizes, such as joist, in which the knot is likely to run directly through the piece, the strength is measured by the square of the effective depth, assuming the knot in its worst position, near the edge of the piece, and the reduction in strength due to the knot is approximately twice the ratio of the size of the knot to the width of the face. In similar material used flat, as plank, the influence of a knot is directly proportional to the size, as on the top and bottom edges of beams.

Location of Knots—Joist and Plank

8. Knot limitations on edges of wide faces of dimension sizes, for use as joist, are more severe than would be required for use flat, as plank, the sizes applying along the center lines of the wide faces as joist being those which could theoretically apply at any point across the width if used only as plank. It has been found, however, that under practically all conditions of use, knots along the edges of planks are more objectionable than knots along the center lines and this is recognized in some commercial yard grades of plank in a stricter limitation of knots along the edges of the wide faces than along the center lines. The same knot limitations are applied, therefore, to material to be used either as joist or plank, and the same working stresses are assigned for use either on edge or flat.

Increase in Size of Knots

9. In both joist and beams, knots reduce strength most along the top and bottom edges through the center portion. The sizes of knots permitted in various portions of a joist or beam are limited in accordance with the stresses, and they are allowed to increase toward the ends and toward the centerlines of the vertical faces, no knot, however, being permitted of more than double the size allowed at the point of maximum stress.

Small and Large Knots

10. There is greater proportional distortion of grain around a large knot than around a smaller one, and shrinkage in seasoning causes greater internal stresses, so knot sizes are increased proportionately to width of faces only up to 6 inch top and bottom faces of beams, 12 inch vertical faces of beams and 12 inch faces of posts. Beyond these widths of face, increase is proportional to the square root of the ratio of the wider faces to these widths. The distribution and aggregate diameter of knots is limited, as well as the maximum size of the single knot.

Knots in Joist and Plank

11. In joist and plank, the mean or average diameter of a knot is taken as its size. In such thin and relatively wide material, whether used on edge or flat, this is a safe measure of the influence of knots on strength, and has the commercial advantage of being directly applicable to yard grades of lumber. This method of measurement will exclude damaging spike knots, and can be applied to them as well as to round or oval knots.

12. On the top or bottom of a beam, the influence of knots is measured largely by the surface fibers cut. The projection of the knot on a line at a right angle to the edge is, therefore, used. On the vertical face of a beam, the depth to which a knot penetrates is of great importance, while the influence of the number of surface fibers cut, and the amount of grain distortion, is considerably less important than on the horizontal faces. The smallest diameter of the knot is, therefore, used.

Spike Knots

13. One of the best examples illustrating the reason for the smallest diameter being taken on the vertical face is the splitting of a boxed heart timber into two pieces. The long spike knots which might be opened up in this way would be no more injurious to the strength of the two pieces than they would as a single knot in a boxed heart piece, and the two pieces so cut would be less subject to seasoning checks than a boxed heart piece.

Knots in Columns

14. In columns there are two factors: area of cross-section occupied by knot, which would probably be measured best by the small diameter of the knot, and the influence of bending stresses when the column begins to fail, probably measured best by the projection of the knot. In short columns, the area of the cross-section is of primary importance; as the column gets longer, the factor of bending strength increases in importance until the condition of the Euler formula is reached, when stiffness, on which knots have practically no influence, becomes the ruling factor. The average diameter, therefore, is used as that which applies best to the average condition.

Knots and Holes

15. In grades for structural uses no distinction is made between intergrown knots and encased knots or knotholes, observation at the Forest Products Laboratory in recent tests having shown that intergrown knots reduce strength fully as much as encased knots or knotholes.

Shakes and Checks

16. Shakes reduce the area of a beam acting in resistance to shear, and the limitations placed on shake are based on this reduction. Checks are limited on the same basis as shakes, and no combination of shakes and checks is permitted which would reduce strength to a greater extent than would the allowable size of either separately.

17. Shake and Checks in Dense Select and Select Joist and Plank shall not exceed when green ¼ width of end nor when seasoned ⅓ width of end.

Shake and Checks in Common Joist and Plank shall not exceed when green 4/10 width of end nor when seasoned 4/9 width of end.

Shake and Checks in Dense Select and Select Beams and Stringers shall not exceed when green ¼ width of end nor when seasoned ⅓ width of end.

Shake and Checks in Common Beams and Stringers shall not exceed when green 4/10 width of end nor when seasoned 4/9 width of end.

Shake and Checks in Dense Select and Select Posts and Timbers shall not exceed when green 4/10 width of end nor when seasoned ½ width of end.

Shake and Checks in Common Posts and Timbers shall not exceed when green ½ width of end nor when seasoned 6/10 width of end.

Slope of Grain

18. Slope of grain, resulting either from diagonal sawing or from spiral or twisted grain in the log, is limited in accordance with the recommendation of the Forest Products Laboratory, based on the results of detailed study of the effect of cross and spiral grain upon strength, and the weakening of material by checks which invariably develop and, without exception, follow the grain.

Wane and Knots

19. Wane is limited by such considerations as bearing area, nailing edge, appearance, etc., rather than by effect on strength. The percentage reduction in strength resulting from wane toward the center of a beam is about double the percentage reduction in cross-sectional area. No combination of wane and knots is permitted which would reduce the strength more than the maximum allowable knot. The occurrence of maximum wane and maximum knot in the same cross-section at the center of a beam would be so rare, however, and the effect of allowable maximum wane is so small a percentage of the effect of maximum allowable knot, that the additional reduction in strength beyond the effect of the knot would be slight and it is usually unnecessary to give attention to combination of wane and knot.

Pitch Pockets

20. Pitch pockets are ordinarily not defects in a structural grade. A large number, however, indicates a general lack of bond, and such a piece should be carefully inspected for shakes.

Heartwood and Sapwood

21. Heartwood and sapwood have been found by the Forest Products Laboratory to be of equal strength, and no requirement of heartwood need be made when strength alone is the governing factor. Heart requirement, when durability of untreated material under exposure is a factor, as in bridges, trestles, docks and piers, or in damp buildings, or buildings in which conditions of high humidity prevail, may be specified in any grade, according to exposure and use. When preservative treatment is to be applied, there should be no restriction as to sapwood, as a large amount of sapwood is to be preferred.

Density and Strength

22. The density of the wood substance of all species is practically the same. The dry weight is, therefore, a measure of the amount of wood substance present; and on the amount of wood substance present depends the strength of the clear wood. No pieces of exceptionally light weight are permitted in the Select grades, but light weight pieces otherwise of Select grade may be accepted in the Common grades.

Density and Summerwood

23. In southern pine and Douglas fir, the proportion of summerwood, the dark portion of the annual ring, furnishes a practical means of estimating density. Selection of these species for density, to the extent that dense material is commercially available, assures material of the highest character from the standpoint of strength, and uniformity in strength, in the clear wood.

Rate of Growth and Strength

24. Selection of these species for rate of growth is not as great an assurance of increased strength as selection for percentage of summerwood, but for many purposes selection for rate of growth will assure material of suitable type. Close grain, i. e., not less than six nor more than twenty annual rings per inch, is required in the Select Structural grades of these species.

Contrast Summerwood and Springwood

25. In acceptance for density the contrast in color between summerwood and springwood should be distinct. Absence of contrast occasionally occurs in bands of growth rings which appear on the whole darker in color than the adjacent material. The summerwood merges into the springwood abnormally with a gradual change of color, leaving practically no material which has the normal appearance of springwood. Such material has been called by a number of names, including proud wood, red wood, and compression wood. It has a decided end shrinkage, is weak in tension, and even a small part of a cross-section of this character is undesirable in high-class structural timbers.

Minimum Requirements, Maximum Defects

26. Structural grades specify minimum requirements and maximum defects, all of which may be present at one time. When a particular piece which is being inspected, therefore, is slightly below the provisions of the grade in some respects but is of average density or above, the relative effect on the properties affected should be given consideration.

Re-inspection

27. In inspection for density, reasonable variation of opinion between inspectors should be recognized. A fair provision for re-inspection of a particular lot of timbers for density would be that for every three timbers accepted as having one-third or more summerwood, one of the remaining timbers be accepted if having between 30 and 33⅓ per cent summerwood.

Yard Grades and Cutting Grades

28. A large percentage of material in standard yard grades of Dimension and Timbers will meet the additional requirements of structural grades for Joist and Plank, and Posts and Timbers, and material to meet these requirements can easily be selected from local stocks: Select from Select Common and Merchantable grades, and Common from No. 1 Common grade. Beams and Stringers vary materially in size and are not stocked extensively. These are essentially special order grades.

Joist and Plank Beam and Stringer

29. As previously noted the provisions of the Joist and Plank grades are such that material graded by them may be used on edge, as joist or rafters, or flat, as scaffold plank or factory flooring. Joist and Plank grades apply to material not thicker than four inches. Material thicker than four inches, for use in bending, should be graded by Beam and Stringer grades.

Timbers used as Beams and Stringers

30. Material to be used for such purposes as caps, bridge ties, etc., where strength in bending is a factor, should be specified in Beam and Stringer grades although of shape more commonly considered as of timber grades, as the method of measuring knots in Post and Timber grades makes it impracticable to assign bending stresses to them. Caps and bridge ties are often square or have horizontal faces wider than the vertical faces, in contrast to beams and stringers in which the narrow faces are horizontal faces and the wide faces are vertical, and this should be noted in applying the knot provisions of the Beam and Stringer grade to such material.

INTRODUCTION TO STRUCTURAL RULES

31. The following rules for Structural Grades conform to the "Basic Provisions for the Selection and Inspection of Softwood Dimension and Timbers where Working Stresses are Required" accepted at the General Lumber Conference, Washington, D. C., May 1, 1925, as the basis for the preparation of grading rules for structural material.

32. They are complete rules, covering all conditions necessary of consideration in structural grading, and are divided into sections from which combinations are made covering specific purposes and conditions.

33. These specifications may be used for mill orders, selection from or appraisal of stock on hand in either manufacturers', middlemen's or users' stock.

34. The rules cover the following Grades and Use Classifications:

Grades: DENSE SELECT,
Douglas Fir and Southern Pine,
SELECT,
Douglas Fir and Southern Pine,
SELECT,
Other Species,
COMMON,
All Species.

Uses: JOIST and PLANK,
Joist, Rafters, Bracing, Scaffold Plank, Factory Flooring, etc.
BEAMS and STRINGERS,
Beams, Girders, Stringers, Bridge Ties, Caps, etc.,
POSTS and TIMBERS,
Posts, Sills, Caps, Timbers, Etc.

Optional Provisions: WANE,
Where Permissible,
SQUARE EDGES,
Where Required or Desired,
HEARTWOOD REQUIREMENTS,
For Durability of Untreated Timbers,
SAPWOOD PERMISSIBILITY,
For Material to be Treated.

Sizes of Joist and Plank

Joist, Rafters, Scaffold Plank, Factory Flooring, etc.

Nominal thickness:	2″ to 4″
Nominal widths:	4″ and wider
Standard thickness:	S1S or S2S: ⅜″ off
Extra Standard thickness:	2″, S1S or S2S: ¼″ off
Standard widths:	2″ to 7″, S1E or S2E: ⅜″ off
	8″ and wider, S1E or S2E: ½″ off.

Sizes of Beams and Stringers

Beams, Girders, Stringers, etc.

Nominal thickness:	5″ and thicker
Nominal widths:	8″ and wider

Sizes of Posts and Timbers

Posts, Caps, Sills, Timbers, etc.

Nominal sizes:	6″ x 6″ and larger

Surfacing of Beams, Stringers, Posts and Timbers

Faces 7″ and narrower:	⅜″ off each dimension
Faces 8″ and wider:	½″ off each dimension

SPECIFICATIONS FOR STRUCTURAL JOIST, PLANK, BEAMS, STRINGERS, AND POSTS

TIMBER SIZE REQUIREMENTS

Standard Joist and Plank Surfaced

1A. Standard structural joist and plank shall be when surfaced S1S or S2S not thinner than the nominal dimension less ⅜ inch and when surfaced S1E or S2E not narrower than the nominal width less ⅜ inch for sizes 2 to 7 inches inclusive and less ½ inch for sizes 8 inches and wider.

Extra Standard Joist and Plank Surfaced

1B. Extra Standard structural joist and plank 2 inch size only shall be when surfaced S1S or S2S not thinner than nominal dimension less ¼ inch and when surfaced S1E or S2E not narrower than the nominal width less ⅜ inch for sizes 2 to 7 inches inclusive and less ½ inch for sizes 8 inches and wider.

Beams, Stringers, Posts, Timbers Surfaced

1C. Structural beams, stringers, posts and timbers shall be when surfaced S1S, S1E, S2S, S4S not smaller than the nominal size less ⅜ inch off for sizes 7 inches and narrower and less ½ inch for sizes 8 inches and wider.

Standard Joist and Plank Rough

1D. Rough standard structural joist and plank shall be not thinner than the nominal dimension less ¼ inch and not narrower than the nominal width less ¼ inch for sizes 2 to 7 inches inclusive and less ⅜ inch for sizes 8 inches and wider.

Extra Standard Joist and Plank Rough

1E. Rough extra standard structural joist and plank 2 inch size only shall be not thinner than nominal dimension less ⅛ inch and not narrower than the nominal width less ⅜ inch for sizes 2 to 7 inches inclusive and less ½ inch for sizes 8 inches and wider.

Beams, Stringers, Posts, Timbers Rough

1F. Rough structural beams, stringers, posts and timbers shall not be smaller than the nominal size less ¼ inch for sizes 7 inches and narrower and less ⅜ inch for sizes 8 inches and wider.

GRADE REQUIREMENTS

Sound Wood

2. This material shall contain only sound wood.

GENERAL

Weight

3a. No pieces of exceptionally light weight shall be permitted, except that light weight pieces otherwise of Select grade may be accepted in Common grade.

Shake, Check and Split

b. Shake shall be measured on the ends of a piece, and its size shall be taken as the shortest distance between lines enclosing the shake and parallel to the wide faces of the piece. Checks and splits shall be limited as provided for shakes. No checks or combinations of checks with shakes which would reduce the strength to a greater extent than the allowable shake shall be permitted.

Wane and Knots

c. Where wane is permitted there shall be no combination of wane and knots which would reduce the strength more than the maximum allowable knot.

Cluster Knots

d. Cluster knots and knots in groups are not permitted.

Holes

e. Knot holes and holes from other causes than knots shall be permitted as provided for knots.

Knot Measurement

f. The size of a knot shall be measured on the section of the knot appearing on the surface under consideration.

Mean Diameter

g. When the mean or average diameter of a knot is specified, the size shall be taken as the average of the maximum and minimum diameters.

Spike Knots

h. Knot sizes specified shall be applied to spike knots as well as to round knots.

Spike Knot Mean Diameter

i. The mean or average diameter of a spike knot shall be taken as the average of its length and its maximum width.

KNOTS

Joist and Plank

Wide Faces

4a. On the wide faces of Joist and Plank, the measurement of a knot shall be made on the mean or average diameter.

Narrow Faces

b. On the narrow faces of Joist and Plank, the size of a knot shall be taken as its width between lines parallel to the edges of the piece.

Increase to Ends

c. The size of knots on the narrow faces and edges of wide faces of Joist and Plank may increase proportionately from the size allowed in the middle third to twice that size at the ends of the pieces.

Increase to Center

d. The size of knots on the wide faces of Joist and Plank may increase proportionately from the size allowed at the edge to that allowed at the center line.

Beams and Stringers

Narrow Faces

5a. On the narrow or horizontal faces of Beams and Stringers the size of a knot shall be taken as its width between lines parallel to the edges of the timber.

Wide Faces

b. On the wide or vertical faces of Beams and Stringers the smallest diameter of a knot shall be taken as its size.

Edges

c. Knots on the edges of wide or vertical faces of Beams and Stringers are limited to the same size as on the adjacent narrow or horizontal faces, except that the size is measured on the least diameter of the knot instead of on its width between lines parallel to the edges of the timber.

Increase to Ends

d. The size of knots on the narrow or horizontal faces and edges of wide or vertical faces of Beams and Stringers may increase proportionately from the size allowed in the middle third to twice that size at the ends of the piece.

Increase to Center

e. The size of knots on the wide or vertical faces of Beams and Stringers may increase proportionately from the size allowed at the edge to that allowed at the center line.

Posts and Timbers

Mean Diameter

6. In Posts and Timbers, the measurement of a knot shall be made on the mean or average diameter.

7a. Maximum Size of Knots in Dense Select and Select Joist and Plank

Knots on Wide Faces

Width of face	*On or near edge, middle third of length*	*Center line of face*
4"	¾"	1¼"
6"	1"	2"
8"	1⅜"	2⅝"
10"	1¾"	3¼"
12"	2⅛"	4"
14"	2⅜"	4¼"
16"	2½"	4⅝"

b. Knots on Narrow Faces of Boxed Heart Pieces Middle Third of Length

Thickness of Piece	
2"	⅝"
3"	1"
4"	1¼"

c. The sum of the diameters of all knots within the center half of the length of a beam shall not exceed one and one-half times the width of the face on which they occur.

8a. MAXIMUM SIZE OF KNOTS IN COMMON JOIST AND PLANK

	Knots on Wide Faces	
Width of face	*On or near edge, middle third of length*	*Center line of face*
4″	1″	1¾″
6″	1½″	2½″
8″	2″	3⅜″
10″	2½″	4¼″
12″	3″	5⅛″
14″	3¼″	5⅝″
16″	3⅜″	6″

b. KNOTS ON NARROW FACES OF BOXED HEART PIECES MIDDLE THIRD OF LENGTH

Thickness of Piece	
2″	⅞″
3″	1¼″
4″	1¾″

c. The sum of the diameters of all knots within the center of the length of a joist or plank shall not exceed two times the width of face on which they occur.

9a. MAXIMUM SIZE OF KNOTS IN DENSE SELECT AND SELECT BEAMS AND STRINGERS

Width of face	*Narrow or horizontal face, middle third of length*	*Center line of wide or vertical face*
5″	1¼″	. . .
6″	1½″	1½″
8″	1¾″	2″
10″	2″	2½″
12″	2⅛″	3″
14″	2¼″	3¼″
16″	2⅜″	3⅜″
18″	. . .	3⅝″
20″	. . .	3⅞″
22″	. . .	4″
24″	. . .	4¼″

b. The sum of the diameters of all knots within the center half of the length of a beam shall not exceed the width of the face on which they occur.

10a. MAXIMUM SIZE OF KNOTS IN COMMON BEAMS AND STRINGERS

Width of face	*Narrow face or horizontal face and edge of wide face, middle third of length*	*Center line of wide face or vertical face*
5″	2″	. . .
6″	2⅜″	2⅜″
8″	2¾″	3⅛″
10″	3⅛″	4″
12″	3⅜″	4¾″
14″	3⅝″	5⅛″
16″	3⅞″	5½″
18″		5⅞″
20″		6⅛″
22″		6½″
24″		6¾″

b. The sum of the diameters of all knots within the center half of length of a post or timber shall not exceed one and one-half times the width of the face on which they occur.

11a. Maximum Size of Knots in Dense Select and Select Posts and Timbers

Width of Face	*Knots*
6″	1½″
8″	2″
10″	2½″
12″	3″
14″	3¼″
16″	3⅜″
18″	3⅝″
20″	3⅞″
22″	4″
24″	4¼″

b. The sum of diameters of all knots in any 6 inches of length shall not exceed twice size of maximum knot allowable.

12a. Maximum Size of Knots in Common Posts and Timbers

Width of Face	*Knots*
6″	2⅜″
8″	3⅛″
10″	4″
12″	4¾″
14″	5⅛″
16″	5½″
18″	5⅞″
20″	6⅛″
22″	6½″
24″	6¾″

b. The sum of diameters of all knots in any 6 inches of length shall not exceed twice size of maximum knot allowable.

13. Maximum Shake and Checks in Dense Select and Select Joist and Plank

Width of Face	*Green*	*Seasoned*
2″	½″	⅝″
3″	¾″	1″
4″	1″	1¼″

14. Maximum Shake and Checks in Common Joist and Plank

Width of Face	*Green*	*Seasoned*
2″	¾″	⅞″
3″	1⅛″	1¼″
4″	1½″	1¾″

15. Maximum Shake and Checks in Dense Select and Select Beams and Stringers

Width of Face	*Green*	*Seasoned*
6″	1½″	2″
8″	2″	2⅝″
10″	2½″	3¼″
12″	3″	4″
14″	3½″	4⅝″
16″	4″	5¼″
18″	4½″	6″
20″	5″	6⅝″
22″	5½″	7¼″
24″	6″	8″

16. Maximum Shake and Checks in Common Beams and Stringers

Width of Face	*Green*	*Seasoned*
5″	2″	2⅛″
6″	2⅜″	2⅝″
8″	3⅛″	3½″
10″	4″	4⅜″
12″	5″	5¼″
14″	5½″	6⅛″
16″	6⅜″	7″
18″	7⅛″	8″
20″	8″	8⅞″
22″	8¾″	9¾″
24″	9½″	10⅝″

17. Maximum Shake and Checks in Dense Select and Select Posts and Timbers

Width of Face	*Green*	*Seasoned*
5″	2″	2½″
6″	2⅜″	3″
8″	3⅛″	4″
10″	4″	5″
12″	4¾″	6″
14″	5½″	7″
16″	6⅜″	8″
18″	7⅛″	9″
20″	8″	10″
22″	8¾″	11″
24″	9½″	12″

18. Maximum Shake and Checks in Common Posts and Timbers

Width of Face	*Green*	*Seasoned*
6″	3″	3½″
8″	4″	4¾″
10″	5″	6″
12″	6″	7⅛″
14″	7″	8⅜″
16″	8″	9½″
18″	9″	10¾″
20″	10″	12″
22″	11″	13⅛″
24″	12″	14⅜″

SLOPE OF GRAIN

19a. DENSE SELECT AND SELECT JOIST AND PLANK
Slope of grain in center half of length shall not exceed 1 in 12.

19b. COMMON JOIST AND PLANK
Slope of grain in center half of length shall not exceed 1 in 10.

19c. DENSE SELECT AND SELECT BEAMS AND STRINGERS
Slope of grain in center half of length shall not exceed 1 in 15.

19d. COMMON BEAMS AND STRINGERS
Slope of grain in center half of length shall not exceed 1 in 10.

19e. DENSE SELECT AND SELECT POSTS AND TIMBERS
Slope of grain shall not exceed 1 in 10.

19f. COMMON POSTS AND TIMBERS
Slope of grain shall not exceed 1 in 8.

WANE AND SQUARE EDGES

WANE, DENSE SELECT AND SELECT GRADE

Wane 1/8

20a. Wane is permitted, not exceeding 1/8 the width of any face.

WANE, COMMON GRADE

Wane 1/4

20b. Wane is permitted, not exceeding 1/4 the width of any face.

SQUARE EDGES

Square

20c. All edges must be square.

HEARTWOOD AND SAPWOOD

DURABILITY UNTREATED

Heartwood requirements to be specified as required from following:

HEARTWOOD PROVISIONS

Joist and Plank

21a. Joist and Plank shall have not less than 85 per cent heart on the two faces.

Beams and Stringers

21b. Beams and Stringers shall have not less than 85 per cent heart on each of the four faces measured across the faces anywhere in the length of the piece.

Timbers 85 Per Cent

21c. These timbers shall have not less than 85 per cent heart on each of the four faces, measured across the face anywhere in the length of the piece.

Timbers More Than 85 Per Cent

21d. These timbers shall have all heart on one face, the other face and two sides shall have not less than 85 per cent of heart, measured across the face or sides anywhere in the length of the piece.

Timbers Less Than 85 Per Cent

21e. These timbers shall have all heart on one face, the other face and two sides shall have not less than 75 per cent of heart, measured across the face or sides anywhere in the length of the piece.

For Treatment

Provision for sapwood for timber to be treated is covered by following:

Sapwood

Sapwood Not Required

22. There is no restriction as to sapwood for this material.

RATE OF GROWTH AND DENSITY

Select

Southern Pine or Douglas Fir of Select grade is to be selected for close grain.

Dense Select

Southern Pine or Douglas Fir of Dense Select grade is to be selected for density.

Close Grain

Close Grain

23. Douglas Fir or Southern Pine shall be of close grain, averaging on either one end or the other not less than six nor more than twenty annual rings per inch measured over a three-inch portion of a radial line located as described below and representative of the average growth on the cross-section. Pieces averaging from five to six annual rings per inch shall be accepted as the equivalent of close grain if having one-third or more summerwood.

Density

Dense

24. Douglas Fir or Southern Pine shall be dense, averaging on either one end or the other not less than six annual rings per inch and, in addition, one-third or more summerwood measured over a three-inch portion of a radial line located as described below and representative of the average growth on the cross-section. The contrast in color between summerwood and springwood shall be distinct. Coarse grained material excluded by this rule shall be accepted as dense if averaging one-half or more summerwood.

Close Grain or Density

Radial Line Not Representative

25. When the radial line specified is not representative, it shall be shifted sufficiently to present a fair average, but the distance from the pith to the beginning of the three-inch portion of the line in boxed heart pieces shall not be changed.

CLOSE GRAIN

Two Radial Lines

26. In case of disagreement, two radial lines shall be chosen, and the number of rings shall be the average determined on these lines.

DENSITY

Average

27. In case of disagreement, two radial lines shall be chosen, and the number of rings and summerwood shall be the average determined on these lines.

LOCATION OF RADIAL LINE IN DOUGLAS FIR

Sidecut Pieces

28a. In side cut pieces of Douglas Fir, the radial line shall be at a right angle to the annual rings and the center of the three-inch portion of the line shall be at the center of the end of the piece.

Boxed Heart Pieces

b. In boxed heart pieces the line shall run from the pith to the corner farthest from the pith. When the least dimension is six inches or less, the three-inch portion of the line shall begin at a distance of one inch from the pith. When the least dimension is more than six inches, the three-inch portion of the line shall begin at a distance from the pith equal to two inches less than one-half the least dimension of the piece.

c. If a three-inch portion of the radial line cannot be obtained, the measurement shall be made over as much of the three-inch portion as is available.

LOCATION OF RADIAL LINE IN SOUTHERN PINE

Boxed Heart Pieces

29a. In boxed heart pieces of Southern Pine, the measurement shall be made over the third, fourth and fifth inches from the pith along the radial line.

No Pith

b. In cases where timbers do not contain the pith, and it is impossible to locate it with any degree of accuracy, the inspection shall be made over three inches on an approximate radial line beginning at the edge nearest the pith in timbers over three inches in thickness and on the second inch nearest to the pith in timbers three inches or less in thickness.

Pith but Small Material, Large Material

c. In material containing the pith but not a five-inch radial line, which is less than two inches by eight inches in section or less than eight inches in width, that does not show over sixteen square inches on the cross-section, the inspection shall apply to the second inch from the pith. In larger material that does not show a five-inch radial line, the inspection shall apply to the three inches farthest from the pith.

STRUCTURAL GRADES AND REFERENCE CODE

Specifications are divided into sections with general numbers for reference.

Where alternate specifications are listed each has a capital letter added to the general number. For any material, appropriate choice must be made of such paragraphs.

Where several paragraphs occur under the general number and each is designated by small letters, all such paragraphs must be used in making a complete specification.

In cases where only a small number of sizes are ordered it is permissible to shorten the tables of maximum defects by only copying sizes of defects corresponding with the sizes being ordered.

Three complete specifications are shown to illustrate the application of the code.

These are followed by a complete list of numbered specifications, brief description of material and appropriate code numbers of sections required to write a complete specification for this material.

EXAMPLE NO. 1. SPECIFICATION NO. 1.

Dense Select Beams and Stringers (Southern Pine) with square edges and heartwood requirement for use untreated, rough.

Size Requirement

1F. Rough structural beams and stringers shall be not smaller than the nominal size less ¼ inch off for sizes 7 inches and narrower and less ⅜ inch off for sizes 8 inches and wider.

Grade Requirements

2. This material shall contain only sound wood.

General

3a. No pieces of exceptionally light weight shall be permitted except that light weight pieces otherwise of Select grade may be accepted in Common grade.

b. Shake shall be measured on the ends of a piece, and its size shall be taken as the shortest distance between lines enclosing the shake and parallel to the wide faces of the pieces. Checks and splits shall be limited as provided for shakes. No checks or combinations of checks with shakes which would reduce the strength to a greater extent than the allowable shake shall be permitted.

c. Where wane is permitted there shall be no combination of wane and knots which would reduce the strength more than the maximum allowable knot.

d. Cluster knots and knots in groups are not permitted.

e. Knot holes and holes from other causes than knots shall be permitted as provided for knots.

f. The size of a knot shall be measured on the section of the knot appearing on the surface under consideration.

g. When the mean or average diameter of a knot is specified, the size shall be taken as the average of the maximum and minimum diameters.

h. Knot sizes specified shall be applied to spike knots as well as to round knots.

i. The mean average diameter of a spike knot shall be taken as the average of its length and its maximum width.

KNOTS

BEAMS AND STRINGERS

5a. On the narrow or horizontal faces of Beams and Stringers the size of a knot shall be taken as its width between lines parallel to the edges of the timber.

b. On the wide or vertical faces of Beams and Stringers the smallest diameter of a knot shall be taken as its size.

c. Knots on the edges of wide or vertical faces of Beams and Stringers are limited to the same size as on the adjacent narrow or horizontal faces, except the size is measured on the least diameter of the knot instead of on its width between lines parallel to the edges of the timber.

d. The size of knots on the narrow or horizontal faces and edges of wide or vertical faces of Beams and Stringers may increase proportionately from the size allowed in the middle third to twice that size at the ends of the piece.

e. The size of knots on the wide or vertical faces of Beams and Stringers may increase proportionately from the size allowed at the edge to that allowed at the center line.

9a. MAXIMUM SIZE OF KNOTS IN DENSE SELECT AND SELECT BEAMS AND STRINGERS

Width of face	*Narrow or horizontal face, middle, third of length*	*Center line of wide or vertical face*
5"	1¼"	....
6"	1½"	1½"
8"	1¾"	2"
10"	2"	2½"
12"	2⅛"	3"
14"	2¼"	3¼"
16"	2⅜"	3⅜"
18"		3⅝"
20"		3⅞"
22"		4"
24"		4¼"

b. The sum of the diameters of all knots within the center half of the length of a beam shall not exceed the width of the face on which they occur.

15. Maximum Shake and Checks in Dense Select and Select Beams and Stringers

Width of Face	*Green*	*Seasoned*
6″	1½″	2″
8″	2″	2⅝″
10″	2½″	3¼″
12″	3″	4″
14″	3½″	4⅝″
16″	4″	5¼″
18″	4½″	6″
20″	5″	6⅝;
22″	5½″	7¼″
24″	6″	8″

19C. Slope of grain in center half of length shall not exceed 1 in 15.

20C. All edges must be square.

21B. Beams and Stringers shall have not less than 85 per cent heart on each of the four faces measured across the faces anywhere in the length of the piece.

24. Southern Pine shall be dense, averaging on either one end or the other not less than six annual rings per inch and, in addition, one-third or more summerwood measured over a three-inch portion of a radial line located as described below and representative of the average growth on the cross-section. The contrast in color between summerwood and spring wood shall be distinct. Coarse-grained material excluded by this rule shall be accepted as dense if averaging one-half or more summerwood.

25. When the radial line specified is not representative, it shall be shifted sufficiently to present a fair average but the distance from the pith to the beginning of the three-inch portion of the line in boxed heart pieces shall not be changed.

27. In case of disagreement, two radial lines shall be chosen, and the number of rings and summerwood shall be the average determined on these lines.

29a. In boxed heart pieces of Southern Pine, the measurement shall be made over the third, fourth and fifth inches from the pith along the radial line.

b. In cases where the timbers do not contain the pith, and it is impossible to locate it with any degree of accuracy, the inspection shall be made over three inches on an approximate radial line beginning at the edge nearest the pith in timbers over three inches in thickness and on the second inch nearest to the pith in timbers three inches or less in thickness.

c. In material containing the pith but not a five-inch radial line, which is less than two inches by eight inches in section or less than eight inches in width, that does not show over sixteen square inches on the cross-section, the inspection shall apply to the second inch from the pith. In larger material that does not show a five-inch radial line, the inspection shall apply to the three inches farthest from the pith.

EXAMPLE NO. 2. SPECIFICATION NO. 50

SELECT POSTS AND TIMBERS (DOUGLAS FIR) WITH WANE PERMITTED AND SAPWOOD WANTED FOR TREATMENT, SURFACED FOUR SIDES

SIZE REQUIREMENT

1C. Structural beams, stringers, posts and timbers shall be when surfaced S1S, S1E, S2S, S4S not smaller than the nominal size less ⅜ inch off for size 7 inches and narrower and less ½ inch off for sizes 8 inches and wider.

GRADE REQUIREMENTS

2. This material shall contain only sound wood.

GENERAL

3a. No pieces of exceptionally light weight shall be permitted, except that light weight pieces otherwise of Select grade may be accepted in Common grade.

b. Shake shall be measured on the ends of a piece, and its size shall be taken as the shortest distance between lines enclosing the shake and parallel to the wide faces of the piece. Checks and splits shall be limited as provided for shakes. No checks or combination of checks with shakes which would reduce the strength to a greater extent than the allowable shake shall be permitted.

c. Where wane is permitted there shall be no combination of wane and knots which would reduce the strength more than the maximum allowable knot.

d. Cluster knots and knots in groups are not permitted.

e. Knot holes and holes from other causes than knots shall be permitted as provided for knots.

f. The size of a knot shall be measured on the section of the knot appearing on the surface under consideration.

g. When the mean or average diameter of a knot is specified, the size shall be taken as the average of the maximum and minimum diameters.

h. Knot sizes specified shall be applied to spike knots as well as to round knots.

i. The mean or average diameter of a spike knot shall be taken as the average of its length and its maximum width.

KNOTS

6. In Posts and Timbers, the measurement of a knot shall be made on the mean or average diameter.

11a. MAXIMUM SIZE OF KNOTS IN DENSE SELECT AND SELECT POSTS AND TIMBERS

Width of Face	*Knots*
6″	1½″
8″	2″
10″	2½″
12″	3″
14″	3¼″
16″	3⅜″
18″	3⅝″
20″	3⅞″
22″	4″
24″	4¼″

b. Sum of diameters of all knots in any 6 inches of length shall not exceed twice size of maximum knot allowable.

17. Maximum Shake and Checks in Dense Select and Select Posts and Timbers

Width of Face	*Green*	*Seasoned*
5″	2″	2½″
6″	2⅜″	3″
8″	3⅛″	4″
10″	4″	5″
12″	4¾″	6″
14″	5½″	7″
16″	6⅜″	8″
18″	7⅛″	9″
20″	8″	10″
22″	8¾″	11″
24″	9½″	12″

19E. Slope of grain shall not exceed 1 in 10.

20A. Wane is permitted, not exceeding ⅛ the width of any face.

22. There is no restriction as to sapwood for this material.

23. Douglas Fir shall be of close grain, averaging on either one end or the other not less than six nor more than twenty annual rings per inch measured over a three-inch portion of a radial line located as described below and representative of the average growth on the cross-section. Pieces averaging from five to six annual rings per inch shall be accepted as the equivalent of close grain if having one-third or more summerwood.

When the radial line is not representative, it shall be shifted sufficiently to present a fair average, but the distance from the pith to the beginning of the three-inch portion of the line in boxed heart pieces shall not be changed.

26. In case of disagreement, two radial lines shall be chosen, and the number of rings shall be the average determined on these lines.

28a. In side cut pieces of Douglas Fir, the radial line shall be at a right angle to the annual rings and the center of the three-inch portion of the line shall be at the center of the end of the piece.

b. In boxed heart pieces the line shall run from the pith to the corner farthest from the pith. When the least dimension is six inches or less, the three-inch portion of the line shall begin at a distance of one inch from the pith. When the least dimension is more than six inches, the three-inch portion of the line shall begin at a distance from the pith equal to two inches less than one-half the least dimension of the piece.

c. If a three-inch portion of a radial line cannot be obtained, the measurement shall be made over as much of the three-inch portion as is available.

EXAMPLE NO. 3. SPECIFICATION NO. 38

Common Joist and Plank With Wane Permissibility and No Heartwood or Sapwood Requirement, Surfaced S1S, S1E

Size Requirement

1A. Standard Structural joist and plank shall be when surfaced S1S or S2S not thinner than the nominal dimension less ⅜ inch and when surfaced S1E or S2E not narrower than the nominal width less ⅜ inch for sizes 2 to 7 inches, inclusive, and less ½ inch for sizes 8 inches and wider.

GRADE REQUIREMENTS

2. This material shall contain only sound wood.

GENERAL

3A. No pieces of exceptionally light weight shall be permitted, except that light weight pieces otherwise of Select grade may be accepted in Common grade.

b. Shake shall be measured on the ends of a piece, and its size shall be taken as the shortest distance between lines enclosing the shake and parallel to the wide faces of the piece. Checks and splits shall be limited as provided for shakes. No checks or combination of checks with shakes which would reduce the strength to a greater extent than the allowable shake shall be permitted.

c. Where wane is permitted there shall be no combination of wane and knots which would reduce the strength more than the maximum allowable knot.

d. Cluster knots and knots are not permitted.

e. Knot holes and holes from other causes than knots shall be permitted as provided for knots.

f. The size of a knot shall be measured on the section of a knot appearing on the surface under consideration.

g. When the mean or average diameter of a knot is specified, the size shall be taken as the average of the maximum and minimum diameters.

h. Knot sizes specified shall be applied to spike knots as well as to round knots.

i. The mean or average diameter of a spike knot shall be taken as the average of its length and its maximum width.

KNOTS

JOIST AND PLANK

4a. On the wide faces of Joist and Plank, the measurement of a knot shall be made on the mean or average diameter.

b. On the narrow faces of Joist and Plank, the size of a knot shall be taken as its width between lines parallel to the edges of the piece.

c. The size of knots on the narrow faces and edges of wide faces of Joist and Plank may increase proportionately from the size allowed in the middle third to twice that size at the ends of the pieces.

d. The size of knots on the wide faces of Joist and Plank may increase proportionately from the size allowed at the edge to that allowed at the center line.

8a. MAXIMUM SIZE OF KNOTS IN COMMON JOIST AND PLANK

KNOTS ON WIDE FACES

Width of Face	*On or near edge middle third of length*	*Center line of face*
4"	1"	1¾"
6"	1½"	2½"
8"	2"	3⅜"
10"	2½"	4¼"
12"	3"	5⅛"
14"	3¼"	5⅝"
16"	3⅜"	6"

b. KNOTS ON NARROW FACES OF BOXED HEART PIECES
MIDDLE THIRD OF LENGTH

Thickness of Piece	*Knots*
2″	⅞″
3″	1¼″
4″	1¾″

c. The sum of diameters of all knots within the center half of the length of a joist or plank shall not exceed two times the width of face on which they occur.

14. MAXIMUM SHAKE AND CHECKS IN COMMON JOIST AND PLANK

Width of Face	*Green*	*Seasoned*
2″	¾″	⅞″
3″	1⅛″	1¼″
4″	1½″	1¾″

19B. Slope of grain in center half of length shall not exceed 1 in 10.
20B. Wane is permitted, not exceeding ¼ the width of any face.

Index to Numbers of Specifications

GRADES	ADDITIONAL REQUIREMENTS						
	For use untreated					For treating	
	For durability Heartwood required			No Heartwood or Sapwood required		Sapwood not restricted	
	One Face 100% Other 3 Faces 85%	All Faces 85%	One Face 100% Other 3 Faces 75%	Square Edge	Wane permitted	Square Edge	Wane permitted
	Square Edge						
Beams and Stringers							
Dense Select Douglas Fir or Southern Pine	....	1	....	2	3	4	5
Select Douglas Fir or Southern Pine	....	6	....	7	8	9	10
Select Any wood	....	11	....	12	13	14	15
Common Any wood	....	16	....	17	18	19	20
Joist and Planks							
Dense Select Douglas Fir or Southern Pine	....	21	....	22	23	24	25
Select Douglas Fir or Southern Pine	....	26	....	27	28	29	30
Select Any wood	....	31	....	32	33	34	35
Common Any wood	....	36	....	37	38	39	40
Post and Timbers							
Dense Select Douglas Fir or Southern Pine	61	41	65	42	43	44	45
Select Douglas Fir or Southern Pine	62	46	66	47	48	49	50
Select Any wood	63	51	67	52	53	54	55
Common Any wood	64	56	68	57	58	59	60

CODED SPECIFICATIONS FOR STRUCTURAL GRADES

No. 1. Beams and Stringers, Douglas Fir or Southern Pine, Dense Select, 85 per cent heartwood, square edges.
1C (surfaced) or 1F (rough), 2, 3 (a+b+c+d+e+f+g-+h+i), 5 (a+b+c+d+e), 9 (a+b), 15, 19C, 20C, 21B, 24, 25, 27, 28 (a+b+c) Douglas Fir or 29 (a+b+c) Southern Pine.

No. 2. Beams and Stringers, Douglas Fir or Southern Pine, Dense Select, no heartwood or sapwood requirement, square edges.
1C (surfaced) or 1F (rough) 2, 3 (a+b+c+d+e+f+g+h-+i), 5 (a+b+c+d+e), 9 (a+b), 15, 19C, 20C, 24, 25, 27, 28 (a+b+c) Douglas Fir or 29 (a+b+c) Southern Pine.

No. 3. Beams and Stringers, Douglas Fir or Southern Pine, Dense Select, no heartwood or sapwood requirement, wane permitted.
1C (surfaced) or 1F (rough) 2, 3 (a+b+c+d+e+f+g+h-+i), 5 (a+b+c+d), 9 (a+b), 15, 19C, 20A, 24, 25, 27, 28 (a+b+c) Douglas Fir or 29 (a+b+c) Southern Pine.

No. 4. Beams and Stringers, Douglas Fir or Southern Pine, Dense Select, sapwood wanted for treatment, square edges.
1C (surfaced) or 1F (rough) 2, 3 (a+b+c+d+e+f+g+h-+i), 5 (a+b+c+d), 9 (a+b), 15, 19C, 20C, 22, 24, 25, 27, 28 (a+b+c) Douglas Fir or 29 (a+b+c) Southern Pine.

No. 5. Beams and Stringers, Douglas Fir or Southern Pine, Dense Select, sapwood wanted for treatment, wane permitted.
1C (surfaced) or 1F (rough) 2, 3 (a+b+c+d+e+f+g+h-+i), 5 (a+b+c+d), 9 (a+b), 15, 19C, 20A, 22, 24, 25, 27, 28 (a+b+c) Douglas Fir or 29 (a+b+c) Southern Pine.

No. 6. Beams and Stringers, Douglas Fir or Southern Pine, Select, 85 per cent heartwood, square edges.
1C (surfaced) or 1F (rough) 2, 3 (a+b+c+d+e+f+g+h-+i), 5 (a+b+c+d), 9 (a+b), 15, 19C, 20C, 21B, 23, 25, 26, 28 (a+b+c), Douglas Fir or 29 (a+b+c) Southern Pine.

No. 7. Beams and Stringers, Douglas Fir or Southern Pine, Select, no heartwood or sapwood requirement, square edges.
1C (surfaced) or 1F (rough) 2, 3 (a+b+c+d+e+f+g+h-+i), 5 (a+b+c+d), 9 (a+b), 15, 19C, 20C, 23, 25, 26, 28 (a+b+c), Douglas Fir or 29 (a+b+c) Southern Pine.

No. 8. Beams and Stringers, Douglas Fir or Southern Pine, Select, no heartwood or sapwood requirement, wane permitted.
1C (surfaced) or 1F (rough) 2, 3 (a+b+c+d+e+f+g+h-+i), 5 (a+b+c+d), 9 (a+b), 15, 19C, 20A, 23, 25, 26, 28 (a+b+c), Douglas Fir or 29 (a+b+c) Southern Pine.

No. 9. Beams and Stringers, Douglas Fir or Southern Pine, Select, sapwood wanted for treatment, square edges.
1C (surfaced) or 1F (rough) 2, 3 (a+b+c+d+e+f+g+h-+i), 5 (a+b+c+d), 9 (a+b), 15, 19C, 20C, 22, 23, 25, 26, 28 (a+b+c), Douglas Fir or 29 (a+b+c) Southern Pine.

No. 10. Beams and Stringers, Douglas Fir or Southern Pine, Select, sapwood wanted for treatment, wane permitted.

1C (surfaced) or 1F (rough) 2, 3 (a+b+c+d+e+f+g+h+i), 5 (a+b+c+d), 9 (a+b), 15, 19C, 20A, 22, 23, 25, 26, 28 (a+b+c) Douglas Fir or 29 (a+b+c) Southern Pine.

No. 11. Beams and Stringers, Select, 85 per cent heartwood, square edges.

1C (surfaced) or 1F (rough) 2, 3 (a+b+c+d+e+f+g+h+i), 5 (a+b+c+d+e), 9 (a+b), 15, 19C, 20C, 21B.

No. 12. Beams and Stringers, Select no heartwood or sapwood requirement, square edges. .

1C (surfaced) or 1F (rough) 2, 3 (a+b+c+d+e+f+g+h+i), 5 (a+b+c+d+e), 9 (a+b), 15, 19C, 20C.

No. 13. Beams and Stringers, Select, no heartwood or sapwood requirement, wane permitted.

1C (surfaced) or 1F (rough) 2, 3 (a+b+c+d+e+f+g+h+i), 5 (a+b+c+d+e), 9 (a+b), 15, 19C, 20A.

No. 14. Beams and Stringers, Select, sapwood wanted for treatment, square edges.

1C (surfaced) or 1F (rough) 2, 3 (a+b+c+d+e+f+g+h+i), 5 (a+b+c+d+e), 9 (a+b), 15, 19C, 20C, 22.

No. 15. Beams and Stringers, Select, sapwood wanted for treatment, wane permitted.

1C (surfaced) or 1F (rough) 2, 3 (a+b+c+d+e+f+g+h+i), 5 (a+b+c+d+e), 9 (a+b), 15, 19C, 20A, 22.

No. 16. Beams and Stringers, Common, 85 per cent heartwood, square edges.

1C (surfaced) or 1F (rough) 2, 3 (a+b+c+d+e+f+g+h+i), 5 (a+b+c+d), 10 (a+b), 16, 19D, 20C, 21B.

No. 17. Beams and Stringers, Common, no heartwood or sapwood requirement, square edges.

1C (surfaced) or 1F (rough) 2, 3 (a+b+c+d+e+f+g+h+i), 5 (a+b+c+d), 10 (a+b), 16, 19D, 20C.

No. 18. Beams and Stringers, Common, no heartwood or sapwood requirement, wane permitted.

1C (surfaced) or 1F (rough) 2, 3 (a+b+c+d+e+f+g+h+i), 5 (a+b+c+d), 10 (a+b), 16, 19D, 20B.

No. 19. Beams and Stringers, Common, sapwood wanted for treatment, square edges.

1C (surfaced) or 1F (rough) 2, 3 (a+b+c+d+e+f+g+h+i), 5 (a+b+c+d), 10 (a+b), 16, 19D, 20C, 22.

No. 20. Beams and Stringers, Common sapwood wanted for treatment, wane permitted.

1C (surfaced) or 1F (rough) 2, 3 (a+b+c+d+e+f+g+h+i), 5 (a+b+c+d), 10 (a+b), 16, 19D, 20B, 22.

Joist and Plank

No. 21. Joist and Plank, Douglas Fir or Southern Pine, Dense Select, 85 per cent heartwood, square edges.

1A (surfaced) or 1D (rough), 2, 3 (a+b+c+d+e+f+g+h+i), 4 (a+b+c+d), 7 (a+b+c), 13, 19A, 20C, 21A, 24, 25, 27, 28 (a+b+c) Douglas Fir or 29 (a+b+c) Southern Pine.

No. 22. Joist and Plank, Douglas Fir or Southern Pine, Dense Select, no heartwood or sapwood requirement, square edges.

1A (surfaced) or 1D (rough), 2, 3 (a+b+c+d+e+f+g+h+i), 4 (a+b+c+d), 7 (a+b+c), 13, 19A, 20C, 24, 25, 27, 28 (a+b+c), Douglas Fir or 29 (a+b+c) Southern Pine.

No. 23. Joist and Plank, Douglas Fir or Southern Pine, Dense Select, no heartwood or sapwood requirement, wane permitted.
1A (surfaced) or 1D (rough), 2, 3 (a+b+c+d+e+f+g+h+i), 4 (a+b+c+d), 7 (a+b+c), 13, 19A, 20A, 24, 25, 27, 28 (a+b+c) Douglas Fir or 29 (a+b+c) Southern Pine.

No. 24. Joist and Plank, Douglas Fir or Southern Pine, Dense Select, sapwood wanted for treatment, square edges.
1A (surfaced) or 1D (rough), 2, 3 (a+b+c+d+e+f+g+h+i), 4 (a+b+c+d), 7 (a+b+c), 13, 19A, 20C, 22, 24, 25, 27, 28 (a+b+c) Douglas Fir or 29 (a+b+c) Southern Pine.

No. 25. Joist and Plank, Douglas Fir or Southern Pine, Dense Select, sapwood wanted for treatment, wane permitted.
1A (surfaced) or 1D (rough), 2, 3 (a+b+c+d+e+f+g+h+i), 4 (a+b+c+d), 7 (a+b+c), 13, 19A, 20A, 22, 24, 25, 27, 28 (a+b+c) Douglas Fir or 29 (a+b+c) Southern Pine.

No. 26. Joist and Plank, Douglas Fir or Southern Pine, Select, 85 per cent heartwood, equare edges.
1A (surfaced) or 1D (rough), 2, 3 (a+b+c+d+e+f+g+h+i), 4 (a+b+c+d), 7 (a+b+c), 13, 19A, 20C, 21A, 23, 25, 26, 28 (a+b+c) Douglas Fir or 29 (a+b+c) Southern Pine.

No. 27. Joist and Plank, Douglas Fir or Southern Pine, Select, no heartwood or sapwood requirement, square edges.
1A (surfaced) or 1D (rough), 2, 3 (a+b+c+d+e+f+g+h+i), 4 (a+b+c+d), 7 (a+b+c), 13, 19A, 20C, 23, 25, 26, 28 (a+b+c) Douglas Fir or 29 (a+b+c) Southern Pine.

No. 28. Joist and Plank, Douglas Fir or Southern Pine, Select, no heartwood or sapwood requirement, wane permitted.
1A (surfaced) or 1D (rough), 2, 3 (a+b+c+d+e+f+g+h+i), 4 (a+b+c+d), 7 (a+b+c), 13, 19A, 20A, 23, 25, 26, 28 (a+b+c) Douglas Fir or 29 (a+b+c) Southern Pine.

No. 29. Joist and Plank, Douglas Fir or Southern Pine, Select, sapwood wanted for treatment, square edges.
1A (surfaced) or 1D (rough), 2, 3 (a+b+c+d+e+f+g+h+i), 4 (a+b+c+d), 7 (a+b+c), 13, 19A, 20C, 22, 23, 25, 26, 28, (a+b+c) Douglas Fir or 29 (a+b+c) Southern Pine.

No. 30. Joist and Plank, Douglas Fir or Southern Pine, Select, sapwood wanted for treatment, wane permitted.
1A (surfaced) or 1D (rough), 2, 3 (a+b+c+d+e+f+g+h+i), 4 (a+b+c+d), 7 (a+b+c), 13, 19A, 20A, 22, 23, 25, 26, 28 (a+b+c), Douglas Fir or 29 (a+b+c) Southern Pine.

No. 31. Joist and Plank, Select, 85 per cent heartwood, square edges.
1A (surfaced) or 1D (rough), 2, 3 (a+b+c+d+e+f+g+h+i), 4 (a+b+c+d), 7 (a+b+c), 13, 19A, 20C, 21A.

No. 32. Joist and Plant, Select, no heartwood or sapwood requirement, square edges.
1A (surfaced) or 1D (rough), 2, 3 (a+b+c+d+e+f+g+h+i), 4 (a+b+c+d), 7 (a+b+c), 13, 19A, 20C.

No. 33. Joist and Plank, Select, no heartwood or sapwood requirement, wane permitted.
1A (surfaced) or 1D (rough), 2, 3 (a+b+c+d+e+f+g+h-+i), 4 (a+b+c+d), 7 (a+b+c), 13, 19A, 20A.

No. 34. Joist and Plank, Select, sapwood wanted for treatment, square edges.
1A (surfaced) or 1D (rough), 2, 3 (a+b+c+d+e+f+g+h-+i), 4 (a+b+c+d), 7 (a+b+c), 13, 19A, 20C, 22.

No. 35. Joist and Plank, Select, sapwood wanted for treatment, wane permitted.
1A (surfaced) or 1D (rough), 2, 3 (a+b+c+d+e+f+g+h-+i), 4 (a+b+c+d), 7 (a+b+c), 13, 19A, 20A, 22.

No. 36. Joist and Plank, Common, 85 per cent heartwood, square edges.
1A (surfaced) or 1D (rough), 2, 3 (a+b+c+d+e+f+g+h-+i), 4 (a+b+c+d), 8 (a+b+c), 14, 19B, 20C, 21A.

No. 37. Joist and Plank, Common, no heartwood or sapwood requirement, square edges.
1A (surfaced) or 1D (rough), 2, 3 (a+b+c+d+e+f+g+h-+i), 4 (a+b+c+d), 8 (a+b+c), 14, 19B, 20C.

No. 38. Joist and Plank, Common, no heartwood or sapwood requirement, wane permitted.
1A (surfaced) or 1D (rough), 2, 3 (a+b+c+d+e+f+g+h-+i), 4 (a+b+c+d), 8 (a+b+c), 14, 19B, 20B.

No. 39. Joist and Plank, Common, sapwood wanted for treatment, square edges.
1A (surfaced) or 1D (rough), 2, 3 (a+b+c+d+e+f+g+h-+i), 4 (a+b+c+d), 8 (a+b+c), 14, 19B, 20C, 22.

No. 40. Joist and Plank, Common, sapwood wanted for treatment, wane permitted.
1A (surfaced) or 1D (rough), 2, 3 (a+b+c+d+e+f+g+h-+i), 4 (a+b+c+d), 8 (a+b+c), 14, 19B, 20B, 22.

Posts and Timbers

No. 41. Posts and Timbers, Douglas Fir and Southern Pine, Dense Select, 85 per cent heartwood, square edges.
1C (surfaced) or 1F (rough), 2, 3 (a+b+c+d+e+f+g+h-+i), 6, 11 (a+b), 17, 19E, 20C, 21C, 24, 25, 27, 28 (a+b+c), Douglas Fir or 29 (a+b+c) Southern Pine.

No. 42. Posts and Timbers, Douglas Fir and Southern Pine, Dense Select, no heartwood or sapwood requirement, square edges.
1C (surfaced) or 1F (rough), 2, 3 (a+b+c+d+e+f+g+h-+i), 6, 11 (a+b), 17, 19E, 20C, 24, 25, 27, 28 (a+b+c), Douglas Fir or 29 (a+b+c) Southern Pine.

No. 43. Posts and Timbers, Douglas Fir and Southern Pine, Dense Select, no heartwood or sapwood requirement, wane permitted.
1C (surfaced) or 1F (rough), 2, 3 (a+b+c+d+e+f+g+h-+i), 6, 11 (a+b), 17, 19E, 20A, 24, 25, 27, 28 (a+b+c) Douglas Fir or 29 (a+b+c) Southern Pine.

No. 44. Posts and Timbers, Douglas Fir and Southern Pine, Dense Select, sapwood wanted for treatment, square edges.
1C (surfaced) or 1F (rough), 2, 3 (a+b+c+d+e+f+g+h-+i), 6, 11 (a+b), 17, 19E, 20C, 22, 24, 25, 27, 28 (a+b+c) Douglas Fir or 29 (a+b+c) Southern Pine.

No. 45. Posts and Timbers, Douglas Fir and Southern Pine, Dense Select, sapwood wanted for treatment, wane permitted.

1C (surfaced) or 1F (rough), 2, 3 (a+b+c+d+e+f+g+h+i), 6, 11 (a+b), 17, 19E, 20A, 22, 24, 25, 27, 28 (a+b+c) Douglas Fir or 29 (a+b+c) Southern Pine.

No. 46. Posts and Timbers, Douglas Fir and Southern Pine, Select, 85 per cent heartwood, square edges.

1C (surfaced) or 1F (rough), 2, 3 (a+b+c+d+e+f+g+h+i), 6, 11 (a+b), 17, 19E, 20C, 21C, 23, 25, 26, 28 (a+b+c) Douglas Fir or 29 (a+b+c) Southern Pine.

No. 47. Posts and Timbers, Douglas Fir and Southern Pine, Select, no heartwood or sapwood requirement, square edges.

1C (surfaced) or 1F (rough), 2, 3 (a+b+c+d+e+f+g+h+i), 6, 11 (a+b), 17, 19E, 20C, 23, 25, 26, 28 (a+b+c) Douglas Fir or 29 (a+b+c) Southern Pine.

No. 48. Posts and Timbers, Douglas Fir and Southern Pine, Select, no heartwood requirement, wane permitted.

1C (surfaced) or 1F (rough), 2, 3 (a+b+c+d+e+f+g+h+i), 6, 11 (a+b), 17, 19E, 20A, 23, 25, 26, 28 (a+b+c) Douglas Fir or 29 (a+b+c) Southern Pine.

No. 49. Posts and Timbers, Douglas Fir and Southern Pine, Select, sapwood wanted for treatment, square edges.

1C (surfaced) or 1F (rough), 2, 3 (a+b+c+d+e+f+g+h+i), 6, 11 (a+b), 17, 19E, 20C, 22, 23, 25, 26, 28 (a+b+c), Douglas Fir, or 29 (a+b+c) Southern Pine.

No. 50. Posts and Timbers, Douglas Fir and Southern Pine, Select, sapwood wanted for treatment, wane permitted.

1C (surfaced) or 1F (rough), 2, 3 (a+b+c+d+e+f+g+h+i), 6, 11 (a+b), 17, 19E, 20A, 22, 23, 25, 26, 28 (a+b+c) Douglas Fir or 29 (a+b+c) Southern Pine.

No. 51. Posts and Timbers, Select, 85 per cent heartwood, square edges.

1C (surfaced) or 1F (rough), 2, 3 (a+b+c+d+e+f+g+h+i), 6, 11 (a+b), 17, 19E, 20C, 21C.

No. 52. Posts and Timbers, Select, no heartwood, or sapwood requirement, square edges.

1C (surfaced) or 1F (rough), 2, 3 (a+b+c+d+e+f+g+h+i), 6, 11 (a+b), 17, 19E, 20C.

No. 53. Posts and Timbers, Select, no heartwood or sapwood requirement, wane permitted.

1C (surfaced) or 1F (rough), 2, 3 (a+b+c+d+e+f+g+h+i), 6, 11 (a+b), 17, 19E, 20A.

No. 54. Posts and Timbers, Select, sapwood wanted for treatment, square edges.

1C (surfaced) or 1F (rough), 2, 3 (a+b+c+d+e+f+g+h+i), 6, 11 (a+b), 17, 19E, 20C, 22.

No. 55. Posts and Timbers, Select, sapwood wanted for treatment, wane permitted.

1C (surfaced) or 1F (rough), 2, 3 (a+b+c+d+e+f+g+h+i), 6, 11 (a+b), 17, 19E, 20A, 22.

No. 56. Posts and Timbers, Common, 85 per cent heartwood, square edges.

1C (surfaced) or 1F (rough), 2, 3 (a+b+c+d+e+f+g+h+i), 6, 12 (a+b), 18, 19E, 20C, 21C.

No. 57. Posts and Timbers, Common, no heartwood or sapwood requirement, square edges.

1C (surfaced) or 1F (rough), 2, 3 (a+b+c+d+e+f+g+h+i), 6, 12 (a+b), 18, 19E, 20C.

No. 58. Posts and Timbers, Common, no heartwood or sapwood requirement, wane permitted.
1C (surfaced) or 1F (rough), 2, 3 (a+b+c+d+e+f+g+h+i), 6, 12 (a+b), 18, 19E, 20B.

No. 59. Posts and Timbers, Common, sapwood wanted for treatment, square edges.
1C (surfaced) or 1F (rough), 2, 3 (a+b+c+d+e+f+g+h+i), 6, 12 (a+b), 18, 19E, 20C, 22.

No. 60. Posts and Timbers, Common, sapwood wanted for treatment, wane permitted.
1C (surfaced) or 1F (rough), 2, 3 (a+b+c+d+e+f+g+h+i), 6, 12 (a+b), 18, 19E, 20B, 22.

No. 61. Posts and Timbers, Douglas Fir or Southern Pine, Dense Select. One face all heartwood and remaining face and sides 85 per cent heartwood, square edges.
1C (surfaced) or 1F (rough), 2, 3 (a+b+c+d+e+f+g+h+i), 6, 11 (a+b), 17, 19E, 20C, 21D, 24, 25, 27, 28 (a+b+c) Douglas Fir or 29 (a+b+c) Southern Pine.

No. 62. Posts and Timbers, Douglas Fir or Southern Pine, Select. One face all heartwood and remaining face and sides 85 per cent heartwood, square edges.
1C (surfaced) or 1F (rough), 2, 3 (a+b+c+d+e+f+g+h+i), 6, 11 (a+b), 17, 19E, 20C, 21D, 23, 25, 26, 28 (a+b+c) Douglas Fir or 29 (a+b+c) Southern Pine.

No. 63. Posts and Timbers, Select, one face all heartwood and remaining face and sides 85 per cent heartwood, square edges.
1C (surfaced) or 1F (rough), 2, 3 (a+b+c+d+e+f+g+h+i), 6, 11 (a+b), 17, 19E, 20C, 21D.

No. 64. Posts and Timbers, Common, one face all heartwood and remaining face and sides 85 per cent heartwood, square edges.
1C (surfaced) or 1F (rough), 2, 3 (a+b+c+d+e+f+g+h+i), 6, 12 (a+b), 18, 19F, 20C, 21D.

No. 65. Posts and Timbers, Douglas Fir or Southern Pine, Dense Select. One face all heartwood and remaining face and sides 75 per cent heartwood, square edges.
1C (surfaced) or 1F (rough), 2, 3 (a+b+c+d+e+f+g+h+i), 6, 11 (a+b), 17, 19E, 20C, 21E, 24, 25, 27, 28 (a+b+c), Douglas Fir, or 29 (a+b+c) Southern Pine.

No. 66. Posts and Timbers, Douglas Fir or Southern Pine, Select. One face all heartwood and remaining face and sides 75 per cent heartwood, square edges.
1C (surfaced) or 1F (rough), 2, 3 (a+b+c+d+e+f+g+h+i), 6, 11 (a+b), 17, 19E, 20C, 21E, 23, 25, 26, 28 (a+b+c) Douglas Fir or 29 (a+b+c) Southern Pine.

No. 67. Posts and Timbers, Select, one face all heartwood and remaining face and sides 75 per cent heartwood, square edges.
1C (surfaced) or 1F (rough), 2, 3 (a+b+c+d+e+f+g+h+i), 6, 11 (a+b), 17, 19E, 20C, 21E.

No. 68. Posts and Timbers, Common, one face all heartwood and remaining face and sides 75 per cent heartwood, square edges.
1C (surfaced) or 1F (rough), 2, 3 (a+b+c+d+e+f+g+h+i), 6, 12 (a+b), 18, 19F, 20C, 21E.

Exhibit C

NOTES ON TABLES OF WORKING STRESSES

Authority

1. The working stresses in the accompanying table are recommended by the Forest Products Laboratory, United States Forest Service, for structural grades complying with Basic Provisions for Structural Material of American Lumber Standards, including, also, stresses for red and white oak, as the same structural grades can be applied to hardwoods as to soft. In Beam and Stringer, and Post and Timber grades, stresses are given only for the species commonly cut to those sizes. Stresses for any other species can be obtained from the Forest Products Laboratory.

Minimum Strength Value

2. Structural grades are developed to insure minimum strength values. The defects permitted in the Common grades provide material having not less than 60 per cent of the strength of green clear wood, and in the Select grades, of 75 per cent, although in Douglas fir and southern pine the stresses recommended in compression and in extreme fiber in bending are 80 per cent of green clear wood strength on account of the limitation on rate of growth.

Elastic Limit as Breaking Strength

3. In determining working stresses, the Forest Products Laboratory has considered both elastic limit and breaking strength. Elastic limit, however, is more variable and less definite than ultimate strength, and the latter is taken as the more dependable basis for the determination of safe working stresses.

Factor of Safety

4. The factor of safety at a given working stress varies materially with the duration of the stress. At the recommended working stresses, given in the table for continuously dry locations, the average timber in buildings has a factor of safety of 6 on impact loading,* a factor of 4 for five-minute loads and 2¼ for long-time loading, with a minimum factor of safety of 2 on 75 per cent of the pieces under long-time loading. About one piece in 100, of very light weight and with maximum defects for the grade, would be expected to break at 1½ times the recommended stress under loading of approximately 10 years duration. For new timbers in bridge construction, the factors of safety are about 15 per cent greater.

Basis of Working Strength

5. Working stresses are based on the strength of the clear wood of the various species and, in some properties, on grade as fixed by limita-

---

*If impact stresses are neglected when less than 100 per cent of the live load producing them, the factor of safety for such loads would be reduced from 6 to a minimum of 3.

tion on size and location of knots, extent of shake and checks, and extent of cross grain, on conditions of exposure during use, and on size of piece. In southern pine and Douglas Fir working stresses in some properties are increased for rate of growth and percentage of summerwood.

Variations, Exposure, Grade, Size

6. Working stresses for extreme fiber in bending are varied with grade, extent of exposure, and size of piece; in horizontal shear, they are varied with grade; in compression parallel to grain, with grade and exposure; in compression perpendicular to grain, with exposure.

7. Working stresses in shear are not varied with size or extent of exposure; in compression parallel to grain they are not varied with size; in compression perpendicular to grain they are not varied with grade or size; in modulus of elasticity they are taken as the same in all grades.

Rate of Growth and Density

8. In Southern Pine and Douglas Fir, working stresses for extreme fiber in bending, compression parallel to grain and compression perpendicular to grain are increased for rate of growth and percentage of summerwood requirements. Values in these species in shear are increased for summerwood requirements but not for limitation on rate of growth. Modulus of elasticity is not varied with these properties.

Variations in Working Stresses

9.

Property	*Governing Defects*	*Conditions of Exposure*	*Grade*	*Size of Piece*	*Rate of Growth*	*Density*
Extreme fiber in bending	Knots and Angle of Grain	x	x	x*	x	x
Horizontal shear	Shake and Checks	–	x	–	–	x
Compression parallel	Knots and Angle of Grain	x	x	–	x	x
Compression Perpendicular		x	–	–	x	x
Modulus of Elasticity		–	–	–	–	–

---

*Dry location only.
xVaries with.
–Does not vary with.

Exposure

10. Working values are given for three conditions of exposure during use: (a) Continuously dry, (b) Occasionally wet but quickly dried, (c) More or less continuously damp or wet. Judgment should be exercised as to the values to be used in a particular case.

Continuously Dry

(a) Continuously dry contemplates use in interior or protected construction not subject to conditions of excessive dampness or high humidity.

Occasionally Wet

(b) Occasionally wet but quickly dried assumes use in such exterior structures as bridges, trestles, grandstands or bleachers, and exposed frame work of open sheds.

Continuously Wet

(c) More or less continuously damp or wet would apply to material exposed to waves or tidewater, or in contact with earth, or used in a building in portions that would be more or less continuously wet.

Impact

11. The working values recommended may be used without allowance for impact up to 100 per cent. Shear stresses for joint details may be taken as 50 per cent greater than the values for horizontal shear given in the table.

Analysis for Shear Stress

12. Recognition of all loads in designing for moving loads, or loads concentrated near a support, gives an assumed shearing stress higher than is actually developed. In calculating the shear at one end of a beam, the concentrated loads between this end and a point distant three times the depth of the beam from the support may be considered as acting at this point. In moving loads, as on highway bridges or railway stringers, in computing the shear at one end it is safe to ignore all wheel loads between this support and a point three times the depth of the beam or stringer from this point when the balance of the span is assumed loaded so as to give a maximum shear stress.

Permanent Set

13. Timber constantly yields under long continued loading, acquiring a permanent set. This set with a fully loaded beam is about equal to the deflection using the modulus of elasticity as given in the tables. In order to minimize the results of sag, it is advisable to use values one-half those given in the tables.

Compression in Short Columns

14. The working stresses for compression parallel to grain are for use on posts, struts, etc., with unsupported length not greater than eleven times their least dimension. They are also for use in end bearing on compression members, as a short column or strut is more likely to fail at the end than at any other point in its length, and the variations in moisture content are greater there.

Compression in Medium Length Columns

15. For columns of intermediate length, the Forest Products Laboratory finds from tests recently made that a fourth-power parabola, tangent to the Euler curve, is a conservative representation of the law controlling the strength. That is, from the short block to the long column in which

the strength is dependent in stiffness, there is a falling off in ultimate strength which follows a smooth curve, very flat at first but curving sharply to become tangent to the Euler curve at two-thirds of the ultimate crushing strength.

Formula

16. For columns from $\frac{l}{d} = 11$ until $\frac{P}{A} = \frac{2S}{3}$:

$$\frac{P}{A} = S\left[1 - \frac{1}{3}\left(\frac{l}{Kd} \right)^4 \right]$$

where P = Total load in pounds.
A = Area in square inches.
$\frac{P}{A}$ = Unit compressive stress.
S = Safe stress in compression parallel to grain.
l = Unsupported length in inches.
d = Least dimension in inches.
K = A constant dependent on the modulus of elasticity and compressive strength parallel to grain.

Influence of Defects

17. The influence of defects on the compressive strength of columns of constant cross-section decreases as the length increases. When $\frac{l}{d}$ equals the value of K for the species and grade, defects such as are allowable in the Select grade have little influence on the strength as a column. Within this length the Laboratory does not find justification for increasing the stresses on square-end columns over those for carefully centered pin-end columns. Beyond this length the investigation of the strength of columns indicated that the Euler formula is quite accurate for long wooden columns with pin-end connections and that the maximum load is dependent upon stiffness. In such columns, a factor of safety of 4 should be applied to values of modulus of elasticity in order to obtain safe loading.

Long Columns

18. For long columns, with factor of safety of 4 =

$$\frac{P}{A} = \frac{E}{5\left(\frac{l}{d} \right)^2}$$

Where E = Modulus of elasticity and other notation is as above.

Maximum Length

19. Columns should be limited in slenderness to $\frac{l}{d} = 50$.

Direct Tension

20. For direct tension the same values as for extreme fiber stress in bending may be used. Straight grained wood has greater resistance to

DESIGNING STRESSES

(Pounds per square inch)
Developed by Forest Products Laboratory, United States Forest Service

Joist and Plank

4″ and less in thickness
SELECT GRADE

SPECIES	Varied with Conditions of Exposure to Moisture						Not Varied with Conditions of Exposure	
	Continuously dry		Occasionally wet but quickly dried		More or less continuously damp or wet			
	Extreme fibre in bending	Compression perpendicular to grain	Extreme fiber in bending	Compression perpendicular to grain	Extreme fiber in bending	Compression perpendicular to grain	Horizontal shear	Modulus of elasticity
Cedar, western red	900	200	710	150	670	125	80	1,000,000
northern and southern white	750	175	580	140	535	100	70	800,000
Port Orford	1100	250	890	200	800	150	90	1,200,000
Alaska	1100	250	890	200	800	150	85	1,200,000
Cypress, southern	1300	350	980	250	800	225	100	1,200,000
Douglas fir:								
Coast Region: Select	1600	345	1235	240	950	215	90	1,600,000
Dense Select	1750	380	1350	265	1040	235	100	1,600,000
Rocky Mountain Region	1100	275	800	225	625	200	85	1,200,000
Fir, balsam	900	150	670	125	535	100	70	1,000,000
Golden, noble, silver, white	1100	300	800	225	710	200	70	1,100,000
Hemlock, West Coast	1300	300	980	225	800	200	75	1,400,000
Eastern	1100	300	800	225	710	200	70	1,100,000
Larch, western	1200	325	980	225	800	200	100	1,300,000
Oak, red and white	1400	500	1070	375	890	300	125	1,500,000
Pine, southern: Select	1600	345	1235	240	950	215	110	1,600,000
Dense Select	1750	380	1350	265	1040	235	120	1,600,000
California, Idaho and Northern white, Pondosa and sugar	900	250	710	150	670	125	85	1,000,000
Norway	1100	300	890	175	710	150	85	1,200,000
Redwood	1200	250	890	150	710	125	70	1,200,000
Spruce, red, white, Sitka	1100	250	800	150	710	125	85	1,200,000
Engelmann	750	175	580	140	445	100	70	800,000
Tamarack, eastern	1200	300	980	225	800	200	95	1,300,000

COMMON GRADE

SPECIES	Extreme fiber in bending	Compression perpendicular to grain	Extreme fiber in bending	Compression perpendicular to grain	Extreme fiber in bending	Compression perpendicular to grain	Horizontal shear	Modulus of elasticity
Cedar, western red	720	200	600	150	565	125	64	1,000,000
northern and southern white	600	175	490	140	450	100	56	800,000
Port Orford	880	250	750	200	675	150	72	1,200,000
Alaska	880	250	675	200	600	150	68	1,200,000
Cypress, southern	1040	350	825	250	675	225	80	1,200,000
Douglas fir, Coast region	1200	325	980	225	750	200	72	1,600,000
Rocky Mountain region	880	275	675	225	525	200	68	1,200,000
Fir, balsam	720	150	565	125	450	100	56	1,000,000
Golden, noble, silver, white	880	300	675	225	600	200	56	1,100,000
Hemlock, West Coast	1040	300	825	225	675	200	60	1,400,000
Eastern	880	300	675	225	600	200	56	1,100,000
Larch, western	960	325	825	225	675	200	80	1,300,000
Oak, red and white	1120	500	900	375	750	300	100	1,500,000
Pine, southern	1200	325	980	225	750	200	88	1,600,000
California, Idaho and northern white								
Pondosa and sugar	720	250	600	150	565	125	68	1,000,000
Norway	880	300	750	175	600	150	68	1,200,000
Redwood	960	250	750	150	600	125	56	1,200,000
Spruce, red, white, Sitka	880	250	675	150	600	125	68	1,200,000
Engelmann	600	175	490	140	375	100	56	800,000
Tamarack, eastern	960	300	825	225	675	200	76	1,300,000

Beams and Stringers

5″ and thicker

SELECT GRADE

SPECIES	Extreme fiber in bending	Compression perpendicular to grain	Extreme fiber in bending	Compression perpendicular to grain	Extreme fiber in bending	Compression perpendicular to grain	Horizontal shear	Modulus of elasticity
Cedar, western red	900	200	800	150	750	125	80	1,000,000
Port Orford	1100	250	1000	200	900	150	90	1,200,000
Douglas fir: Coast region: Select	1600	345	1385	240	1065	215	90	1,600,000
Dense Select	1750	380	1515	265	1165	235	100	1,600,000
Rocky Mountain region	1100	275	900	225	700	200	85	1,200,000
Hemlock, West Coast	1300	300	1100	225	900	200	75	1,400,000
Larch, western	1200	325	1100	225	900	200	100	1,300,000
Oak, red and white	1400	500	1200	375	1000	300	125	1,500,000
Pine, southern: Select	1600	345	1385	240	1065	215	110	1,600,000
Dense Select	1750	380	1515	265	1165	235	120	1,600,000
Redwood	1200	250	1000	150	800	125	70	1,200,000
Spruce, red, white, Sitka	1100	250	900	150	800	125	85	1,200,000

COMMON GRADE

SPECIES	Varied with Conditions of Exposure to Moisture						Not Varied with Conditions of Exposure	
	Continuously dry		Occasionally wet but quickly dried		More or less continuously damp or wet			
	Extreme fiber in bending	Compression perpendicular to grain	Extreme fiber in bending	Compression perpendicular to grain	Extreme fiber in bending	Compression perpendicular to grain	Horizontal shear	Modulus of elasticity
Cedar, western	720	200	640	150	600	125	64	1,000,000
Port Orford	880	250	800	200	720	150	72	1,200,000
Douglas fir: Coast region	1200	325	1040	225	800	200	72	1,600,000
Rocky Mountain region	880	275	720	225	560	200	68	1,200,000
Hemlock, West Coast	1040	300	880	225	720	200	60	1,400,000
Larch, western	960	325	880	225	720	200	80	1,300,000
Oak, red and white	1120	500	960	375	800	300	100	1,500,000
Pine, southern	1200	325	1040	225	800	200	88	1,600,000
Redwood	960	250	800	150	640	125	56	1,200,000
Spruce, red, white, Sitka	880	250	720	150	640	125	68	1,200,000

Posts and Timbers
6″ x 6″ and larger
SELECT GRADE

SPECIES	Varied with Conditions of Exposure to Moisture						Not Varied with Conditions of Exposure
	Continuously dry		Occasionally wet but quickly dried		More or less continuously damp or wet		
	Compression parallel to grain	Compression perpendicular to grain	Compression parallel to grain	Compression perpendicular to grain	Compression parallel to grain	Compression perpendicular to grain	Modulus of elasticity
Cedar, western red	700	200	700	150	650	125	1,000,000
Port Orford	900	250	825	200	750	150	1,200,000
Douglas fir:							
Coast region: Select	1175	345	1065	240	905	215	1,600,000
Dense Select	1285	380	1165	265	990	235	1,600,000
Rocky Mountain region	800	275	800	225	700	200	1,200,000
Hemlock, West Coast	900	300	900	225	800	200	1,400,000
Larch, western	1100	325	1000	225	800	200	1,300,000
Oak, red and white	1000	500	900	375	800	300	1,500,000
Pine, southern: Select	1175	345	1065	240	905	215	1,600,000
Dense Select	1285	380	1165	265	990	235	1,600,000
Redwood	1000	250	900	150	750	125	1,200,000
Spruce, red, white, Sitka	800	250	750	150	650	125	1,200,000

Common Grade

SPECIES	Compression parallel to grain	Compression perpendicular to grain	Compression parallel to grain	Compression perpendicular to grain	Compression parallel to grain	Compression perpendicular to grain	Modulus of elasticity
Cedar, western red	560	200	560	150	520	125	1,000,000
Port Orford	720	250	660	200	600	150	1,200,000
Douglas fir, Coast region	880	325	800	225	680	200	1,600,000
Rocky Mountain region	640	275	640	225	560	200	1,200,000
Hemlock, West Coast	720	300	720	225	640	200	1,400,000
Larch, western	880	325	800	225	640	200	1,300,000
Oak, red and white	800	500	720	375	640	300	1,500,000
Pine, southern	880	325	800	225	680	200	1,600,000
Redwood	800	250	720	150	600	125	1,200,000
Spruce, red, white, Sitka	640	250	600	150	520	125	1,200,000

tension than to any other kind of stress. It has been found, however, practically impossible to design joints that will develop anywhere near the full tensile strength.

Joists and Beams in Direct Tension

21. Grades of Joists or Beams may be used for members in direct tension, as in bottom chords of trusses, increase in size of defects towards ends being permissible because of the gradual application of stresses through splice plates or end connections.

Joist and Plank—Vertical or Horizontal

22. The provisions of the Joist and Plank grades are such that working stresses for these grades may be applied to material used with wide faces vertical or horizontal.

Working Stresses in Timbers Nearly Square

23. Where working stresses in bending are required for caps, bridge ties, etc., they should be graded on Beam and Stringer grades, but as such material is often square or has horizontal faces wider than the vertical faces, in contrast to beams and stringers in which the narrow faces are horizontal faces and the wide faces are vertical, care should be exercised that the knot limitations are applied to the proper faces.

Two-Span Stringers

24. In railway stringers of two spans length, defects throughout the center two-thirds should be limited as in the center third of single span stringer, for the maximum moment will be over the center support and although the full positive moment would not be developed in either span as long as there was resistance to negative moment over the center support, there might be circumstances in which full positive moment of resistance at the centers of the two spans would be desirable.

SAFE LOADS FOR WOODEN COLUMNS

1. The unit working stresses in compression parallel to grain for columns whose ratio of unsupported length to least dimension does not exceed 11 shall be not greater than that given for the species in the accompanying table of Designing Stresses.

2. For columns the ratio of whose unsupported length to least dimension is greater than 11, the following formula shall be used until the reduction in allowable stress equals one-third the stress for short columns:

$$\frac{P}{A} = S\left[1 - \frac{1}{3}\left(\frac{l}{Kd}\right)^4\right]$$

when $\frac{P}{A}$ = Unit compressive stress

S = Safe stress in compression parallel to grain

l = Unsupported length in inches

d = Least dimension in inches

K = A constant dependent on the modulus of elasticity and the compressive strength parallel to grain.

3. For columns of greater length the Euler formula below which includes factor of safety of 4 shall be used:

$$\frac{P}{A}=\frac{E}{5\left(\frac{l}{d}\right)^2}$$

where E = modulus of elasticity, and other notation is as above.

4. Columns shall be limited in slenderness to $\frac{l}{d}=50$.

VALUES OF "K" FOR COLUMNS OF INTERMEDIATE LENGTH

SPECIES	GRADE	
	Select	*Common*
Cedar, western red	21	23
Port Orford	20	22
Douglas Fir,		
Coast region: Select	20	23
Dense Select	20	23
Rocky Mountain region	21	24
Hemlock, West Coast	22	24
Larch, western	19	21
Oak, red and white	21	24
Pine, southern: Select	20	23
Dense Select	20	23
Redwood	19	21
Spruce, red, white, Sitka	21	24

STRENGTH OF COLUMNS OF INTERMEDIATE LENGTH

IN PER CENT OF STRENGTH OF SHORT COLUMNS

Values for the expression $\left[1-\frac{1}{3}\left(\frac{l}{Kd}\right)^4\right]$

in the Formula: $\frac{P}{A}=S\left[1-\frac{1}{3}\left(\frac{l}{Kd}\right)^4\right]$

K	PERCENTAGE $=\left[1-\frac{1}{3}\left(\frac{l}{Kd}\right)^4\right]$													
18	93	91	88	84	80	74	67							
19	95	93	90	87	83	79	73	67						
20	96	94	92	89	86	83	78	73	67					
21	96	95	93	91	89	86	82	78	73	67				
22	97	96	95	93	91	88	85	81	77	72	67			
23	98	97	95	94	92	90	87	84	81	77	72	67		
24	98	97	96	95	93	92	89	87	84	80	76	72	67	
25	98	98	97	96	94	93	91	89	86	83	80	76	72	67
$\frac{l}{d}$	12	13	14	15	16	17	18	19	20	21	22	23	24	25

Ratio of Length to Least Dimension in Rectangular Timbers.

This table can also be used for columns not rectangular, the l/d being equivalent to .289 l/r, where r is the least radius of gyration of the section.

Appendix C

(3) THE VALUE OF TREATED TIMBER IN WOODEN BRIDGES AND TRESTLES

C. S. Heritage, Chairman, Sub-Committee; O. C. Badger, F. H. Cramer, J. A. Newlin, C. E. Paul, G. C. Tuthill, J. T. Vitt, S. R. Young.

Treated timber is used extensively for the construction of wooden railway bridges, especially trestles. Statistics show that the use of treated timber for this purpose is increasing.

The value of treated timber in wooden bridges and trestles can best be determined by comparing it with untreated timber.

The primary consideration is whether or not the use of treated timber is economical. Other features to be considered are the strength and fire hazard as compared with untreated timbers, and the effect of the creosote on the fastenings. In special cases where timber is subject to ravages of the teredo, treated timber is satisfactory for use where untreated timber is entirely unsuited.

Timber treated for use in railway bridges is usually creosoted and the treated timber considered in this report is timber treated by creosoting.

The relative economy of treated timber depends on the first cost, the life and annual maintenance charges of treated timber structures as compared with untreated timber structures.

The cost of timber and of creosoting timber are both variable, but in general creosoted trestles will cost approximately one and one-half times as much as similar untreated structures.

The life of both treated and untreated timber is variable depending upon climatic conditions, species and grade of timber used. When treated, the method of handling the construction will affect the life of the structure, that is, creosoted timbers must have all surfaces that are cut into protected, or decay will start at such places and the benefit of the treatment will be largely lost. When possible timbers should be framed before treatment.

The life of untreated timber in trestles will generally not exceed ten years except in favorable climates. Sometimes trestles are kept in service much longer but at considerable maintenance expense for replacing decayed timbers.

Creosoted timber has not been generally used in railway bridges a sufficiently long time to absolutely determine its average life. Some structures have lasted thirty and forty years and still retain a big per cent of the original timber. Others have been renewed after a service life of less than twenty years. Of the latter class the short life has usually been due to imperfect knowledge of handling, either in the treatment of the timber itself or by failing to protect the cut surfaces when framing the timbers. The art of creosoting timbers and of handling creosoted timbers has improved so that it is safe to predict a minimum useful life of twenty-five or more years for creosoted timbers in bridge structures.

Mr. A. F. Robinson, Bridge Engineer of the Santa Fe, in a paper before the Western Society of Engineers and American Wood Preservers' Association in 1922, stated that creosoted ballasted deck structures on their line, from sixteen to twenty years old, seemed to be in perfect condition and gave promise of being good for fifteen to twenty years of additional service. Bridge Engineers on various roads have reported their estimate of the life of creosoted trestles anywhere from twenty-five to thirty-five years. The Southern Pacific, with more than 130 miles of creosoted pile trestle and 3000 creosoted timber drain boxes, say from their experience they feel that an average life of thirty years can be expected, and further state that they have hundreds of structures twenty-nine years old that are in good condition and thousands twenty-five years old that give every promise of still being good when they reach the age of thirty years.

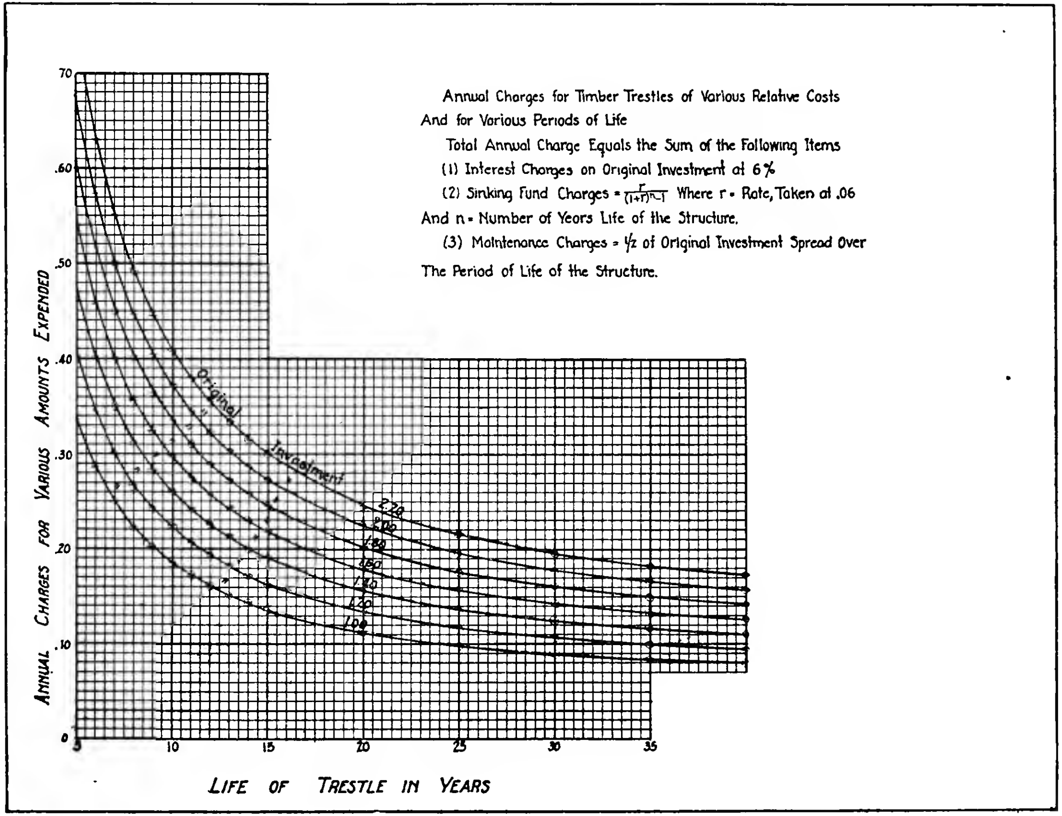
Mr. R. H. Rawson, Consulting Timber Engineer, estimates the average time at which untreated fir should be removed from a structure is ten years and of treated fir thirty years.

As to maintenance costs on timber structures, this is variable and the practice of roads is different, some replacing bridges more frequently to avoid high maintenance charges after the structure has deteriorated, others carrying the structure with repairs and partial renewals for longer periods. In general, the Committee believes that when the structure has deteriorated to the extent that one-half of the original cost has been used for maintenance that the structure should be replaced.

Following is a diagram showing the annual charges for timber trestles for various periods of useful life. These charges are based on an interest charge of 6 per cent on the invested capital, a sinking fund for renewal at the end of the life of the structure, and a maintenance charge equal to one-half of the total cost of the structure spread over the life of the structure. The maintenance charges will naturally be small during the first years of the life of the structure and increase during the last years, but for a matter of comparison, it is assumed to be spread over the period of useful life uniformly.

Assuming the cost of an untreated structure as unity and of a similar creosoted structure as 1.5, the life of an untreated structure as ten years and of the creosoted structure as twenty-five years, then the annual charges for the untreated structure will be .186, as against .147 for the creosoted structure. This may be taken as a fair average condition, but for different relative costs and different periods of life comparisons can readily be made.

Again assume that the untreated structure has a cost of unity and a life of ten years; that a similar creosoted structure cost 1.4 as much as the untreated structure, then for the same cost per year the creosoted structure would have to last less than sixteen years. If the creosoted structure cost 1.5 it would have to last 17½ years, and if it cost 1.6 it would have to last 19½ years.



Annual Charges for Timber Trestles of Various Relative Costs
And for Various Periods of Life

Total Annual Charge Equals the Sum of the Following Items

(1) Interest Charges on Original Investment at 6%

(2) Sinking Fund Charges = $\frac{r}{(1+r)^n-1}$ Where r = Rate, Taken at .06
And n = Number of Years Life of the Structure.

(3) Maintenance Charges = ½ of Original Investment Spread Over
The Period of Life of the Structure.

From observations on the life of creosoted structures we can safely predict longer average life than the necessary minimum to produce annual charges as low as that for untreated structures. In other words, the Committee believes that creosoted timber used for bridge structures will show a considerable saving over a period of years.

The above examples are based on similar construction for both untreated and treated structures. Creosoted ballasted deck structures are being built extensively by many roads. This type of structure is rarely built of untreated timber on account of its short life. The relative cost of untreated open deck structures and creosoted ballast deck structures is more variable than when trestles of similar design are considered because the variation of design must be considered as well as the variation of the cost of materials. Our estimates indicate that a creosoted ballasted deck trestle will cost from 1.8 to 1.9 times as much as an untreated open deck trestle for the same loading. The diagram can be used for comparing the economy in this case just as well, it is only necessary to determine the relative cost and relative life. Assuming the cost of the untreated structure as unity and with a 10-year life as before, then a creosoted ballasted deck trestle costing 1.8 would have to have a life of 23½ years to be as economical as the untreated structure, and if the cost were double the minimum economical life would be a little less than 28 years. It is thought that such a structure will have a life in excess of the minimum required for economy and that such a structure will have the added advantage of a better riding track, less maintenance and the fire hazard nearly eliminated.

The above discussion is based on the assumption that the cost for timber in place will be the same for each successive renewal. It is probable, however, on account of the increasing cost of timber and labor that the cost of timber in place will increase to a considerable extent between renewals, so that the savings accomplished by the use of creosoted timber will be even greater than indicated.

The strength of creosoted timber as compared with untreated has been studied to a considerable extent, but the data obtainable is conflicting and unsatisfactory. In general, pine takes creosote oil quite readily and the strength is very little affected under modern processes of treatment. Fir is more difficult to treat, the timber being more highly resistant to the penetration of the oil. Under some processes the high temperatures used in boiling and pressure used in treatment have lessened the strength from 15 per cent to 40 per cent. However, the methods are improving and it is thought that the fir being treated at the present time has lost very little if any of its original strength. Tests are now under way which are expected to bear this out. With proper handling of the treating of timber the same working stresses can be used for creosoted timber structures as for untreated structures. The specifications for treatment and the quality of timber used must be considered in assigning working stresses.

The fire hazard of creosoted timber is less than for untreated after the creosoted timber has been exposed to the weather for six months to one year, so that the more volatile oils have evaporated. This is borne out by tests on the ignition point of treated and untreated timbers and by tests on amount of treated and untreated timber consumed by fire under similar conditions as reported in the National Fire Prevention Association's Proceedings for 1915, also by the observation of numerous cases of fire in creosoted timber structures.

The treatment of timber is advisable by prolonging its life and by utilizing certain grades of timber that are satisfactory for use when treated, but which are entirely unsuitable in the untreated state. For instance, it is not necessary to restrict the sap content of timber that is to be treated, while untreated sap pine or fir decays so quickly that it cannot be used untreated. Creosoted timber has proven satisfactory for use in teredo infected waters, where untreated timber cannot be economically used. The effect of creosote in timber is not detrimental to the metal used for fastenings (see A.R.E.A. Proceedings, 1917).

The Committee concludes that the construction of wooden railway bridges and trestles should be of treated timber, except when such construction is known to be temporary.

The use of creosoted timber will in general reduce the annual charges as compared with untreated timber.

If properly handled in the creosoting plants, the strength will not be materially reduced and the same working stresses can be used as for untreated timber.

The fire hazard is somewhat reduced, and if the treated structures are of the ballasted deck type, the fire hazard is practically eliminated.

Appendix D

(5) CONTINUE THE STUDY ON CLASSIFICATION OF THE USES OF TIMBER AND LUMBER UNDER AMERICAN RAILWAY ENGINEERING ASSOCIATION SPECIFICATIONS.

W. H. Hoyt, Chairman, Sub-Committee; C. R. Chevalier, W. J. Gooding, T. F. Laist, J. B. Maddock, D. W. Smith, S. R. Young.

This subject was reported upon last year, but was referred back to the Committee for further study pending the adoption of new lumber standards.

Revisions have been made to keep the report in line with the report of this Committee this year on lumber and timber specifications.

The report is covered by recommended grades shown in Exhibit D.

Exhibit D

Note—Details of heartwood, sapwood, wane and square edge specification not included in these grades, but left to the discretion of the person consulting this reference and ordering material.

1. Bridge and Construction Timber

A. Combination and Howe Truss Spans	American Lumber Standards Grades Recommended for Use
1. Compression members	Select Structural Posts and Timbers
2. Tension	Select Structural Joist and Plank
3. Diagonals subject to reversal of stress	Select Structural Posts and Timbers
4. Floor Beams	Select Structural or Dense Select Structural Beams and Stringers
5. Stringers	
6. Ties	Select Structural Timbers
7. Guard Timbers	Common Structural Timbers
8. Railing	No. 1 Common Dimension
9. Stiffeners	No. 1 Common Dimension
10. Splices	No. 1 Common Dimension
11. Nailing Strips	No. 1 Common Dimension
12. Grillage	Common Structural Timbers
13. Deck Plank	No. 1 Common Dimension
14. Bridging	No. 2 Common Boards
B. Pile and Frame Trestles	
1. Sills and Mud Sills	Select Structural Timbers
2. Posts	Select Structural Posts
3. Caps	Select Structural Timbers
4. Sash Bracing	Common Structural Plank
5. Cross Bracing	Common Structural Plank
6. Longitudinal Bracing	Common Structural Plank
7. Girts	Common Structural Timbers
8. End Planks	Common Structural Planks
9. Stringers	Select Structural or Dense Select Structural Stringers
10. Ties	Select Structural Timbers
11. Guard Timbers	Common Structural Timbers
12. Planking for Ballasted Deck	Select Structural Plank
13. Railing	No. 1 Common Dimension

	AMERICAN LUMBER STANDARDS GRADES RECOMMENDED FOR USE
C. FALSEWORK	
1. Sills and Mud Sills	Common Structural Timbers
2. Posts	Common Structural Posts
3. Caps	Common Structural Timbers
4. Stringers	Select Structural Stringers
5. Truss Timbers	Common Structural Timbers
6. Centering	No. 1 Common Dimension
7. Lagging	No. 1 Common Dimension
8. Bracing	Common Structural Plank
9. Wedges	No. 1 Common Dimension
10. Scaffolding	No. 2 Common Dimension
D. CONCRETE FORMS	
1. Dimension Lumber	No. 1 Common Dimension
2. D & M Planks	No. 2 Common Boards
3. Bracing	No. 2 Common Boards
E. TANKS AND SUPPORTS	
1. Sills	Common Structural Timber
2. Posts	Select Structural Posts
3. Caps	Select Structural Timbers
4. Bracing	Common Structural Plank
5. Joists	Select Structural Joist
6. D & M Flooring	C Flooring
7. Staves	C Tank Stock
8. Rafters	No. 1 Common Dimension
9. Roof	No. 1 Common Shiplap
10. Ladders, Etc.	C Ladder Stock
11. Frost-box Material	No. 1 Common Shiplap
F. DOCKS AND WHARVES	
1. Timber Sheet Piling	Common Structural Timber
2. Timber in Cribs	Common Structural Timber
3. Caps	Select Structural Timber
4. Stringers	Select Structural or Dense Select Structural Stringers
5. Bracing	Common Structural Plank
6. Guard Timber	Common Structural Timber
7. Ties	Select Structural Timber
8. Plank Decking	Select Structural Planks
9. Mooring Posts	Select Structural Timber
10. Fenders and Wales	Common Structural Timber
11. Warehouse, see Frame Buildings	
G. COALING STATIONS AND ORE STATIONS	
1. Sills and Mud Sills	Common Structural Timbers
2. Posts	Select Structural Posts
3. Caps	Select Structural Timber
4. Bracing	Common Structural Plank
5. Stringers	Select Structural or Dense Select Structural Stringers
6. Joists	Select Structural Joists
7. Bin Lining	No. 1 Common Dimension
8. Rafters	No. 1 Common Dimension
9. Flooring	No. 1 Common Boards
10. Chutes	No. 1 Common Boards
11. Decking	No. 1 Common Boards
12. Coal Pockets and Bins	No. 1 Common Dimension
13. Roofing	No. 2 Common Shiplap

	AMERICAN LUMBER STANDARDS GRADES RECOMMENDED FOR USE
H. TUNNELS	
1. Posts	Select Structural Timber
2. Sills	Select Structural Timber
3. Caps	Select Structural Timber
4. Segments	Select Structural Timber
5. Lagging	No. 1 Common Dimension
6. Struts	No. 1 Common Dimension
J. CAISSON	Select Structural Timber
2. Frame Buildings.	
A. STATION BUILDINGS, PASSENGER, FREIGHT, PLATFORM SHELTERS	
1. Caps	Common Structural Timber
2. Sills	Common Structural Timber
3. Posts	Common Structural Timber
4. Stringers	Select Structural Stringers
5. Joists	Common Structural Joists
6. Bridging	No. 3 Common Boards
7. Sub-Flooring	No. 2 Common Shiplap
8. Finish Flooring	A or B Flooring (for Natural Finish) C or D Flooring (for Paint Finishes)
9. Studding and Plates	No. 1 Common Dimension
10. Sheathing	No. 2 Common Shiplap
11. Furring	No. 2 Common Strips
12. Siding	B or C Siding
13. Ceiling	B Ceiling (for Natural Finishes) C Ceiling (for Paint Finishes)
14. Truss Timbers	No. 1 Common Dimension
15. Purlins	No. 1 Common Dimension
16. Rafters	No. 1 Common Dimension
17. Roof Boards	No. 2 Common Shiplap
18. Shingles on Roofs and Side Walls	A (for roofs) B (for Side Walls)
19. Door and Window Frames	C Finish
20. Outside Finish Lumber	C Finish
21. Inside Finish Lumber	A or B Finish (for Natural Finishes) C or D Finish (for Paint Finishes)
22. Millwork	
a. Mouldings	A Moulding Stock or C Moulding Stock
b. **Stairs**	A Finish or C Finish
23. Partitions	B Partition or C Partition
24. Shelving	C Finish
B. ENGINE HOUSE	
1. Caps	Common Structural Timber
2. Sills	Common Structural Timbers
3. Posts	Common Structural Timbers
4. Stringers	Select Structural Stringers
5. Joists	Select Structural Joists
6. Bridging	No. 3 Common Boards
7. Flooring	No. 1 Common Dimension
8. Pit Timbers	Common Structural Timbers
9. Studding	No. 1 Common Dimension
10. Furring	No. 2 Common Strips
11. Siding	C or D Siding
12. Ceiling	C Ceiling

B. ENGINE HOUSE.—CONTINUED	AMERICAN LUMBER STANDARDS GRADES RECOMMENDED FOR USE
13. Truss Lumber	No. 1 Common Dimension
14. Purlins	No. 1 Common Dimension
15. Rafters	No. 1 Common Dimension
16. Roof Boards	No. 2 Common Shiplap
17. Shingles	A
18. Door and Window Frames	C Finish
19. Outside Finish Lumber	C or D Finish
20. Inside Finish Lumber	C Finish
21. Millwork	C Finish
22. Sleepers	No. 2 Common Dimension
C. MACHINE SHOPS.	
1. Caps	Common Structural Timbers
2. Sills	Common Structural Timbers
3. Posts	Common Structural Timbers
4. Stringers	Select Structural Stringers
5. Joists	Select Structural Joists
6. Bridging	No. 3 Common Boards
7. Flooring	No. 1 Common Dimension
8. Studding	No. 1 Common Dimension
9. Sheathing	No. 2 Common Shiplap
10. Furring	No. 2 Common Strips
11. Siding	C or D Siding
12. Ceiling	C or D Ceiling
13. Truss Timbers	Select Structural
14. Purlins	No. 1 Common Dimension
15. Rafters	No. 1 Common Dimension
16. Roofing Boards	No. 2 Common Shiplap
17. Shingles	A
18. Door and Window Frames	C Finish
19. Outside Finish Lumber	C Finish
20. Inside Finish Lumber	C Finish
21. Millwork	C Finish
22. Sleepers	No. 2 Common Dimension
D. SECTION HOUSES	
1. Posts	No. 2 Common Dimension
2. Sills	No. 2 Common Dimension
3. Caps	No. 2 Common Dimension
4. Joists	No. 1 Common Dimension
5. Bridging	No. 3 Common Boards
6. Sub-flooring	No. 2 Common Shiplap
7. Finish Flooring	B Flooring (for Natural Finishes) C Flooring (for Paint Finishes)
8. Studding and Plates	No. 1 Common Dimension
9. Sheathing	No. 2 Common Shiplap
10. Furring	No. 2 Common Strips
11. Siding	C or D Siding
12. Ceiling	C or D Ceiling
13. Rafters	No. 1 Common Dimension
14. Roof Boards	No. 2 Common Shiplap
15. Shingles	A
16. Door and Window Frames	C Finish
17. Outside Finish Lumber	C Finish
18. Inside Finish Lumber	C Finish
19. Millwork	C Finish

E. Miscellaneous Small Buildings	American Lumber Standards Grades Recommended for Use
1. Posts	No. 2 Common Dimension
2. Sills	No. 2 Common Dimension
3. Caps	No. 2 Common Dimension
4. Joists	Common Structural Joists
5. Bridging	No. 3 Common Boards
6. Sub-Flooring	No. 2 Common Shiplap
7. Finish Flooring	C Flooring
8. Studding and Plates	No. 1 Common Dimension
9. Sheathing	No. 2 Common Shiplap
10. Furring	No. 3 Common Strips
11. Siding	C or D Siding
12. Ceiling	C or D Ceiling
13. Rafters	No. 1 Common Dimension
14. Roof Boards	No. 2 Common Shiplap
15. Shingles	C
16. Door and Window Frames	C Finish
17. Outside Finish Lumber	C Finish
18. Inside Finish Lumber	C Finish
19. Millwork	C Finish
F. Warehouses	
1. Caps	Common Structural Timbers
2. Sills	Common Structural Timbers
3. Posts	Common Structural Timbers
4. Stringers	Select Structural Stringers
5. Joists	Select Structural Joists
6. Bridging	No. 2 Common Boards
7. Sub-Flooring	No. 2 Common Shiplap
8. Finish Flooring	C Flooring
9. Studding and Plates	No. 1 Common Dimension
10. Sheathing.	No. 2 Common Shiplap
11. Furring	No. 2 Common Strips
12. Siding	C or D Siding
13. Ceiling	C or D Ceiling
14. Truss Timbers	No. 1 Common Dimension
15. Purlins	No. 1 Common Dimension
16. Rafters	No. 1 Common Dimension
17. Roof Boards	No. 2 Common Shiplap
18. Shingles	A
19. Door and Window Frames	C Finish
20. Outside Finish Lumber	C Finish
21. Inside Finish Lumber	C Finish
22. Millwork	C Finish
23. Sleepers	No. 2 Common Strips
G. Ice Houses.	
1. Sills	Common Structural Timbers
2. Caps	Common Structural Timbers
3. Posts	Common Structural Timbers
4. Stringers	Select Structural Stringers
5. Joists	No. 1 Common Dimension
6. Bridging	No. 2 Common Boards
7. Sleepers	No. 2 Common Strips
8. Sub-Flooring	No. 2 Common Shiplap
9. Finish Flooring	C Flooring
10. Studding	No. 1 Common Dimension
11. Sheathing	No. 2 Common Shiplap
12. Furring	No. 3 Common Strips
13. Siding	C or D Siding
14. Ceiling	C or D Ceiling

4. Miscellaneous Roadway Material

	AMERICAN LUMBER STANDARDS GRADES RECOMMENDED FOR USE
A. CROSSING PLANK.	No. 1 Common Dimension
B. PLATFORMS.	
1. Posts	No. 1 Common Dimension
2. Caps	No. 1 Common Dimension
3. Sills	No. 1 Common Dimension
4. Stringers	Select Structural Stringers
5. Joists	Select Structural Joists
6. Bridging	No. 3 Common Boards
7. Planking	No. 1 Common Dimension
8. Railing	No. 1 Common Dimension
9. Steps	No. 1 Common Boards
10. Skids	No. 1 Common Dimension
C. STOCK GUARDS.	
1. Posts	No. 1 Common Dimension
2. Ties	Select Structural Timbers
3. Wing Fences and Aprons	No. 1 Common Boards
4. Slats	No. 1 Common Boards
5. Fillers	No. 2 Common Boards
D. SIGNS AND POSTS.	
1. Posts	No. 1 Common Dimension
2. Bracing	No. 2 Common Dimension
3. Sign Boards	C Finish
4. Moulding	C Moulding Stock
E. FENCING, INCLUDING SNOW FENCE.	
1. Posts	No. 1 Common Dimension
2. Bracing	No. 2 Common Boards
3. Stringers	No. 1 Common Dimension
4. Fence Boards	No. 2 Common Boards
5. Gate Materials	No. 1 Common Boards
6. Stakes	No. 2 Common Boards
F. CULVERTS AND DRAINS.	
1. Sills	Common Structural
2. Bracing	No. 2 Common Boards
3. Timbers	Common Structural Timbers
4. Planking	No. 2 Common Dimension
5. Grillage	Common Structural Timbers
G. STOCK PENS.	
1. Posts	No. 1 Common Dimension
2. Sills	No. 1 Common Dimension
3. Fencing	No. 1 Common Dimension
4. Studding	No. 1 Common Dimension
5. Sheathing	No. 2 Common Shiplap
6. Rafters	No. 1 Common Dimension
7. Roof Boards	No. 2 Common Shiplap
8. Shingles	B
9. Outside Finish Lumber	C Finish
H. POLES.	Select Structural Timber
I. CONDUITS.	No. 1 Common Dimension
J. BUMPING BLOCKS.	Select Structural Timber

REPORT OF COMMITTEE XVII—WOOD PRESERVATION

S. D. Cooper, *Chairman;*	F. C. Shepherd, *Vice-Chairman;*
W. G. Atwood,	R. S. Belcher,
H. C. Bell,	Z. M. Briggs,
G. M. Davidson,	G. F. Eberly,
J. E. Fanning,	H. J. Force,
C. F. Ford,	E. B. Fulks,
Andrew Gibson,	E. W. Hammond,
R. H. Howard,	W. H. Kirkbride,
J. B. McClain,	J. F. Pinson,
L. J. Reiser,	W. R. Rhodes,
Frank Ringer,	Dr. Hermann von Schrenk,
O. C. Steinmayer,	J. H. Waterman,
J. W. Williams,	Galen Wood,

Committee.

To the American Railway Engineering Association:

This Committee respectfully presents herewith a report covering the following subjects:

(1) Revision of Manual (Appendix A).
(2) Treatment of Douglas Fir (Appendix B).
(3) Service test records (Appendix C).
(4) Marine piling investigations (Appendix D).
(5) Preservative treatment of trunking and capping (Appendix E).
(6) Treatment with creosote and petroleum (Appendix F).
(7) Treatment with zinc-chloride and petroleum (Appendix G).
(8) Outline of work for ensuing year.

Action Recommended

Your Committee recommends that Appendix A, Revision of the Manual; Appendix B, Treatment of Douglas Fir; Appendix E, Preservative Treatment of Trunking and Capping, be adopted and published in the Manual.

Your Committee recommends that Appendix C, Service Test Records; Appendix D, Marine Piling Investigations; Appendix F, Treatment with Creosote and Petroleum; Appendix G, Treatment with Zinc-Chloride and Petroleum, be accepted as information.

Outline of Work for Ensuing Year

1. Revision of Manual.
2. Service test records.
3. Marine piling.
4. Treatment with creosote and petroleum.
5. Treatment with zinc-chloride and petroleum.
6. Preparation of structural material before treatment with preservatives.
7. Outline of work for the ensuing year.

Respectfully submitted,

The Committee on Wood Preservation,

S. D. Cooper, *Chairman.*

Bulletin 284, February, 1926.

Appendix A

(1) REVISION OF THE MANUAL

Dr. H. von Schrenk, Chairman, Sub-Committee.

The work of the Sub-Committee consisted of two parts: First, an editorial revision of the Manual, given in Exhibit A. This is simply a revision as to form so as to bring co-related subjects together. Certain changes as to wording have also been made, but in none of the revisions have any changes as to the matter been made. The Committee recommends the adoption of the editorial revision as given in Exhibit A. It should be noted that if the revisions recommended in the second part of the Sub-Committee's report are adopted, there should be a further revision of Exhibit A to include such changes.

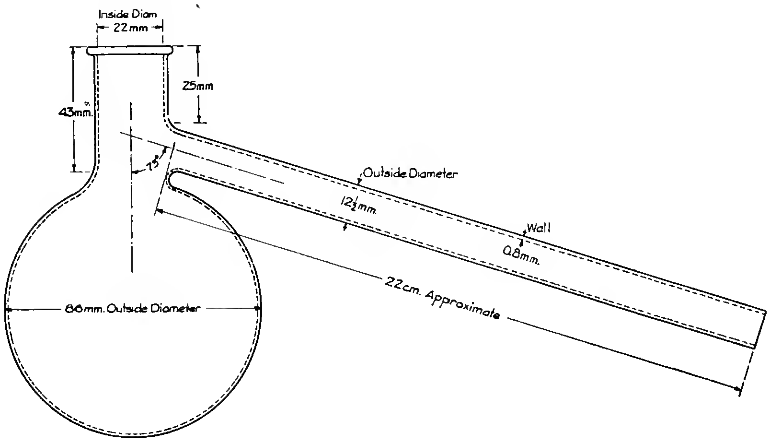


Fig. 7—Flask for Distillation.

The second part of the Committee's work consists in the report on actual revisions of the matter now in the Manual with changes recommended for adoption as follows:

Page 819, paragraph 13, line 2, reads "an auger ¾ to 1 inch in diameter." This should be changed to *"increment borer."*

Page 821, line 20. This reads "cubic yard" and should be changed to *"cubic foot."*

The following sections which are herewith recommended for omission were adopted in 1914 at a time when creosote coal-tar solution had not been used long enough to establish its value as a preservative. In the eleven years that have elapsed since the adoption of these clauses it has been found that the addition of coal-tar actually increases the value of the preservative and its use is very widespread. Probably in excess of one-half the ties, poles and piling now being creosoted in the Unitd States and Canada are treated with creosote coal-tar solution.

Page 822. "Precautions to be followed in the purchase and use of creosote-coal-tar solution," Sections 1 to 6. *Omit the heading and entire section.* Clauses 1, 2 and 3 under the heading "Precautions" are simply statements of fact and are unnecessary. Similar statements are equally applicable to any other specifications for material in the Manual. Clauses 4 and 6 are partial specifications which are covered equally well in other parts of the present oil and treatment specifications. Paragraph 5 is simply a statement of two ways of doing something which could not be done in any other way. The part relating to the method of mixing, as at present written, is not correct, and after all, the method will vary with the material and apparatus available for making the solution. It is believed that the finished specification for the creosote coal-tar solution now in the Manual properly describes the type of oil which should be used.

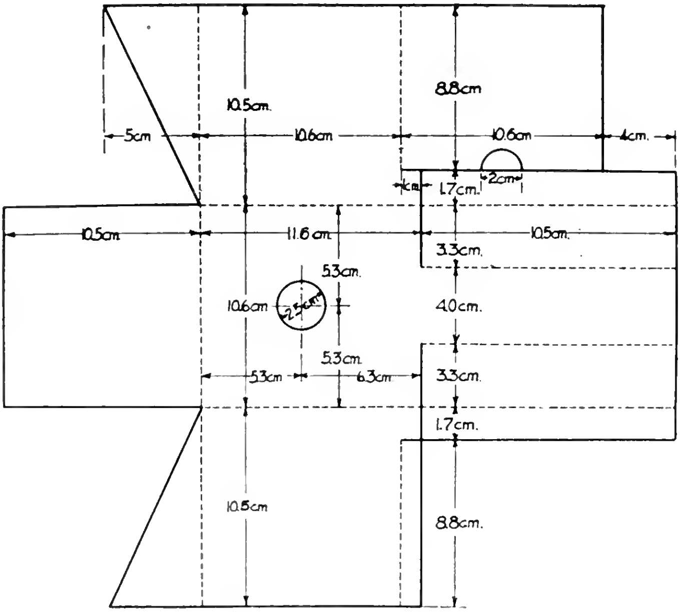


Fig. 9—Asbestos Shield.

Page 822, second column, "The use of coal-tar in creosote." Third column, *omit title and Section 1.*

As it is considered an advantage to add tar to creosote for certain purposes, there is no reason why it should not be added to Grade No. 1 as well as to any other grade, consequently the clause relating to this addition should be eliminated. Coal-tar is being added, at the present time, to large quantities of Grade No. 1 creosote in actual practice all over the United States with the very best results.

Page 828, line 2. Withdraw paragraph A, including Fig. 7, retort for distillation test, and substitute therefor *(a) flask shall be of the form and dimensions as shown in Fig. 7.*

Page 828, paragraph C. Revise the first sentence to read "Shield of asbestos as shown in Fig. 9 shall be used to protect the *flask* from air currents and to prevent radiation."

Page 829. Omit Fig. 9 and substitute revised drawing submitted herewith.

Page 830, Fig. 10. Substitute for the figure now in the Manual revised drawing submitted herewith.

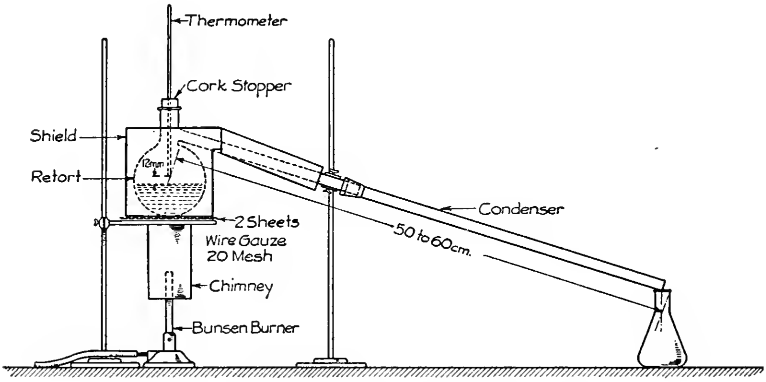


FIG. 10—DISTILLATION APPARATUS SET-UP.

Page 830, last paragraph. For the words, "retort" in the first, fifth and seventh lines, substitute the word *"flask."*

Page 831, lines 2, 10, 12, 17 and 18, substitute for the word "retort" the word *"flask."*

Referring to the recommendations to change wording and drawings now on page 828 to 831, inclusive, of the Manual, it should be noted that in the 1925 report (Volume 26, page 74) the Committee described a new side-neck flask for distilling creosote and gave reasons why the suggested flask would probably be more satisfactory for the distillation of creosote than the present standard retort, chief of which was that the suggested flask can be made of absolutely uniform size and shape. Work during the past year has shown that the results obtained with the new flask are practically the same as those obtained with the retort, hence the results of the distillations with the new flask may be compared with the results hitherto obtained with the retort.

Tables 1, 2 and 3, which follow herewith, are given to show the results from the distillation of a number of different creosote oils made by

TABLE 1—OIL No. 1.

aboratory	Distillation—Degrees Centigrade														
	Below 200			200–210			210–235			235–315			315–355		
	Retort	Flask	Dif.	Retort	Flask	Dif.	Retort	Flask	Dif.	Retort	Flask	Dif.	Retort	Flask	Dif.
A	0.0	0.0	0.0	0.0	0.0	0.0	9.0	8.7	0.3	44.0	43.2	0.8	18.9	18.1	0.8
B	0.0	0.0	0.0	0.0	0.0	0.0	4.8	5.1	0.3	48.6	47.2	1.4	19.7	20.0	0.3
C	0.0	0.0	0.0	0.7	0.0	0.7	14.3	11.5	2.8	39.7	39.7	0.0	23.3	23.6	0.3
D	0.0	0.0	0.0	0.4	0.0	0.4	14.1	13.0	1.1	38.9	39.2	0.3	22.7	22.6	0.1
E	0.4	0.0	0.4	0.7	0.7	0.0	18.5	11.4	4.1	38.4	36.5	1.9	21.8	21.7	0.1
F	0.4	0.0	0.4	0.9	0.5	0.4	16.1	13.6	2.5	39.8	40.8	1.0	22.6	21.5	1.1
G	0.0	0.0	0.0	1.7	0.9	0.8	13.0	11.7	1.3	44.6	41.2	3.4	21.3	21.8	0.5
H	1.0	0.4	0.6	1.2	0.7	0.5	14.6	13.1	1.5	42.4	40.0	2.4	21.5	21.2	0.3
Max.	1.0	0.4	0.6	1.7	0.9	0.8	18.5	14.4	4.1	48.6	47.2	3.4	23.3	23.6	1.1
Min.	0.0	0.0	0.0	0.0	0.0	0.0	4.8	5.1	0.3	38.4	36.5	0.0	18.9	18.1	0.1
Dif.	1.0	0.4	0.6	1.7	0.9	0.8	13.7	9.3	3.8	10.2	10.7	3.4	4.4	5.5	1.0

TABLE 2—OIL No. 2.

aboratory	Distillation—Degrees Centigrade														
	Below 200			200–210			210–235			235–315			315–355		
	Retort	Flask	Dif.	Retort	Flask	Dif.	Retort	Flask	Dif.	Retort	Flask	Dif.	Retort	Flask	Dif.
A	0.6	0.0	0.6	1.2	1.7	0.5	40.7	40.8	0.1	37.6	36.7	0.9	11.8	11.6	0.2
B	0.0	0.0	0.0	2.3	1.6	0.7	32.3	33.0	0.7	47.1	46.6	0.5	9.9	10.0	0.1
C	0.0	0.0	0.0	2.2	1.5	0.7	48.1	41.4	6.7	30.3	34.5	4.2	13.5	14.1	0.6
D	0.0	0.0	0.0	2.7	1.3	1.4	48.8	46.5	2.3	30.4	32.6	2.2	11.8	11.5	0.3
E	0.9	0.0	0.9	3.2	2.5	0.7	32.4	34.7	2.3	42.2	38.4	3.8	17.5	15.9	1.6
F	0.3	0.0	0.3	1.8	1.1	0.7	49.5	45.3	4.2	29.8	33.6	3.8	13.7	12.4	1.3
G	0.0	0.0	0.0	5.8	2.6	3.2	45.9	39.7	6.2	32.5	35.8	3.3	13.3	14.3	1.0
H	2.1	0.6	1.5	3.7	1.8	1.9	42.7	43.1	0.4	37.7	34.4	3.3	....	......	.....
Max.	2.1	0.6	1.5	5.8	2.6	3.2	49.5	46.5	6.7	47.1	46.6	4.2	17.5	15.9	1.6
Min.	0.0	0.0	0.0	1.2	1.1	0.5	32.3	33.0	0.1	29.8	32.6	0.5	9.9	10.0	0.1
Dif.	2.1	0.6	1.5	4.6	1.5	2.7	17.2	13.5	6.6	17.3	14.0	3.7	7.6	5.9	1.5

TABLE 3—DISTILLATION.

Oil	Sp. Gr. 1.052		Sp. Gr. 1.047		Sp. Gr. 1.058		Sp. Gr. 1.093		Sp. Gr. 1.074	
	Retort	Flask	Retort	Flask	Retort	Flask	Retort	Flask	Retort	Flask
200°C.	0.35	0.00	1.00	0.10	0.95	0.25	0.80	0.00	0.35	0.00
210°C.	1.35	0.20	2.05	1.10	2.05	1.00	2.90	0.65	1.65	0.40
235°C.	21.65	21.10	22.25	22.80	18.65	17.95	19.90	16.30	16.55	16.20
315°C.	72.40	73.65	72.75	71.75	65.35	65.55	53.45	52.20	63.15	61.70
355°C.	93.65	95.50	91.90	91.25	84.90	84.20	67.10	66.85	81.75	81.15
Res.	6.30	4.40	8.10	8.70	15.10	15.80	32.80	33.10	18.20	18.80
Specific Gravity of Fractions at 38 Deg. C.										
235–315	1.039	1.040	1.036	1.035	1.035	1.034	1.044	1.044	1.035	1.036
315–355	1.110	1.110	1.104	1.104	1.099	1.100	1.104	1.104	1.104	1.103

different laboratories. Tables 1 and 2 represent analyses of two different oils by eight laboratories. Table 3 represents the analyses of five different oils by one laboratory. The distillate figures represent "per cent of original oil."

These figures show that the results obtained by the flask are more consistent than by the retort and that at the critical temperatures (235°, 315°, 355°) the difference between the retort and flask for any one laboratory is very much less than the difference among the various laboratories is for either the flask or retort.

The Committee, therefore, recommends the substitution of the new flask as shown in Fig. 7, together with the set-up in Fig. 9 and 10, to replace the present standard retort.

Page 834, paragraph 7, coke residue. Withdraw the present apparatus and method for testing coke residue and substitute therefor revised apparatus and method for determining coke residue as follows:

Coke Residue

Apparatus—The crucible shall be of platinum and shall have a capacity of 20 to 30 cc. The cover of the crucible shall be of the inverted type, having a depth of about 1 cm., the wall tightly fitting the crucible except for a slight crease.

Procedure—The residue resulting from the distillation test shall be poured directly into the tared crucible or into a tin box, wherein it may be heated on a water or steam bath, but not over a flame. About 1 g. of the residue shall be weighed into the covered crucible and then placed on a platinum, nichrome, or fire-clay triangle over a Bunsen burner, with the bottom of the crucible 6 to 8 cm. from the top of the burner. The burner flame shall be regulated to a height of 20 cm. while burning free and the crucible shall be exposed to the full flame for 7 minutes. A Meeker burner may be used, or the crucible may be heated for several minutes in an electric furnace. Whatever the method of heating employed, the temperature during the entire 7-minute period shall be not less than 950 deg. C. and should be as near that temperature as possible. At the end of this period the flame shall be removed, the crucible transferred to a desiccator and permitted to cool, after which it shall be weighed. The residue in the crucible after ignition shall be reported as "fixed carbon" (i. e., coke).

The test shall be conducted in a part of the laboratory free from draughts.

The percentage of coke obtained in accordance with Section 2 shall be calculated on the basis of the original sample of oil.

Example—With a retort distillation of 15.9 per cent of residue at 355 deg. C., the residue containing 7.2 per cent of fixed carbon:

$$\text{Coke in oil} = \frac{15.9 \times 7.2}{100} = 1.14 \text{ per cent.}$$

The revision of the method for determining coke residue is the same as was recommended to the American Society for Testing Materials in 1923 as a tentative standard. The essential difference between the old and new method is that in the new method a platinum crucible is used instead of the glass bulb. Another difference between the old and the new method is that in the latter the determination is made on the residue instead of the complete oil. The new method has the advantage in that it is simpler to operate, and does away with the difficulty of obtaining suitable glass bulbs. It also gives more concordant results, as is indicated by the following analyses, made with the bulb and the crucible with five different oils in three different laboratories. The figures express per cent of original oil.

Oil No.	I		II		III		IV		V	
Method..........	Bulb	Cruc.	Bulb	Cruc.	Bulb	Cruc.	Bulb	Cruc.	Bulb	Cruc.
Coke............	8.9	7.7	5.1	4.4	6.5	5.3	7.13	6.27	4.80	4.39
	8.2	8.0	4.7	4.2	5.9	5.4	7.15	6.14	3.85	4.44
	8.2	8.1	5.4	4.6	7.1	5.3	....	6.24	....	......
Average.........	8.4	7.9	5.0	4.4	6.5	5.3	7.14	6.22	4.32	4.41
Variation........	0.7	0.4	0.7	0.2	1.2	0.1	0.02	0.13	.95	0.05

Page 836, Section 2. Eliminate this section and substitute therefor the following: *"The zinc-chloride shall conform to the standard A.R.E.A. Specifications."*

Page 838, paragraph 2, for the words,

Creosote oil Grade No. 1,
Creosote oil Grade No. 2,
Creosote oil Grade No. 3,
Creosote-coal-tar solution,

substitute the following:

CREOSOTE OIL GRADES 1, 2 OR 3,
CREOSOTE-COAL-TAR SOLUTION.

Page 838, paragraph 5, lines 1, 2, 3, 4 and 5. Eliminate the first two sentences in these five lines and substitute therefor the following: *"The zinc-chloride used shall be in accordance with the A.R.E.A. Standard Specifications."*

Page 839. After the title zinc-chloride and creosote oil, add in parenthesis as part of the title *"Card Process."* Eliminate "(see U. S. patents 815,404 and 1,178,132)."

Page 839, paragraph 2. Eliminate this paragraph and substitute therefor the following: *"The zinc-chloride used shall be in accordance with the A.R.E.A. Specifications."*

Page 842. Change the title "Creosote oil (empty cell process with final vacuum)" to read *"Creosote oil—Lowry Process (empty cell process with final vacuum)."* Omit the line below the title reading "(see U. S. patents 707,799 and 831,450)."

Page 842, paragraph 2, for the lines,

Creosote oil Grade No. 1,
Creosote oil Grade No. 2,
Creosote oil Grade No. 3,
Creosote-coal-tar solution,

substitute the following:

CREOSOTE OIL GRADES 1, 2 OR 3,
CREOSOTE-COAL-TAR SOLUTION.

Page 843. Change the title "Creosote oil (empty cell process with initial air and final vacuum)" to read *"Creosote oil—Rueping Process (empty cell process with initial air and final vacuum)."*

Page 843, paragraph 2, change the lines,

Creosote oil Grade No. 1,
Creosote oil Grade No. 2,
Creosote oil Grade No. 3,
Creosote-coal-tar solution,

to read:

CREOSOTE OIL GRADES 1, 2 OR 3,
CREOSOTE-COAL-TAR SOLUTION.

Exhibit A

WOOD PRESERVATION

GENERAL PROVISIONS[1]

(1) Creosote oil and zinc-chloride are effective wood preservatives when properly applied and when used under proper conditions.

(2) It is desirable to air-season wood in order to prepare it for treatment. Most woods can be treated best after being air-seasoned.

(3) It is essential that wood should be grouped properly in order that successful treatment may be obtained. The species, the proportion of heartwood and sapwood, the condition of the timber with respect to its moisture content and wood structure will determine, in general, this grouping.

(4) Bridge material and any wood which is to be treated should have all framing and boring done as far as possible before treating.

(5) It is better to inject quantities of chemicals in excess of the requirements than to skimp the treatment in any way.

(6) Chemicals used should be tested for purity from time to time.

(7) When treating with creosote oil or creosote-coal-tar solution the quantity to be used should be specified in gallons for ties, posts, cross-arms and other material of uniform size, and in pounds per cubic foot for other material.

(8) Absorption of creosote oil should be based on the treatment which will give the most complete penetration for each class or kind of wood, specifying complete penetration of the sapwood and as much of the heartwood as possible.

(9) In order to determine the penetration of the oil, borings should be made with an increment borer in at least six pieces in each cylinder load. The holes should be plugged with creosoted plugs at least one-sixteenth inch larger than the diameter of the hole.

(10) Ties treated with water soluble salts should be allowed to dry some time before they are put in the track.

(11) Daily reports should be kept at the works and duplicate sent to the General Office, if desired, in order to check the operation.

(12) Accurate records should be kept in order to form proper conclusions as to the merits of different methods and processes.

(13) Preserved wood may be destroyed by mechanical action long before it is decayed, and, therefore, should be protected by economical devices when the mechanical life limits the life of the tie.

(14) For best results it is recommended that certain sections of track be selected on each railroad for the purpose of making accurate tests covering the life of treated and untreated ties of various kinds of timber and

---

[1] Adopted Vol. 10, 1909, pp. 629-631, 669-676; Vol. 11, Part 2, 1910, pp. 737, 761, 859. Vol. 15, 1914, pp. 632, 1088; Vol. 18, 1917, pp. 1271, 1579; Vol. 20, 1919, pp. 126, 840.

various treatments, and that a record be kept of all ties in these sections of track in order to be able hereafter to improve treatment. All ties inserted in such test sections should be marked with dating nails, and, if necessary, with other identification marks.

GROUPING, STACKING AND PREPARING WOOD BEFORE TREATMENT[2]

(1) Wood should be separated into groups previous to treatment. The factors to be considered in grouping are: condition of seasoning, species of wood, percentage of heartwood and sapwood and size of pieces.

(2) Pieces of wood of approximately the same period of seasoning should be grouped together; green pieces should not be mixed with seasoned ones.

(3) Pine and other coniferous woods should be separated on the basis of the percentage of heartwood and sapwood.

(4) Grouping of the pieces by species and families is desirable. From this it follows that red oak, beech, longleaf pine, loblolly pine and gum should be stacked and treated separately. Birch, beech and hard maples are examples of grouping of species which may be stacked and treated together.

(5) Wood should not be treated until seasoned. If it arrives at the treating plant in a seasoned condition, ready for treatment, it may be loaded directly to trams for treatment. Otherwise it should be stacked in the yard for air seasoning.

(6) The seasoning yard should be arranged so that adjacent stacks of ties, piling, timbers, etc., shall have an alley at least 3 feet wide between them.

(7) All wood shall be piled on treated sills or other non-decaying material in such manner that, in the case of ties, there shall be a space of at least 6 inches between the bottom of the lowest tier and the ground, and in the case of piling or timbers a space of at least 12 inches.

(8) The space in the seasoning yard under and between the rows of stacks shall be kept free, at all times, from rotting wood, weeds and rubbish. The yard shall be drained so that no water can stand under the stacks or in their immediate vicinity.

(9) Ties should be stacked in layers of one or two and seven to ten.

(10) Caps, stringers and other large timbers should be stacked so as to leave air spaces between adjacent pieces in the same layer and layers should be separated by 4 inch by 4 inch strips.

(11) Lumber should be segregated according to size and each layer in a stack separated by strips at least 1 inch thick, and an air space of 1 inch or more left between each piece of lumber in every layer.

(12) Piling should be stacked according to length, using strips 4 inches by 4 inches, or saplings of equal size, between each layer.

---

[2] Adopted Vol. 13, 1912, pp. 864, 1040-1041; Vol. 21, 1920, pp. 325-334, 1385. Vol. 23, 1922, pp. 979, 1169.

(13) Since the rate of seasoning varies with the latitude, time of year, the exposure and the climatic peculiarities of the season, it is essential to establish the seasoning period for each class of wood for any particular locality.

(14) Wood piled for seasoning should be closely watched and not allowed to overseason or deteriorate. No wood should be treated which does not conform to the requirements of the specifications as to shakes, checks, etc.

(15) Wood which shows signs of checking should be provided with "S" irons, bolts or other devices to prevent further checking, both before and after treatment.

(16) All adzing, boring and framing should be done before treatment.

SPECIFICATIONS FOR PRESERVATIVE TREATMENT OF WOOD[3]

Creosote Oil (Full Cell Process)

1. Except when ordered otherwise by the railroad's representative, the material shall be air-seasoned until in his judgment any moisture in it will not prevent injection of the specified amount of preservative; shall be restricted in any charge to woods into which approximately equal quantities of preserving fluid can be injected; and shall consist of pieces approximately equal in size and sapwood content, on which all framing, boring or adzing shall have been done, so separated as to insure contact of steam and preservatives with all surfaces.

2. The preservative used shall be the one most suitable and available of the following standards of the American Railway Engineering Association:

Creosote Oil, Grade 1.
Creosote Oil, Grade 2.
Creosote-Coal-Tar Solution.
Creosote Oil, Grade 3.

3. The material shall retain the amount of creosote oil necessary to permeate all of the sapwood and as much of the heartwood as practicable. The quantities specified may vary from 10 pounds per cubic foot for material from needle-leaved trees from which most of the sapwood has been removed to 24 pounds per cubic foot for piling which has wide sapwood. The quantity of creosote oil retained shall be calculated, on the basis of 100 deg. Fahr., from readings of working tank gages and scales, or from weights of at least one-tenth of the material on a suitable track before and after treatment, checked as may be desired by the railroad's representative.

4. After the material is placed in the cylinder, a vacuum of at least 22 inches shall be maintained until the wood is as dry and as free of air as practicable. The creosote oil shall then be introduced, without breaking the vacuum, until the cylinder is filled. The pressure shall be gradually

---

[3] Adopted, Vol. 21, 1920, pp. 325-334, 1385.

raised, and maintained at a minimum of 125 lb. per square inch until the required quantity of preservative is injected into the material, or until the railroad's representative is satisfied that the largest volumetric injection that is practicable has been obtained. The temperature of the preservative during the pressure period shall be not less than 170 deg. Fahr., nor more than 200 deg. Fahr., and shall average at least 180 deg. Fahr. After pressure is completed and the cylinder emptied of preservative, a vacuum shall be maintained until the material can be removed from the cylinder free of dripping preservative.

5. At least once each day the railroad's representative shall determine penetration by sampling ties at middle and rail sections; from other material samples shall be taken as desired. Any holes that may be bored shall be filled with tight-fitting creosoted plugs.

6. The treating plant shall be equipped with the thermometers and gages necessary to indicate and record accurately the conditions at all stages during the treatment, and all equipment shall be maintained in condition satisfactory to the railroad. The owner of the treating plant shall also provide and keep in condition for use at all times the apparatus and chemicals necessary for making the analyses and tests required in this specification.

7. When permission is given to prepare material for treatment by steaming instead of seasoning by air, it shall not be subjected to pressures or temperatures for periods sufficient to injure the wood.

Creosote Oil (Empty-Cell Process with Final Vacuum)

(See U. S. Patents 707,799 and 831,450)

1. Except when ordered otherwise by the railroad's representative, the material to be treated shall be air-seasoned until in his judgment any moisture in it will not prevent injection of an adequate amount of preservative; shall be confined in any charge to woods into which approximately equal quantities of preserving fluid can be injected; and shall consist of pieces approximately equal in size and sapwood content, on which all framing, boring or adzing shall have been done, so separated as to insure contact of steam and preservative with all surfaces.

2. The preservative used shall be the one most suitable of the following standard of the American Railway Engineering Association:

Creosote Oil, Grade 1.
Creosote Oil, Grade 2.
Creosote-Coal-Tar Solution.
Creosote Oil, Grade 3.

3. The material shall retain an average of at least six lb. of creosote oil per cubic foot, which will permeate all of the sapwood and as much of the heartwood as practical, and no charge shall contain less than 90 per cent nor more than 110 per cent of the quantity per cubic foot that may be specified. The quantity of preservative retained shall be calculated, on the basis of 100 deg. Fahr., from readings of working tank gages or scales or from weights of at least one-tenth of the material on a suitable track scale

before and after treatment, checked as may be desired by the railroad's representative.

4. After the material is placed in the cylinder, the preservative shall be introduced, at not over 200 deg. Fahr., until the cylinder is filled.

5. The pressure shall be raised and maintained until there is obtained the largest practicable volumetric injection that can be reduced to the required retention by a quick high vacuum. The pressure and temperature within the cylinder shall be so controlled as to give the maximum penetration by the quantity of preservative injected. After the pressure is completed the cylinder shall be speedily emptied of preservative and a vacuum of at least 22 inches promptly created and maintained until the quantity of preservative injected is reduced to the required retention.

6. At least once each day the railroad's representative shall determine penetration by sampling ties at middle and rail sections; from other material samples shall be taken as desired. Any holes that may be bored shall be filled with tight-fitting creosoted plugs.

7. The treating plant shall be equipped with the thermometers and gages necessary to accurately indicate and record conditions at all stages during the treatment, and all equipment shall be maintained in condition satisfactory to the railroad. The owner of the treating plant shall also provide and keep in condition for use at all times the apparatus and chemicals necessary for making the analyses and tests required in this specification.

Creosote Oil (Empty-Cell Process with Initial Air and Final Vacuum)

1. Except when ordered otherwise by the railroad's representative, the material to be treated shall be air-seasoned until in his judgment any moisture in it will not prevent injection of an adequate amount of preservative; shall be restricted in any charge to woods into which approximately equal quantities of preserving fluid can be injected; and shall consist of pieces approximately equal in size and sapwood content, on which all framing, boring, or adzing shall have been done, so separated as to insure contact of air and preservative with all surfaces.

2. The preservative used shall be the one most suitable and available of the following standards of the American Railway Engineering Association:

Creosote Oil, Grade 1.
Creosote Oil, Grade 2.
Creosote-Coal-Tar Solution.
Creosote Oil, Grade 3.

3. The material shall retain an average of at least 5 lb. of creosote oil per cubic foot, which shall permeate all of the sapwood and as much of the heartwood as practicable, and no charge shall retain less than 90 per cent nor more than 110 per cent of the quantity per cubic foot that may be specified. The amount of preservative retained shall be calculated, on the basis of 100 deg. Fahr., from readings of working tank gages

or scales or from weights of at least one-tenth of the material on a suitable track scale before and after treatment, checked as may be desired by the railroad's representative.

4. After the material is placed in the cylinder it shall be subjected to air pressure of sufficient intensity and duration to provide under a vacuum the injection of preservative necessary to insure the required retention. For example: With red oak pressures of 40 to 60 lb. for 30 minutes, while with pine having a large percentage of sapwood pressures of 70 to 90 lb. for 30 minutes will be required. The preservative shall then be introduced, the air pressure being maintained constant until the cylinder is filled. The pressure shall be gradually raised to at least 150 lb. per square inch, and maintained until all of the sapwood and as much of the heartwood as practicable is saturated, or until the railroad's representative is satisfied that the largest volumetric injection that is practicable has been obtained. The temperature of the preservative during the pressure period shall be not less than 170 deg. Fahr., nor more than 200 deg. Fahr., and shall average at least 180 deg. Fahr. After the pressure is completed the cylinder shall be speedily emptied of preservative and a vacuum of at least 22 inches be promptly created, and maintained until the material can be removed from the cylinder free of dripping preservative.

5. At least once each day the railroad's representative shall determine penetration by sampling ties at middle and rail sections; from other material samples shall be taken as desired. Any holes that may be bored shall be filled with tight-fitting creosoted plugs.

6. The treating plant shall be equipped with the thermometers and gages necessary to indicate and record accurately the conditions at all stages during the treatment, and all equipment shall be maintained in condition satisfactory to the railroad. The owner of the treating plant shall also provide and keep in condition for use at all times the apparatus and chemicals necessary for making the analyses and tests required in this specification.

Zinc-Chloride

1. Except when ordered otherwise by the railroad's representative, the material to be treated shall be air-seasoned until in his judgment any moisture in it will not prevent injection of the specified amount of preservative; shall be restricted in any charge to woods into which approximately equal quantities of preserving fluid can be injected; and shall consist of pieces approximately equal in size and sapwood content, on which all framing, boring, or adzing shall have been done, so separated as to insure contact of steam and preservative with all surfaces.

2. The zinc-chloride used shall be acid-free and shall not contain more than 0.1 per cent iron. Dry zinc-chloride shall contain at least 94 per cent soluble zinc-chloride, and in any solution purchased the percentage of zinc-chloride specified shall be the amount of soluble zinc-chloride required.

3. The material shall retain an average of 0.5 lb. of dry zinc-chloride per cubic foot, which shall permeate all of the sapwood and as much of the heartwood as practicable, and no charge shall retain less than 90 per cent nor more than 110 per cent of this quantity.

4. The treating solution shall be no stronger than necessary to obtain the required retention of preservative with the largest volumetric absorption that is practicable, and shall be thoroughly mixed before use. Its strength shall not exceed 5 per cent and shall be determined by analysis. Chemical titration, using a silver-nitrate solution with potassium-chromate indicator, will usually be satisfactory. For example: With red oak the strength shall not exceed 4 per cent, and the volume injected shall be not less than 20 per cent, while with pine having a large percentage of sapwood it shall not exceed 2 per cent, and the volume injected shall be not less than 40 per cent. The amount of solution retained shall be calculated from readings of working tank gages or scales or from weights of at least one-tenth of the material on a suitable track scale before and after treatment, checked as may be desired by the railroad's representative.

5. Air-seasoned material shall be steamed in the cylinder for not less than one hour nor more than two hours, at a pressure of not more than 20 lb. per square inch, the cylinder being provided with vents to relieve it of stagnant air and insure proper circulation of the steam and being drained to prevent condensate from accumulating in sufficient quantity to reach the material. After steaming is completed, a vacuum of at least 22 inches shall be maintained until the wood is as dry and as free from air as practicable. Before the preservative is introduced, the cylinder shall be drained of condensate, and if the vacuum is broken, a second one as high as the first shall be created. The preservative shall be introduced, without breaking the vacuum until the cylinder is filled. The pressure shall be gradually raised and maintained at a minimum of 125 pounds per square inch until the required quantity of preservative is injected into the material, or until less than 5 per cent of the total quantity required has been injected during the latter half of one hour throughout which the rate of injection has persistently decreased while the pressure has been held continuously at 165 or more lb. per square inch. The temperature of the preservative during the pressure period shall be not less than 130 deg. Fahr., nor more than 190 deg. Fahr., and shall average at least 150 deg. Fahr. After the cylinder is emptied of preserving solution, a vacuum shall be maintained until the material can be removed from the cylinder free of dripping preservative.

6. At least once each day the railroad's representative shall determine penetration by analysis. The "Iodine-Potassium Ferricyanide Starch" color reaction test to determine the penetration by its visibility will generally be satisfactory.

7. From ties, samples shall be taken at middle and rail sections; from other material samples shall be taken as desired. Any holes that may be bored shall be filled with tight-fitting treated plugs.

8. The treating plant shall be equipped with the thermometers and gages necessary to indicate and record accurately the conditions at all stages during the treatment, and all equipment shall be maintained in condition satisfactory to the railroad. The owner of the treating plant shall also provide and keep in condition for use at all times the apparatus and chemicals necessary for making the analysis and tests required in this specification.

Zinc-Chloride and Creosote Oil

(See U. S. Patents 815,404 and 1,178,132)

1. Except when ordered otherwise by the railroad's representative, the material to be treated shall be air-seasoned until in his judgment any moisture in it will not prevent injection of the specified amount of preservative; shall be restricted in any charge to woods into which approximately equal quantities of preserving fluid can be injected; and shall consist of pieces approximately equal in size and sapwood content, on which all framing, boring, or adzing shall have been done, so separated as to insure contact of steam and preservative with all surfaces.

2. The zinc-chloride used shall be acid-free and shall not contain more than 0.1 per cent iron. Dry zinc-chloride shall contain at least 94 per cent soluble zinc-chloride, and in any solution purchased the percentage of zinc-chloride specified shall be the quantity of zinc-chloride required.

3. The creosote oil shall meet the standard for Grade 3 Creosote oil.

4. The material shall retain an average of 0.5 lb. of dry zinc-chloride and 3 lb. of creosote oil per cubic foot, which shall permeate all of the sapwood and as much of the heartwood as practicable, and no charge shall retain less than 90 per cent nor more than 110 per cent of these quantities per cubic foot.

5. The preserving mixture shall be composed of the volumetric proportions of creosote oil and of zinc-chloride solution of the necessary strength which are required to obtain the specified retention of the preservatives with the largest volumetric injection that is practicable, and shall be agitated in the working tank and cylinder so as to insure thorough mixing before and while the cylinder is being filled with preservative and while the preservative is being injected into the material. The strength of the zinc-chloride solution shall not exceed 5 per cent and shall be determined by analysis. Chemical titration—using a silver-nitrate solution with potassium-chromate indicator, before the zinc-chloride solution is mixed with the creosote oil will usually be satisfactory. For example: With red oak the proportions shall be not less than 77 per cent of 5 per cent zinc-chloride solution and not more than 23 per cent of creosote oil, and the volume injected shall be not less than 20 per cent, while with pine having a large percentage of sapwood they shall be not less than 88 per cent of 2.5 per cent zinc-chloride and not more than 12 per cent of creosote oil, and the volume injected shall not be less than 40 per cent. The quantities of preservatives retained shall be calculated from readings of working tank gages or scales and from weights of at least one-tenth of the

material on a suitable track scale before and after treatment, checked as may be desired by the railroad's representative.

6. Air-seasoned material shall be steamed in the cylinder for not less than one hour nor more than two hours, at a pressure of not more than 20 lb. per square inch, the cylinder being provided with vents to relieve it of stagnant air and insure proper circulation of the steam and being drained to prevent condensate from accumulating in sufficient quantity to reach the material. After steaming is completed, a vacuum of at least 22 inches shall be maintained until the wood is as dry and as free from air as practicable. Before the preservative is introduced the cylinder shall be drained of condensate, and if the vacuum is broken a second one as high as the first shall be created. The preserving mixtures shall be introduced without breaking the vacuum until the cylinder is filled. The pressure shall be gradually raised, and maintained at a minimum of 125 lb. per square inch until the required amount of preservative is injected into the material, or until less than 5 per cent of the total quantity required has been injected during the latter half of one hour throughout which the rate of injection has persistently decreased while the pressure has been held continuously at 165 or more pounds per square inch. The temperature of the preservative during the pressure period shall be not less than 170 deg. Fahr., nor more than 200 deg. Fahr., and shall average at least 180 deg. Fahr. After the cylinder is emptied of preserving mixture, a vacuum shall be maintained until the material can be removed from the cylinder free of dripping preservative.

7. At least once each day the railroad's representative shall determine penetration by analysis. The "Iodine-Potassium Ferricyanide Starch" color reaction test to determine the penetration by its visibility will generally be satisfactory. From ties, samples shall be taken at middle and rail sections; from other material samples shall be taken as desired. Any holes that may be bored shall be filled with tight-fitting creosoted plugs.

8. The treating plant shall be equipped with the thermometers and gages necessary to indicate and record accurately the conditions at all stages during the treatment, and all equipment shall be maintained in condition satisfactory to the railroad. The owner of the treating plant shall also provide and keep in condition for use at all times the apparatus and chemicals necessary for making the analyses and tests required in this specification.

9. When water-gas-tar solution instead of creosote is used, it shall meet the following requirements:

10. The oil shall be a water gas-tar product, of which at least sixty per cent shall be a distillate of water gas tar and the remainder shall be refined or filtered water gas tar. It shall comply with the following requirements:

1. It shall not contain more than 3 per cent water.
2. It will not contain more than 2 per cent of matter insoluble in benzol.

3. The specific gravity of the oil at 38/15.5 degrees Centigrade shall not be less than 1.03 nor more than 1.07.
4. The distillate, based on water free oil, shall be within the following limits:
   Up to 210 degrees Centigrade, not more than 8 per cent.
   Up to 235 degrees Centigrade, not more than 20 per cent.
   Up to 355 degrees Centigrade, not less than 60 per cent.
5. The specific gravity of the fractions between 235 degrees Centigrade and 315 degrees Centigrade shall not be less than .98 nor more than 1.02 at 38/15.5 deg. C.
6. The residue above 355 degrees Centigrade, if it exceeds 5 per cent, shall have a float test of not more than 50 seconds at 70 deg. C.
7. The oil shall not yield more than 10 per cent coke residue.
8. The foregoing tests shall be made in accordance with the standard methods of the American Railway Engineering Association.

When a distillate of water gas tar is used, it shall meet the following requirements:

The oil shall be a distillate of water gas tar. It shall comply with the following requirements:

1. It shall not contain more than 3 per cent of water.
2. It shall not contain more than 0.5 per cent of matter insoluble in benzol.
3. The specific gravity of the oil at 38/15.5 degrees Centigrade shall be not less than 1.02.
4. The distillate, based on water free oil, shall be within the following limits:
   Up to 210 degrees Centigrade, not more than 5 per cent.
   Up to 235 degrees Centigrade, not more than 25 per cent.
   Up to 355 degrees Centigrade, not less than 80 per cent.
5. The specific gravity of the fractions between 235 degrees Centigrade and 315 degrees Centigrade shall not be less than .98 nor more than 1.02 at 38/15.5 deg. C.
6. The residue above 355 degrees Centigrade, if it exceeds 5 per cent shall have a float test of not more than 50 seconds at 70 deg. C.
7. The oil shall not yield more than 2 per cent coke residue.
8. The foregoing tests shall be made in accordance with the standard methods of the American Railway Enginering Association.

Zinc-Tannin

1. The zinc-chloride solution shall be introduced and adequate pressure shall be applied and maintained until the desired absorption is obtained The amount of solution injected shall be equivalent to ½-lb. of dry soluble zinc-chloride per cubic foot of timber. The solution shall be as weak as can be used and still obtain the desired absorption of zinc-chloride, and shall not be stronger than 5 per cent.

2. The solution shall be heated to a temperature of not less than 140 degrees Fahrenheit before admission to the cylinder. If the cylinders are provided with steam coils, steam shall be maintained in these coils during the entire treatment.

3. The cylinder shall be entirely filled with preservative, and so maintained while the pressure is on, an air vent being provided by which the air in the cylinder and that coming from the charge while under pressure may be released.

4. After the required amount of zinc-chloride has been injected, this solution shall be run off and the ties allowed to drain for 15 minutes. The chloride draining off shall be blown or run off, and a 2 per cent solution of tannic acid, made by mixing 6 2/3 lb. of 30 per cent extract of tannin with 100 lb. of water, run in, and a pressure of 100 lb. produced and maintained one-half hour. This shall then be run off, a 1 per cent solution of glue (made by dissolving 2 1/10 lb. of glue containing 50 per cent gelatine in 100 lb. water) shall be admitted to the cylinder, and a pressure of 100 lb. produced and maintained for one-half hour. Care shall be taken to maintain the solution containing the glue and tannic acid up to their organized strength in these elements.

5. The zinc-chloride used shall be acid free and shall not contain more than 0.1 per cent iron. Dry zinc-chloride shall contain at least 94 per cent soluble zinc-chloride, and in any solution specified the percentage of zinc-chloride specified shall be the amount of soluble zinc-chloride required. The amount of chloride specified to be injected shall be of soluble zinc-chloride only. The amount of solution absorbed shall be determined by calculation based on the gage readings of the tank holding the supply of solution. This should be checked occasionally by weighing the ties loaded on the cylinder tram cars, before and after treatment, a scale being inserted in the tram tracks. The strength of the zinc-chloride solution shall be carefully controlled from time to time by hydrometer readings. Borings shall be taken from time to time from at least six ties treated in the same run, and a determination of the actual zinc-chloride according to the standard method made. The holes made in taking these borings shall be plugged tightly and completely with creosoted plugs.

[*]PRESERVATIVE TREATMENT TO BE USED ON PILES AND TIMBERS IN LAND CONSTRUCTION

Piling for Land Construction

Treatment shall be in accordance with specifications for preservative treatment of wood with creosote oil (full cell process). The net amount of oil left in the piling shall be not less than 15 pounds per cubic foot of wood, except in the case of Douglas Fir, ten pounds per cubic foot shall be the minimum.

---

[*] Adopted Vol. 23, 1922, p. 977; Vol. 24, 1923, p. 944.

TIMBERS IN LAND CONSTRUCTION

Treatment shall be in accordance with any of the following specifications:

1. Specification for preservative treatment of wood with creosote oil (full cell process).
2. Specification for preservative treatment of wood with creosote oil (empty cell process, with final vacuum).
3. Specification for preservative treatment of wood with creosote oil (empty cell process, with initial air and final vacuum).

The various processes of treatment shall be so manipulated as to reach a net retention of not less than 12 pounds of oil per cubic foot in all timbers, excepting bridge ties and guard rails in which the minimum amount may be not less than 8 pounds of oil per cubic foot of wood.

INSTRUCTIONS FOR FIELD TREATMENT FOR CREOSOTED MATERIAL

All treated timber and piling which is cut or bored after treatment shall have the surfaces so exposed covered with creosote oil. Where cut, the surfaces shall be painted thoroughly with creosote. Where holes are bored they shall be poured full of creosote where possible.

Horizontal holes such as those for Sway Brace Bolts shall be filled by pouring creosote into them through a bent funnel.

The creosote shall be heated before using.

Where it is absolutely necessary to bore holes in piles to support scaffolding, or for other reasons, the holes shall not be left open but shall be poured full of creosote and a tight-fitting creosoted timber plug inserted.

[5]SPECIFICATIONS FOR CREOSOTED PILES AND TIMBER FOR USE IN ATLANTIC COAST WATERS INFESTED WITH MARINE BORERS

(I) MATERIALS

(A) Piles

(1) Piles shall be unhewn Yellow Pine.

(2) For lengths not exceeding 30 feet, the minimum diameter at the tip shall be 9 inches. For lengths over 30 feet, but not exceeding 50 feet, the minimum diameter at the tip shall be 8 inches. For lengths exceeding 50 feet the minimum diameter at the tip shall be 7 inches. The minimum diameter one-quarter of the length from the butts shall be 12 inches, and the maximum diameter at the butt shall be 20 inches.

(Same as A.R.E.A. "Railroad Heart Grade.")

(3) Piles shall be butt cut above the ground swell, have a uniform taper from butt to tip, shall be free from short bends, and so straight that a straight line from center of butt to center of tip shall lie within the body of the pile. When cut they shall be peeled and shall have the inner skin or bark completely removed. They shall not be allowed to lie

---

[5] Adopted Vol. 24, 1923, pp. 962, 963, 964, 1221, 1223.

on the ground, but if not moved at once to the treating plant they shall be placed on skids. All knots and scars shall be trimmed close to the body of the pile, so that when it enters the cylinder its surface shall be smooth.

(4) Piles shall be sound and free from the following defects: Large, loose, unsound or hollow knots; worm holes; knot holes; round shakes; red heart; or other defects which will impair their strength or durability. Turpentine faces not over 2 feet in length will be allowed, provided they do not materially reduce the size.

(5) Piles shall have a sap ring of not less than 3 inches nor more than 5 inches.

(6) Piles shall preferably be treated green; not later than two months after cutting. If partly seasoned piles are accepted for treatment, they shall receive same treatment as green piles.

(B) Timbers

(7) Timbers shall be Southern Yellow Pine.

(8) Except as noted, timbers shall be sawed to standard size full length, square cornered and straight; close grained and free from defects such as injurious wind shakes and cross grain, unsound or loose knots, knots in groups, decay, or other defects that will materially impair its strength.

(9) Timbers shall be sound, sap no objection. Wane may be allowed one-eighth of the width of the piece measured across the face of the wane, and extending one-fourth the length of the piece on one corner, or its equivalent on two or more corners, provided that not more than 10 per cent of the pieces of any one size shall show such wane.

(Same as "Standard." Interstate rules of 1905.)

(10) The bark and inner skin shall be completely removed from the wane.

(C) Oil

(11) Oil shall meet A.R.E.A. Standard Specifications for Creosote Oil. It shall be analyzed when received at the work in accordance with the recommended practice. (See (20).)

(II) TREATMENT

(12) The treating plant and all equipment shall be maintained in first-class condition satisfactory to the Inspector throughout the treatment.

(13) Cylinders shall be supplied with air vents, steam coils; with recording gages and thermometers, necessary to record the condition at all times.

(14) The owner of the plant shall provide and keep in condition for use at all times the apparatus and chemicals necessary for making the analyses and tests required by the specifications.

(15) Each charge shall include only piles of approximately equal sap wood content and equal seasoning.

(16) After placing in the cylinder, piles or timbers shall be steamed at least twenty hours. The temperature shall be gradually raised to 280 deg. Fahr. (138 deg. C.) in three hours, held at this temperature for eight hours and gradually lowed to 250 deg. Fahr. (121 deg. C.) at the end of the steaming period. The cylinder shall be frequently drained of condensation. The steam shall then be blown off. A vacuum of at least 24 inches shall be created in one-half hour and held at least 24 inches for a period of at least five hours. Oil shall be introduced without breaking vacuum until the cylinder is filled. Pressure shall be applied gradually, and maintained until sufficient oil has been injected to leave the required amount in the piles after releasing, or until in the judgment of the inspector the refusal point has been reached. The pressure shall not exceed at any time 200 lb. per sq. in. The temperature of the oil during the pressure period shall not be less than 170 deg. Fahr. (77 deg. C.) nor more than 200 deg. Fahr. (93 deg. C.) and shall average at least 180 deg. Fahr. (82 deg. C.).

(17) After treatment has been completed and the oil has been removed from the cylinder, the piles or timber shall be allowed to drain one-half hour.

(18) Unless the oil has been injected to refusal, at least 22 lb. per cubic foot shall be retained in the piles.

(19) All measurements of oil shall be based on a temperature of 100 deg. Fahr. (38 deg. C.) and correction shall be made for actual temperature by applying a proper reduction factor.

(20) Oil from each charge shall be analyzed for water content. No oil containing more than 3 per cent of water shall be used.

(21) Vacuum measurements specified herein are for treating plants located at the sea level. If plant is not located at sea level, proper correction for altitude shall be made.

(22) At least three piles in each tram shall be bored to test penetration of oil, and record shall be kept by inspector.

(23) Hole for testing shall be bored about 6 feet from butt and plugged by a round creosoted plug, $\frac{1}{16}$ inch larger than the hole.

RECOMMENDATIONS FOR HANDLING AND INSTALLATION

(1) Do not use cant hooks or dogs in handling. Use rope slings.

(2) Do not drop the piles when unloading so as to crack them or injure them.

(3) Frame and bore all timbers before treatment, whenever practicable.

(4) Whenever it is necessary to cut the piles, or timbers, or whenever they become scarred or abraded, carefully trim the abrasions and coat the cut surfaces with hot creosote oil and cover with roofing pitch.

(5) Bore bolt holes $\frac{1}{16}$ inch smaller than the bolt and pour in hot creosote oil before driving bolts.

(6) Pour hot creosote oil into all unfilled holes and plug with treated plugs.

(7) Particularly avoid cutting or boring below high water mark.

(8) Drive piles as soon as possible after treatment. If necessary to store them cover with earth to prevent checking.

(9) These particular marine borers live and breed in wood exclusively. It is, therefore, probable that a great deal can be accomplished in checking their attacks by destroying their breeding places. It is recommended that all unused or untreated piles or timber be removed from the water in the vicinity.

(10) The purpose of the heavy treatment and care in handling recommended here is, first of all, to prevent the borers from gaining foothold, and, therefore, really applies only to that part of the pile between high-water mark and the mud line.

[6]SPECIFICATIONS FOR PRESERVATIVES

Creosote Oil, Grade One

The oil shall be distillate of coal-gas or coke-oven tar. It shall comply with the following requirements:

1. It shall contain not more than 3 per cent of water.

2. It shall contain not more than 0.5 per cent of matter insoluble in benzol.

3. The specific gravity of the oil at 38 deg./15.5 deg. C. shall be not less than 1.03.

4. The distillate, based on water-free oil, shall be within the following limits:

Up to 210 degrees Centigrade not more than 5 per cent.
Up to 235 degrees Centigrade not more than 25 per cent.

5. The specific gravity of the fraction between 235 degrees Centigrade and 315 degrees Centigrade shall be not less than 1.03 at 38 deg./15.5 deg. C.

The specific gravity of the fraction between 315 degrees Centigrade and 355 degrees Centigrade shall be not less than 1.10 at 38 deg./ 15.5 deg. C.

6. The residue above 355 degrees Centigrade, if it exceeds 5 per cent, shall have a float test of not more than 50 seconds at 70 degrees Centigrade.

7. The oil shall yield not more than 2 per cent coke residue.

8. The foregoing tests shall be made in accordance with the standard methods of the American Railway Engineering Association.

In addition to the oil conforming to the above standard specification, the two grades specified below may be used when the higher grade oil cannot be procured:

Creosote Oil, Grade Two

The oil shall be a distillate of coal-gas or coke-oven tar. It shall comply with the following requirements.

1. It shall contain not more than 3 per cent of water.

---

[6] Adopted Vol. 20, 1919, pp. 122, 124, 838, 839; Vol. 21, 1920, pp. 325, 1384.

2. It shall contain not more than 0.5 per cent of matter insoluble in benzol.

3. The specific gravity of the oil at 38 deg./15.5 deg. C. shall be not less than 1.03.

4. The distillate, based on water-free oil, shall be within the following limits:

Up to 210 degrees Centigrade not more than 8 per cent.
Up to 235 degrees Centigrade not more than 35 per cent.

5. The specific gravity of the fraction between 235 degrees Centigrade and 315 degrees Centigrade shall be not less than 1.03 at 38 deg./15.5 deg. C.

The specific gravity of the fraction between 315 degrees Centigrade and 355 degrees Centigrade shall be not less than 1.10 at 38 deg./15.5 deg. C.

6. The residue above 355 degrees Centigrade, if it exceeds 5 per cent, shall have a float test of not more than 50 seconds at 70 degrees Centigrade.

7. The oil shall yield not more than 2 per cent coke residue.

8. The foregoing tests shall be made in accordance with the standard methods of the American Railway Engineering Association.

Creosote Oil, Grade Three

The oil shall be a distillate of coal-gas or coke oven tar. It shall comply with the following requirements:

1. It shall contain not more than 3 per cent of water.

2. It shall contain not more than 0.5 per cent of matter insoluble in benzol.

3. The specific gravity of the oil at 38 deg. /15.5 deg. C. shall be not less than 1.03.

4. The distillate, based on water-free oil, shall be within the following limits:

Up to 210 degrees Centigrade not more than 10 per cent.
Up to 235 degrees Centigrade not more than 40 per cent.

5. The specific gravity of the fraction between 235 degrees Centigrade and 315 degrees Centigrade shall be not less than 1.03 at 38 deg./15.5 deg. C.

The specific gravity of the fraction between 315 degrees Centigrade and 355 degrees Centigrade shall be not less than 1.10 at 38 deg./15.5 deg. C.

6. The residue above 355 degrees Centigrade, if it exceeds 5 per cent, shall have a float test of not more than 50 seconds at 70 degrees Centigrade.

7. The oil shall yield not more than 2 per cent coke residue.

8. The foregoing tests shall be made in accordance with the standard methods of the American Railway Engineering Association.

It is urged that when Grades 2 or 3 are used, consideration be given to the injection of a greater quantity of creosote oil per cubic foot.

CREOSOTE-COAL-TAR SOLUTION

The oil shall be a coal-tar product, of which at least 80 per cent shall be a distillate of coal-gas or coke-oven tar, and the remainder shall be refined or filtered coal-gas or coke-oven tar. It shall comply with the following requirements:

1. It shall contain not more than 3 per cent water.
2. It shall contain not more than 2 per cent of matter insoluble in benzol.
3. The specific gravity of the oil at 38 deg./15.5 deg. Centigrade shall not be less than 1.05 nor more than 1.12.
4. The distillate, based on water-free oil, shall be within the following limits:

   Up to 210 degrees Centigrade not more than 5 per cent.
   Up to 235 degrees Centigrade not more than 25 per cent.
5. The specific gravity of the fraction between 235 degrees Centigrade and 315 degrees Centigrade shall not be less than 1.03 at 38 deg./15.5 deg. C.

   The specific gravity of the fraction between 315 degrees Centigrade and 355 degrees Centigrade shall be not less than 1.10 at 38 deg./15.5 deg. C.
6. The residue above 355 degrees Centigrade, if it exceeds 26 per cent, shall have a float test of not more than 50 seconds at 70 degrees Centigrade.
7. The oil shall yield not more than 6 per cent coke residue.
8. The foregoing tests shall be made in accordance with the recommended methods of the American Railway Engineering Association.

PRECAUTIONS TO BE FOLLOWED IN THE PURCHASE AND USE OF CREOSOTE-COAL-TAR SOLUTION

1. The specifications for a creosote-coal-tar solution are submitted for the guidance of those desiring to use the coal-tar addition to creosote.
2. There should be a distinct understanding between all concerned that a mixture is specified and used.
3. The refined coal-tar used shall be subject to inspection or analysis by the railway company at any time, such examination to be permitted upon request prior to the mixing of the solution.
4. In case the railway company makes its own solution of coal-tar and creosote, using crude tar for this purpose, it shall specify clearly as to the quality of the tar. Only low carbon coal-tar should be used, the amount of free carbon not to exceed 5 per cent.
5. The coal-tar may be added to the creosote at treating plants when suitable facilities for properly mixing the solutions are available, otherwise the solution should be mixed by the manufacturer, but subject to the

inspection or supervision of the railway company. The coal-tar and creosote should be thoroughly mixed at a temperature of approximately 180 deg. Fahr. before being applied to timber. The mixing should be done in tanks other than the regular working tanks, and the tanks containing the mixture should be heated and agitated thoroughly each time before any oil is transferred to the working tanks.

6. In treating with the mixture the temperature of the solution in the cylinder should not be less than 180 deg. Fahr.

The Use of Coal-Tar in Creosote

Wherever possible only Grade 1 Coal-Tar Creosote should be used, and under no circumstances should coal-tar be added to creosote of this grade.

Zinc-Chloride

The zinc-chloride used shall be acid-free and shall not contain more than 0.1 per cent iron. Dry zinc-chloride shall contain at least 94 per cent soluble zinc-chloride, and in any solution specified the percentage of zinc-chloride specified shall be the amount of soluble zinc-chloride required.

MEASURING, SAMPLING AND ANALYZING PRESERVATIVES

[7] Standard Temperature for Measuring Creosote Oil

All volumetric measurements of creosote oil shall be referred to the volume at 100 deg. Fahr. as standard.

In making corrections for volume, the correction is 1 per cent for every 22½ deg. Fahr., equivalent to .00044 per deg. Fahr.

[8] Water in Creosote

Allowable Limits of Water

(1) The use of creosote in treatment containing up to 3 per cent water is permissible. Where the quantity exceeds 3 per cent proper allowance should be made, but under no circumstances shall timbers be treated with oils having more than 6 per cent water.

Measurement of Oil

(2) In all cases where water separates from the oil in the tank or car, the water should be taken off to as great an extent as practicable and the oil measurement then should be made from the point of separation between the remaining water and oil as nearly as this can be determined. This refers to the physical process of measurement.

Sampling of Oil for Water Content

(3) It is recommended as good practice that, in order to obtain accurate determinations as to the percentage of water contained in creosote oil in tank cars and in storage tanks, the principle of zone sampling

---

[7] Adopted, Vol. 10, Part 1, pp. 621, 1909.

[8] Adopted, Vol. 15, 1914, pp. 632, 1088.

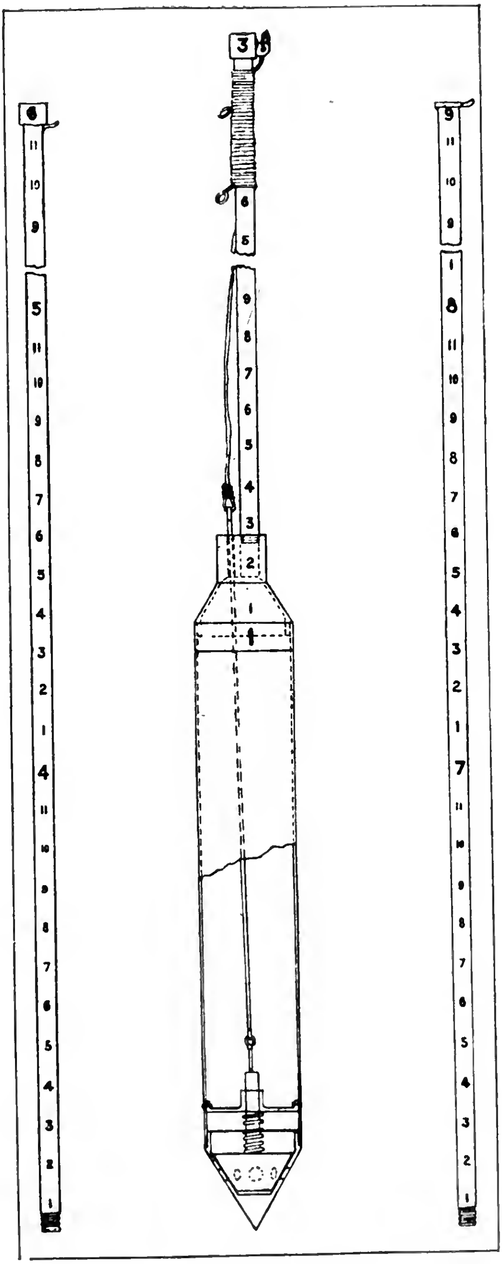


FIG. 1. DETAILS OF ZONE SAMPLING APPARATUS.

be employed, as described in the 1916 report of the Committee (Proceedings, Vol. 17, pp. 447 to 456), and that for the purpose of obtaining zone samples an apparatus of the type illustrated in this report be used. (See Fig. 1.)

Storage Tanks

(4) All storage tanks should have a watertight roof.

[9] SPECIFICATIONS FOR CREOSOTE OIL ANALYSIS

(1) WATER

Apparatus

A vertical, cylindrical copper still, with removable flanged top, and yoke, of the form and approximate dimensions shown in Fig. 2, shall be used.

Method

When any measurable amount of water is present in the distillate below 210 degrees, on testing in accordance with Section 4, Distillation, the oil and water in this fraction shall be separated, if possible, and measured separately. If more than 2 per cent of water is present, or if the water is apparently present to an extent in excess of 2 per cent, but an accurate separation is impossible, the precentage of water present shall be determined by the following method, and the water-free oil so obtained shall be used in distillation test, as described under Section 4.

Measure 200 cc. of oil in graduated cylinder, and pour into copper still (Figs. 2 and 3), allowing the cylinder to drain into the still for several minutes. Attach lid and clamp, using a paper gasket slightly wet with oil around the flange of the still. Apply heat by means of the ring burner, which should be placed just above the level of the oil in the still at the beginning of the test, and gradually lowered when most of the water has distilled over. Continue the distillation until the vapor temperature indicated by the thermometer with the bulb opposite the offtake of the connecting tube reaches 205 degrees Centigrade. Collect distillate in separatory funnel.

When the distillation is completed, and a clear separation of water and oil in the funnel has taken place, the water is read by volume and drawn off, and whatever light oil has distilled over with the water is then returned to the oil in the still. The dehydrated oil from the still is then taken for distillation, described in Section 4, Distillation.

(2) INSOLUBLE IN BENZOL

Apparatus

(a) Extractor may be of the form shown in Fig. 4, or any similar form in which the oil is subjected to direct washing by the boiling vapors of the solvent.

(b) Filtering medium may be either two thicknesses of S. & S. No. 575 or Whatman No. 5 hardened filter paper, 15 cm. in diameter, arranged

---

[9] Adopted, Vol. 18, 1917, pp. 1262, 1577; Vol. 20, 1919, pp. 127, 840.

in the extractor flask by a wire basket hung from two small hooks on the under surface of the metal cover of the flask.

If the alundum thimble is used, it may be supported by making two perforations in the top of the thimble, and suspending from the cover by German silver or platinum wires.

Method

Weigh 10 grams of dry oil in 100 cc. beaker. Add about 50 cc. of pure benzol, and transfer at once to the filter cup. The filter cup or thimble is previously weighed, and the paper cup shall always be kept in a weighing bottle until ready for use. Wash out the beaker with benzol, passing all washings through the filter cup, and place the latter at once in the extraction apparatus.

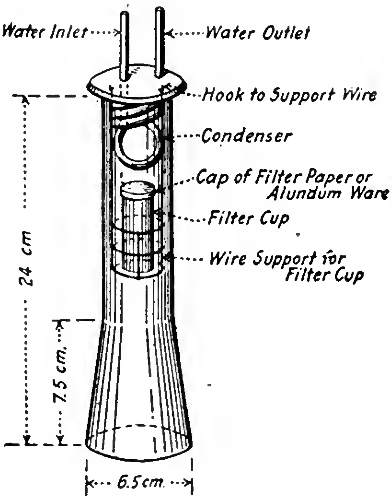


FIG. 4. EXTRACTION FLASK.

Extractor shall contain a suitable quantity of pure benzol. Sufficient heat to boil the solvent shall be provided by means of an electric heater or a steam bath.

Continue the extraction until the descending solvent is practically colorless, and remove the filter cup and dry in steam oven until all solvent is driven off; cool in desiccator and weigh. The balance used for this purpose should be accurate to within 0.5 mg.

(3) SPECIFIC GRAVITY

Apparatus

(a) Hydrometer shall be of the form and dimensions shown in Fig. 5. It shall be standardized at 15.5 degrees Centigrade. A set of two with ranges 1.00 to 1.08 and 1.07 to 1.15 will suffice.

in cup-shape by folding symmetrically; or alundum thimbles, flat bottom, 30x80 R.A. 98. If filter papers are used, prior to using they shall be soaked in benzol to remove grease, dried in a steam oven and kept in a desiccator until ready to be used. The filter-paper cup may be suspended

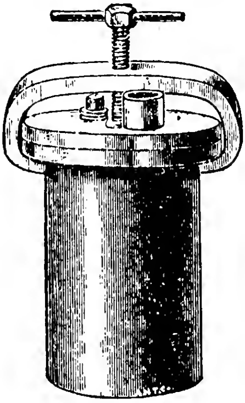


Fig. 2. Copper Still.

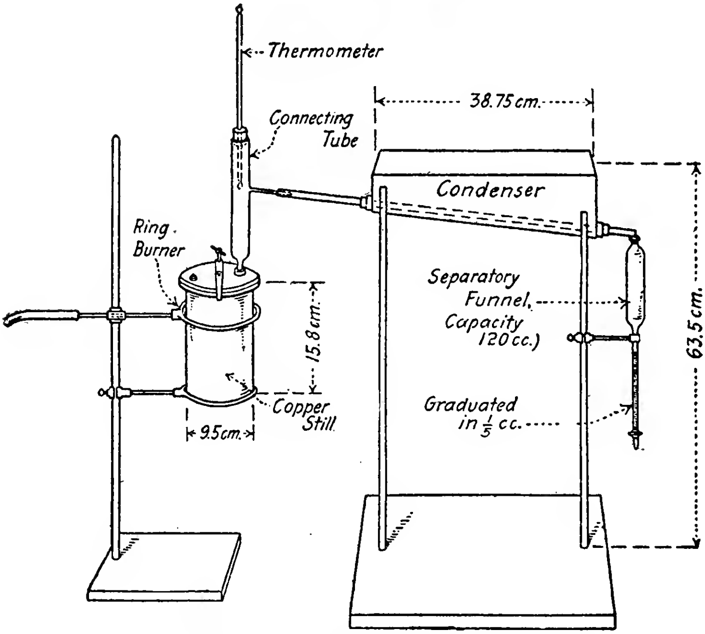


Fig. 3. Assembled Apparatus for Water Test.

(b) Cylinder shall be of the form and dimensions shown in Fig. 6.

(c) If a very accurate method is desired, the specific gravity may be determined by means of a pycnometer or specific gravity bottle, as shown in Fig. 7, having a capacity of at least 25 cubic centimeters.

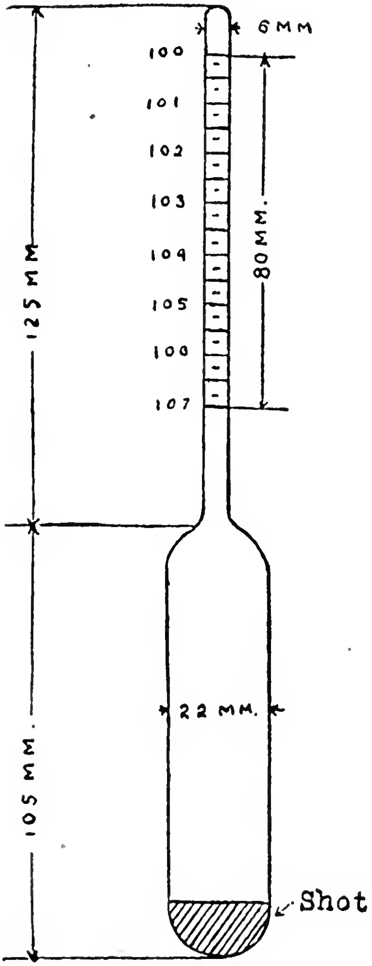


Fig. 5. Hydrometer.

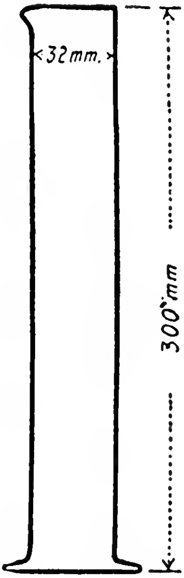


Fig. 6. Specific Gravity Cylinder.

Method

(a) The oil shall be brought to a temperature of 38 degrees Centigrade (100 deg. Fahr.), and the determination shall be made at that temperature unless the oil is not entirely liquid at 38 degrees Centigrade.

In case the oil requires to be brought to a higher temperature than 38 degrees in order to render it completely fluid, it shall be tested at the lowest temperature at which it is completely fluid, and a correction made by adding 0.0008 to the observed specific gravity for each degree Centigrade above 38 degrees Centigrade at which the test is made. This correction does not apply with equal accuracy to all oils, but serious error, due to its use, will be avoided if the foregoing precaution is observed, with respect to avoiding unnecessarily high temperature.

Before taking the specific gravity, the oil in the cylinder should be stirred thoroughly with the glass rod, and this rod, when withdrawn from the liquid, should show no solid particles at the instant of withdrawal. Care should be taken that the hydrometer does not touch the sides or bottom of the cylinder when the reading is taken, and that the oil surface is free from froth and bubbles.

(b) Weigh the pycnometer empty, then fill with recently distilled water and weigh at 38 degrees Centigrade. Empty the pycnometer and then fill with water-free oil at 38 degrees Centigrade, and weigh. The specific gravity 38 deg./15.5 deg. C. is then calculated as below:

Fig. 7. Pycnometer.

The expression "38 degrees / 15.5 degrees Centigrade" means specific gravity taken at 38 degrees Centigrade compared with water at 15.5 degrees Centigrade. This cannot be determined directly. The specific gravity is first determined at 38 degrees Centigrade compared with water at 38 degrees Centigrade, and this determination represents the relation of the weight of a volume of oil at 38 degrees Centigrade to the weight of an equal volume of water at the same temperature. The relation of an equal volume of water at 15.5 degrees Centigrade is obtained by multiplying the former figure by .99385, the density of water at 38 degrees Centigrade compared to water at 15.5 degrees Centigrade.

From the foregoing it will be readily seen that it is incorrect to calculate the specific gravity at 38 deg./15.5 deg. C., by dividing the weight of oil taken at 38 degrees Centigrade by the weight of water taken at 15.5 degrees Centigrade. An example is given herewith of the correct and incorrect methods of calculating; where the weight of a specific gravity bottle is 23.7531, the weight of the bottle filled with water up to the mark at 15.5 degrees Centigrade is 78.3600; the weight of the bottle plus water at 38 degrees Centigrade is 78.1128; the weight of the bottle filled with oil at 38 degrees Centigrade is 80.2755. The correct calculation, therefore, would be as follows:

Specific gravity at 38°/15.5° C.—

$$\frac{80.2755 - 23.7531}{78.1128 - 23.7531} \text{ — } 1.0398$$

Corrected to 38°/15.5° C.—

$$1.0398 \times \frac{.99299 \text{ (D. water 38 degrees)}}{.99913 \text{ (D. water 15 degrees)}}$$

The incorrect method of calculation is as follows:

$$\frac{80.2755 - 23.7531}{78.3600 - 23.7531} \text{ — } 1.0351.$$

(4) DISTILLATION

Apparatus.

(a) Retort shall be a tabulated glass retort of the usual form with a capacity of 250 to 290 cc. The capacity shall be measured by placing the retort with the bottom of the bulb and the end of the offtake in the same horizontal plane, and pouring water into the bulb through the tubulature until it overflows the offtake. The amount remaining in the bulb shall be considered its capacity (Fig. 8).

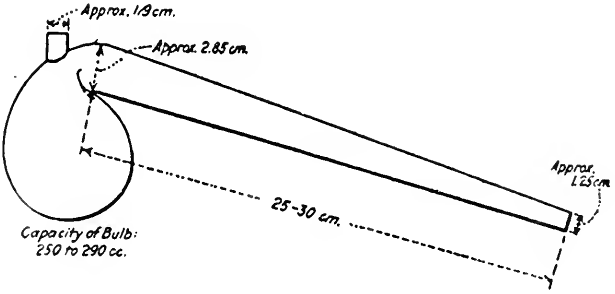


FIG. 8.—RETORT FOR DISTILLATION TEST.

(b) Condenser tube of any suitable form of glass may be used; a convenient one is shown in Fig. 9.

FIG. 9—CONDENSER TUBE.

(c) Shield of asbestos as shown in Fig. 10 shall be used to protect the retort from air currents, and to prevent radiation. This may be covered with galvanized iron, as such an arrangement is more convenient and more permanent.

(d) Receivers (Erlenmeyer flask) of 50 to 100 cc. capacity are most convenient form.

Thermometers should conform to the following specifications:[10]

(e) (1). These specifications cover a total-immersion thermometer graduated in Centigrade degrees as specified, the range being 0 to 400 deg. C.

2. The purpose of these specifications is to provide a thermometer for distillation tests within these ranges.

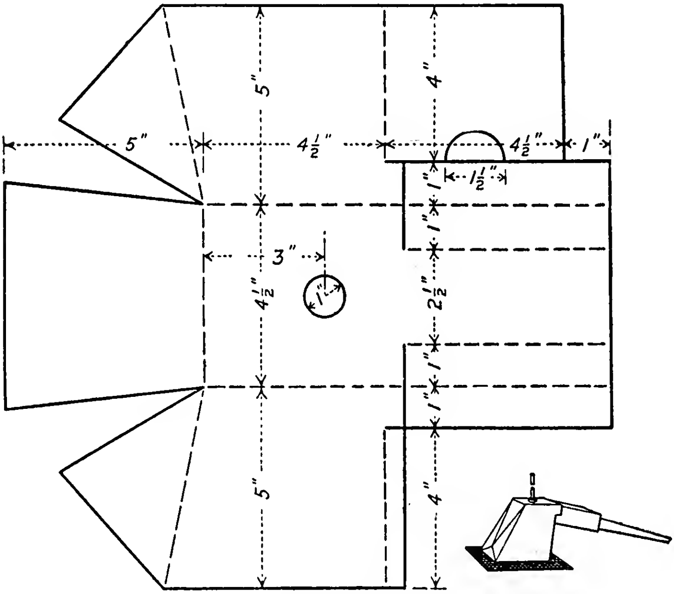


FIG. 10—ASBESTOS SHIELD.

3. The thermometer shall conform to the following requirements:

Type: Etched stem, glass.

Liquid: Mercury.

Range and Subdivision: 0 to 400 deg. C. in 1 deg. C.

Total Length: 378 to 384 mm. (14.88 to 15.12 in.).

Stem: Plain front, enamel back, suitable thermometer tubing. Diameter, 6.0 to 7.0 mm. (0.24 to 0.28 in.).

Bulb: Corning normal or equally suitable thermometric glass. Length, 10 to 15 mm. (0.39 to 0.59 in.). Diameter, 5.0 to 6.0 mm. (0.20 to 0.24 in.).

Distance to 0 deg. C. Line from Bottom of Bulb: 25 to 35 mm. (0.98 to 1.38 in.).

---

[10] Adopted, Vol. 26, 1925, pp. 71, 1252.

Distance to 400 deg. C. Line from Top of Thermometer: 30 to 45 mm. (1.18 to 1.77 in.).

Filling above Merccury: Nitrogen gas.

Top Finish: Glass ring.

Graduation: All lines, figures, and letters clear cut and distinct. The first and each succeeding 5 deg. C. line to be longer than the remaining lines. Graduations to be numbered at each multiple of 10 deg. C.

Immersion: Total.

Special Marking: "A.S.T.M. High Distillation," a serial number and the manufacturer's name or trade mark shall be etched on the stem.

Scale Error: The error at any point of the scale up to 370 deg. C. when the thermometer is standardized, as provided below, shall not exceed 1 deg. C.

Standardization: The thermometers shall be standardized immersed in the testing bath to the top of the mercury column, at the ice point and at temperature intervals of approximately 50 deg. C. up to 370 deg. C.

Test for Permanency of Range: After being subjected to a temperature between 360 to 370 deg. C. for 24 hours, the accuracy shall be within the limit specified.

Case: The thermometer shall be supplied in a suitable case on which shall appear the marking: "A.S.T.M. High Distillation, 0 to 400 deg. C."

NOTE.—For the purpose of interpreting these specifications the following definitions apply:

The total length is the over-all length of the finished instrument.
The diameter is that measured with a ring gage.
The length of the bulb is the distance from the bottom of the bulb to the beginning of the enamel backing.
The top of the thermometer is the top of the finished instrument.

The retort shall be supported on a tripod or rings over two sheets of 20-mesh gauze, 6 in. square. It shall be connected to the condenser tube by a tight cork joint. The thermometer shall be inserted through a cork in the tubulature with the bottom of the bulb ½-inch from the surface of the oil in the retort. The exact location of the thermometer bulb shall be determined by placing a vertical rule graduated in divisions not exceeding $\frac{1}{16}$-in. back of the retort when the latter is in position for the test, and sighting the level of the liquid and the point for the bottom of the thermometer bulb. The distance from the bulb of the thermometer to the outlet end of the condenser tube shall be not more than 24 nor less than 20 in. The burner shall be protected from draughts by a suitable shield or chimney (Fig. 11).

Method

Exactly 100 grams of oil shall be weighed into the retorts, the apparatus assembled, and heat applied. The distillation shall be conducted at the rate of at least one drop and not more than two drops per second, and the distillate collected in weighed receivers. The condenser tube shall be warmed whenever necessary to prevent accumulation of solid distillates. Fractions shall be collected at the following points: 210 degrees, 235 degrees, 270 degrees, 315 degrees, and 355 degrees Centigrade.

The receivers shall be changed as the mercury passes the dividing temperature for each fraction. When the temperature reaches 355 degrees, the flame shall be removed from the retort, and any oil which has condensed in the offtake shall be drained in the 355-degree fraction.

The residue shall remain in the retort with the cork and the thermometer in position until no vapors are visible; it shall then be weighed. If the residue is to be further tested it shall then be poured directly into the brass collar used in the float test or into a tin box and covered and allowed to cool to air temperature. If the residue becomes so cool that it cannot be poured readily from the retort, it shall be re-heated by holding the bulb of the retort in hot water or steam, and not by the application of flame.

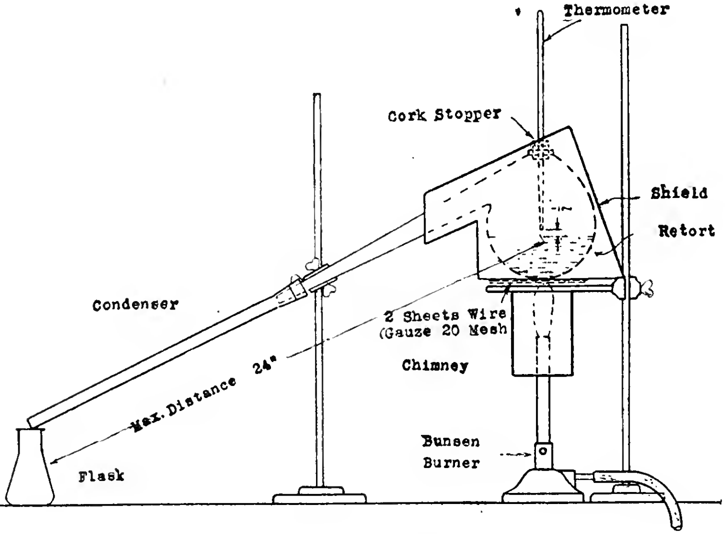


Fig. 11—Distillation Apparatus Set Up.

For weighing the receivers and fractions, a balance accurate to at least 0.05 g. shall be used.

During the progress of the distillation the thermometer shall remain in its original position. No correction shall be made for the emergent stem of the thermometer.

When any measurable amount of water is present in the distillate, it shall be separated as nearly as possible and reported separately, all results being calculated on a basis of dry oil. When more than 2 per cent of water is present, water-free oil shall be obtained by separately distilling a larger quantity of oil, returning to the oil any oil carried over with the water, and using dried oil for final distillation. (See Section 1, Water.)

(5) SPECIFIC GRAVITY OF FRACTIONS

As specific gravity is an absolute physical determination, any recognized method which can be applied to the quantity and quality of material at hand to be tested must be considered satisfactory. The following methods are recommended by the Committee as convenient and accurate means for the relatively small amounts of oil available in determining gravity of fractions to be tested.

LIQUID FRACTIONS

Apparatus

Westphal balance.

Method

If the fraction to be tested is liquid at a temperature not exceeding 60 degrees Centigrade, the Westphal balance can be used with convenience and rapidity. A special type of Westphal balance is obtainable, designed for testing very small quantities. However, the ordinary type Westphal balance can be adapted to testing small fractions by the use of a special plummet. This can be readily made in the laboratory from a piece of ordinary glass tubing 7 mm., outside diameter, sealed at the end, and melting into the glass where sealed a short platinum wire.

After cooling place 9 to 10 grams of mercury in the tube, making a column 35 to 40 mm. high. Seal off the tube within 20 mm. of the top of the mercury column with blowpipe flame. The plummet shall have a length of about 55 to 60 mm. over all, and should weigh between 10 and 12 grams.

SOLID AND SEMI-SOLID FRACTIONS

Methods.

Special platinum or nickel pan as shown in Fig. 12.

For the determination of fractions that are solid and semi-solid and cannot readily be liquefied at a temperature not exceeding 60 degrees Centigrade, a weighing pan constructed of platinum or nickel may be used.

A pan of convenient dimensions is 20 mm. diameter at the base and 25 mm. diameter at the top, and about 12 mm. deep. It is made of platinum and supported by three platinum wires 1 mm. in diameter, and has a total weight of about 7 grams.

Solid or semi-solid fractions of oil can be rapidly and accurately tested in this apparatus by the usual method of weighing in air and in water. The usual precaution, of igniting the pan before use, avoiding the enclosure of air or water in the sample, should be observed.

NOTE.—The method for liquid fractions is usually applicable to the fractions 235 to 315 degrees Centigrade and the method for solid and semi-solid fractions to the fraction 315 to 355 degrees Centigrade.

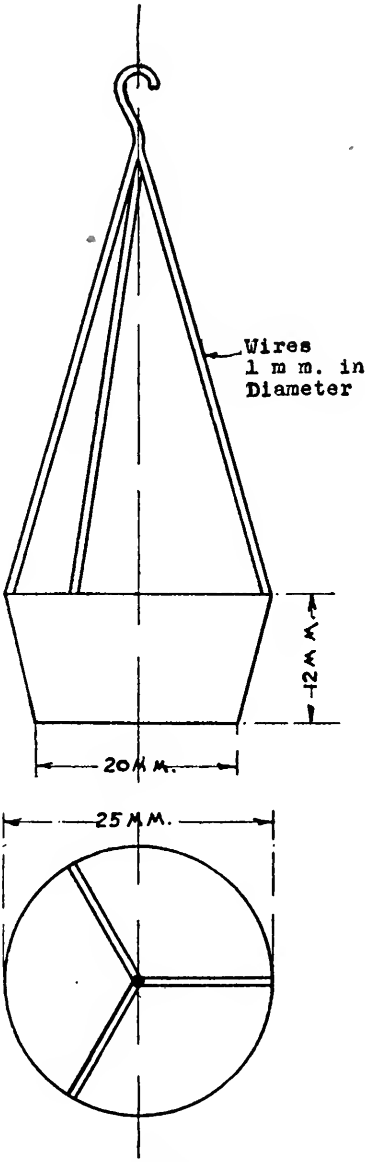


FIG. 12—WEIGHING PAN.

[1]FLOAT TEST

The residue remaining in the retort after the distillation on test shall remain until it reaches a temperature between 100 and 125 deg. C. The consistency of the residue shall then be determined as follows:

(I) APPARATUS

Float

1. The float shall be made of aluminum alloy and shall be in accordance with the following requirements:

	Minimum	*Normal*	*Maximum*
Weight of float, g.	37.70	37.90	38.10
Total height of float, mm.	34.0	35.0	36.0
Height of rim above lower side of shoulder, mm.	26.5	27.0	27.5
Thickness of shoulder, mm.	1.3	1.4	1.5
Diameter of opening, mm.	11.0	11.1	11.2
Height of rim above water with load of 5.5 g., mm.	7.0	8.5	10.0

Collar

2. The collar shall be made of brass and shall be in accordance with the following requirements:

	Minimum	*Normal*	*Maximum*
Weight of collar, g.	9.6	9.8	10.0
Over-all height of collar, mm.	22.3	22.5	22.7
Inside diameter at bottom, mm.	12.72	12.82	12.92
Inside diameter at top, mm.	9.65	9.70	9.75

The top of the collar shall screw up tightly against the lower side of the shoulder.

Thermometer

3. The thermometer shall conform to the following specification:

Type: Etched stem, glass.

Liquid: Mercury.

Range and Subdivision: —2 to +80° C. in 0.2° C.

Total Length: 378 to 384 mm. (14.88 to 15.12 in.).

Stem: Plain front, enamel back, suitable thermometer tubing. Diameter, 6.0 to 7.0 mm. (0.24 to 0.28 in.).

Bulb: Corning normal or equally suitable thermometric glass. Length, 9 to 14 mm. (0.35 to 0.55 in.). Diameter, 4.5 to 5.5 mm. (0.18 to 0.22 in.).

Distance to 0 deg. C. Line from Bottom of Bulb: 75 to 90 mm. (2.95 to 3.54 in.).

Distance to 80 deg. C. Line from Top of Thermometer: 30 to 45 mm. (1.18 to 1.77 in.).

Expansion Chamber: To permit heating the thermometer at least 50 deg. C. above highest temperature on scale.

---

[11] Adopted Vol. 26, 1925, pp. 67, 68, 69, 70, 1252.

Filling above Mercury: Nitrogen gas.

Top Finish: Glass ring.

Graduation: All lines, figures, and letters clear cut and distinct. Each whole degree Centigrade line to be longer than the remaining lines. Graduations to be numbered at each multiple of 2 deg. C.

Immersion: Total.

Special Marking: "A.S.T.M. Low S.P.," a serial number and the manufacturer's name or trade mark shall be etched on the thermometer.

Scale Error: The error at any point of the scale when the thermometer is standardized as provided below, shall not exceed 1.2 deg. C.

Standardization: The thermometer shall be standardized immersed in the testing bath to the top of the mercury column, at the ice point and at temperature intervals of approximately 20 deg. C.

Case: The thermometer shall be supplied in a suitable case on which shall appear the marking: "A.S.T.M. Low S.P., 0 to 80 deg. C."

NOTE—For the purpose of interpreting these specifications the following definitions apply:

The total length is the over-all length of the finished instrument.

The diameter is that measured with a ring gage.

The length of the bulb is the distance from the bottom of the bulb to the beginning of the enamel backing.

Bath

4. The minimum diameter of the bath shall be twice the diameter of the float; the minimum depth of water shall be equal to the diameter of the bath.

(II) PREPARATION OF SAMPLE

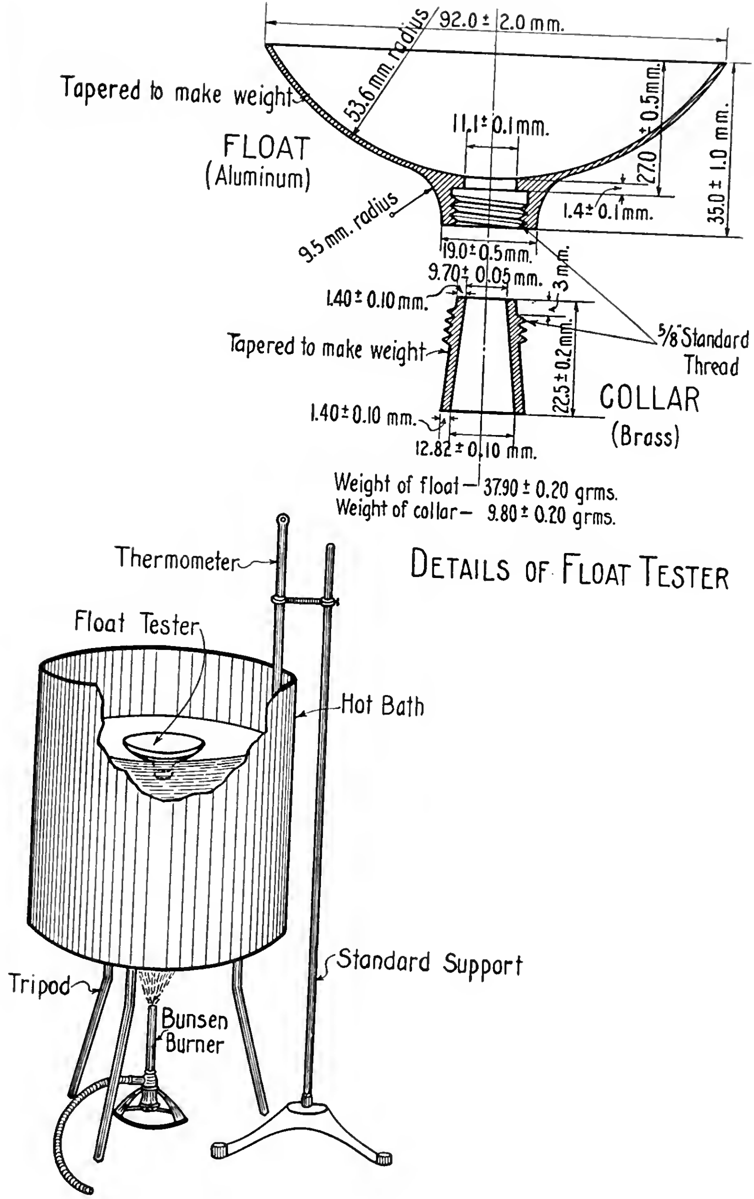
Preparation of Sample

5. The sample shall be completely melted at the lowest possible temperature, heating only sufficiently to bring the product into a fluid condition, but not above 350 deg. Fahr., and stirred thoroughly until it is homogeneous and free from air bubbles.

The brass collar shall be placed with the smaller end on a brass plate which has been previously amalgamated with mercury by first rubbing it with a dilute solution of mercuric chloride or nitrate and then with mercury. The sample shall be poured into the collar in any convenient way until slightly more than level with the top.

Tar Products

6. Tar products shall be poured at a temperature of 100 to 125 deg. C. and immediately immersed in ice water maintained at 5 deg. C. for 5 minutes, after which the surplus material shall be removed by means of a spatula or steel knife, which has been slightly heated. The collar and plate shall then be placed in a tin cup containing ice water maintained at 5° C ± 1° C., and left in this bath for at least 15 minutes.



DETAILS OF FLOAT TESTER

ASSEMBLY OF FLOAT TESTER

FIG. 13

(III) PROCEDURE

Procedure

7. (a) The bath shall be filled with water and the water heated to the temperature at which the test is to be made. This temperature shall be accurately maintained and shall at no time throughout the test be allowed to vary more than 0.5 deg. C. from the temperature specified.

(b) After the material to be tested has been kept in the ice water for not less than 15 minutes nor more than 30 minutes, the collar with its contents shall be removed from the plate and screwed into the aluminum float and immersed in water at 5 deg. C. for one minute. Any water shall then be removed from the inside of the float and the latter immediately floated in the warm bath. As the plug of material becomes warm and fluid, it is forced upward and out of the collar until the water gains entrance into the saucer and causes it to sink.

(c) The time in seconds between placing the apparatus on the water and when the water breaks through the material shall be determined by means of a stop watch, and shall be taken as a measure of the consistency of the material under examination.

NOTE—Special precaution shall be taken to insure the collar fitting tightly into the float and to see that there is no seepage of water between the collar and float during the test.

NOTE—Care must be taken at the end of the distillation test to see that the vapor temperature as indicated on the thermometer does not rise above 355 deg. C.; an excess temperature of only 1 or 2 deg. C. at this point makes the float test invalid.

(7) COKE RESIDUE

Apparatus

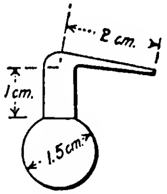


FIG. 14—COKE BULB

Bulb.—The bulb shall be of hard glass, shown in Fig. 14, and shall have the following approximate dimensions:

Diameter of bulb	15 mm.
Length of vertical neck	10 mm.
Length of horizontal neck	20 mm.
Diameter of orifice	1 mm.

Coke Test Residue

Warm the bulb slightly to drive off all moisture, cool in a desiccator, and weigh. Again heat the bulb by placing it momentarily in an open Bunsen flame and place the tubular underneath the surface of the oil to be tested and allow the bulb to cool until sufficient oil is sucked in to fill the bulb about two-thirds full.

Any globules of oil sticking to the inside of the tubular should be drawn into the bulb by shaking or expelled by slightly heating it, and the outer surface should be carefully wiped off and the bulb reweighed. This procedure will give about 1 gr. of oil.

Cut a strip of thin asbestos paper about ¼-in. wide and about 1 in. long, place it around the neck of the bulb and catch the two free ends close up to the neck with a pair of crucible tongs. The oil should then be distilled off as in making ordinary oil distillation, starting with a very low flame and conducting the distillation as fast as can be maintained without spurting.

When the oil vapors cease to come over, the heat should be increased. The bulb should be held in the highest heat of a Bunsen flame until the evolution of gas ceases, and any carbon sticking to the outside of the tubular is completely burned off. The bulb should then be cooled in a desiccator and weighed and the percentage of coke residue calculated to water-free oil.

METHODS OF CHEMICAL ANALYSIS OF ZINC-CHLORIDE[12]

These methods cover the determination of the percentages of insoluble basic zinc-chloride, zinc-chloride, and iron present in commercial concentrated solution of zinc-chloride or in fused or granulated zinc-chloride, for use in the preservative treatment of wood.

Preparation and Standardization of Solutions

Standard Ferrocyanide Solution.—Weigh out 43.25 g. of c.p. potassium ferrocyanide and 14 g. of c.p. crystallized sodium sulphite, dissolve in water and make up to 1 liter at room temperature. Shake thoroughly. Standardize against a zinc solution of known concentration prepared from spelter of known zinc content or from c.p. zinc oxide which has been previously ignited. One cubic centimeter of this solution will be equal to approximately 0.01 g. of zinc. The standardization should be carried out as nearly as possible in the same manner as in the estimation of zinc and approximately the same amount of zinc should be present. Keep the solution in a dark bottle. Shake thoroughly before each using and standardize each time it is used.

Uranium Acetate Indicator.—Dissolve 4.4 g. of c.p. uranium acetate, free from sodium, in 100 cc. of hot water and 2 cc. of glacial acetic acid. Use this as an external indicator on a paraffined plate, making the drops as nearly 0.05 cc. as possible.

---

[12] Adopted Vol. 26, 1925, pp. 72, 73, 74, 1252.

Hydrogen Peroxide.—The usual laboratory reagent is satisfactory, if fresh.

Hydrogen Sulphide Solution.—The usual laboratory reagent is satisfactory.

Determination of Insoluble or Basic Zinc Chloride

Weigh from 10 to 14 g. of the sample, if fused or granulated, from a stoppered weighing bottle, or place an equivalent quantity, if a solution, into a 600-cc. beaker. Add cold water to 400 cc. Stir the contents of the beaker until solution is complete. Allow to settle over night. Filter the solution through a 12.5-cm. filter paper which has previously been washed dried and weighed. Receive filtrate in a 1000-cc. graduated measuring flask. Policeman the beaker, and wash the insoluble matter in the filter paper until the filtrate measures 1 liter. Dry the filter paper containing the insoluble matter over night in an oven heated to 100 deg. C. (212 deg. Fahr.). Cool and weigh between clipped watch glasses. Calculate the increase in weight of filter paper to a percentage of the original sample.*

Duplicate determinations should check within 1.3 per cent.

Determination of Zinc

(*a*) *Volumetric method.* (For use when manganese chloride does not exceed 0.3 per cent.)

The filtrate obtained from the estimation of insoluble basic zinc-chloride and whose volume is exactly 1 liter is shaken and three aliquot portions of 100 cc. each are taken with an accurate 100-cc. pipette and transferred into 450-cc. Griffins beakers. Add to each portion 15 g. of ammonium chloride and 5 cc. of concentrated hydrochloric acid. Dilute to 350 cc. and heat nearly to boiling. Titrate slowly with vigorous stirring, using a solution of potassium ferrocyanide as the standard reagent and uranium acetate as an external indicator. The average of the three aliquot portions should be reported.

(*b*) *Volumetric Method.* (For use when the manganese chloride equals or exceeds 0.3 per cent.)

To the aliquot portions taken as described under (*a*), 1 cc. of hydrogen peroxide (2 to 3 per cent) and 10 cc. of ammonia (1:1) shall be added. Stand on steam bath until settled. Filter off the manganese, wash breaker and paper twice with hot water. Dissolve the precipitate in the smallest amount of hydrochloric acid (1:1) in the original beaker, heat until all is dissolved; the volume of the solution should be about 20 cc. Reprecipitate the manganese with 1 cc. of hydrogen peroxide and 10 cc. of ammonia, boil, filter, and wash several times with hot water. Add the filtrate to that obtained in the first separation. Add 15 cc. of concentrated hydrochloric acid to the combined filtrate and just neutralize with concentrated ammonia, then add 5 cc. of hydrochloric acid in excess. Dilute to 325 cc. and add 25 cc. of saturated hydrogen sulphide water to remove any traces of hydrogen peroxide, heat and titrate as in (*a*).

---

*A Gooch crucible may be used in place of the weighed filter paper.

(*c*) *Gravimetric Method.* (Alternate method, for use when only a limited amount of work is necessary.)

The filtrate obtained from the estimation of insoluble basic zinc-chloride and whose volume is exactly 1 liter is shaken and three aliquot portions of 200 cc. each are taken with an accurate pipette and transferred to 450-cc. Griffins beakers. Add to each 4 cc. of concentrated c.p. sulphuric acid. Evaporate on a steam bath; then on a steam plate or hot plate to copious SO_3 fumes, to completely eliminate chlorides. Cool and take up in 100 cc. of hot distilled water. Add 0.5 g. of aluminum powder. Cover with a watch glass. Heat to boiling and boil 5 minutes. Filter through an 11-cm. filter paper. Receive the filtrate in a covered 1000-cc. Griffins beaker. Wash the beaker and filter thoroughly with hot water until a drop of methyl orange indicator placed behind the double fold of filter paper shows no acidity. Exactly neutralize the filtrate with dilute ammonia. Use great care and precision, and carry the neutralization just to the end point.

Add 10 cc. of 0.1 *N* sulphuric acid (3 cc. of concentrated c.p. sulphuric acid in 1000 cc. of water). Dilute to 650 cc. Cover the beaker, and bubble a rapid stream of hydrogen sulphide for one-half to one hour at room temperature.

Settle and filter through a double filter of one 15-cm. and one 11-cm paper* folded together. Transfer the precipitate to the filter paper. Thoroughly policeman the beaker until the zinc sulphide is all removed except a very thin film which clings tenaciously to the glass at the surface of the liquid. Thoroughly wash the beaker and precipitate at room temperature with water saturated with hydrogen sulphide. Repeat washing of filter paper, and precipitate five or six times. Transfer paper and precipitate to an ignited, cooled, desiccated and weighed porcelain crucible of suitable capacity (about 25 to 30 cc.). Carefully dry the paper and precipitate and when dry completely burn off the paper at as low a temperature as possible. When carbon has been completely burned out, ignite the resultant oxide of zinc strongly to as high a temperature as is available, but not higher than can be attained with a laboratory blast lamp with the aid of gas and air. Heat for 30 minutes. After strong ignition, cool the crucible, desiccate and weigh. The increase in weight is zinc oxide. The weight of the zinc oxide multiplied by the factor 1.6749, multiplied by 100, divided by the weight of sample in the aliquot portion taken, equals the percentages of zinc-chloride.

The average of the results obtained with the three aliquot portions analyzed shall be reported. Results should agree within 1.5 per cent.

ESTIMATION OF IRON AND ALUMINA

Weigh 10 g. of the sample, if fused or granulated, or place an equivalent quantity, if a solution, into a suitable beaker and dissolve in 100 cc. of water or dilute to 100 cc., if a solution. Add sufficient hydro-

---

*Ashless paper should be used.

chloric acid to dissolve any basic zinc-chloride. Add a slight excess of bromine water and boil off excess. Neutralize with a weak solution of sodium carbonate until a permanent precipitate of zinc carbonate is obtained. Add three drops of glacial acetic acid and 2 g. of sodium acetate, and boil. Filter and wash. Redissolve the percipitate in the original beaker with hot hydrochloric acid (1:1). Reprecipitate the iron and alumina with a slight excess of ammonia, filter and wash free from chlorine. Ignite in a platinum crucible and weigh as $Fe_2O_3 + Al_2O_3$.

METHOD FOR DETERMINING THE STRENGTH OF ZINC CHLORIDE SOLUTION[13]

Use.

This method is for the control of the strength of the zinc-chloride solutions as used in actual treatment, and not for the analyses of the concentrated zinc-chloride as purchased.

Principle.—The chlorine is determined by titration with standard silver nitrate solution and then calculated into zinc-chloride according to the following equation:

$$2\,AgNO_3 + ZnCl_2 = 2AgCl + Zn\ (NO_3)_2.$$

Standard Silver Nitrate Solution: 1/10 normal silver nitrate per litre of distilled water.

Indicator: Neutral potassium chromate, $K_2Cr\ O_4$ (Chlorine free), saturated solution, 60 grams in 100 cc. of distilled water.

Method of Procedure.

(a) Specific Gravity.—A quantity of zinc-chloride to be tested, sufficient to float the hydrometer, is filtered into a hydrometer cylinder. Filtration is unnecessary if the solution is perfectly clear and free from Creosote Oil. The specific gravity of the filtered solution at 70 deg. Fahr. is then determined by means of a hydrometer having a scale reading from 1.000 to 1.060.

(b) Titration.—Two (2) cc. of the filtered zinc-chloride solution are introduced into a 500 cc. Erlenmeyer flask by means of an accurately calibrated pipette and diluted to about 100 cc. with distilled water. After adding two (2) drops of the potassium chromate indicator the solution is titrated with the standard silver nitrate solution, using a 50 cc. glass-stoppered burette accurately graduated to tenths of a cubic centimeter. The silver nitrate solution is slowly run into the flask until the solution in the flask just begins to assume a permanent reddish tinge, the flask having been gently shaken after each addition of silver nitrate.

(c) Calculation.—The per cent strength of the zinc-chloride solution is calculated according to the following equation:

$$\frac{\text{cc. } AgNO_3 \times \text{gm. } Ag\ NO_3 \text{ per cc.}}{\text{cc. } ZnCl_2 \times \text{Sp. Gr. } ZnCl_2} \times 100 \times .401 = \%\ \text{Strength } Cl_2$$

---

[13] Adopted, Vol. 20, 1919, pp. 133, 841.

In this equation, the symbols signify the following:

$AgNo_3$ = Silver Nitrate; $ZnCl_2$ = Zinc Chloride;

$$0.401 = \frac{136.31}{2 \times 169.96} = \frac{ZnCl_2}{2\,AgNO_3}$$

Grams $AgNo_3$ per cc. = Strength of the standard silver nitrate solution.

Example: Strength of $AgNO_3$.................... .017 gr. per cc.

cc. of $AgNO_3$ used....................8.2
cc. of $ZnCl_2$...........................2.0
Sp. Gr. $ZnCl_2$.......................1.024

$$\frac{8.2 \times .017}{2 \times 1.024} \times .401 \times 100 = 2.72\% = ZnCl_2$$

The strength of the standard silver nitrate solution should be approximately 1/10 normal or 16.996 grams $AgNO_3$ per litre. The *exact* strength of the solution must be known and should be indicated on the bottle.*

(d) Precautions.—As the above method is based on the estimation of the chlorine in the zinc-chloride, it is essential to determine whether the water used in making up the zinc-chloride solutions at the treating plant contains chlorides, and if so to make the proper deductions. Two (2) cc. of the water should be titrated exactly as described above. The number of cc. of standard silver nitrate solution required to produce the color change should be noted, and this amount should always be deducted from the number of cc. of silver nitrate solution required for the titration of the zinc-chloride solution sample before making calculations. Where the chlorine content of the water used is found to be variable check determinations should be made.

DIRECTIONS FOR THE USE OF IODINE POTASSIUM FERRICYANIDE STARCH COLOR REACTION TEST FOR DETERMINING ZINC-CHLORIDE PENETRATION[14]

This method requires the following chemicals and apparatus:

(1) Potassium Ferricyanide.
(2) Potassium Iodide.
(3) Soluble Starch.
(4) Atomizer.

The chemicals should be purchased chemically pure and half pound each should be enough for any plant at one time. DeVilbiss Atomizer No. 30 is very satisfactory.

---

*The standard silver nitrate solution should be made and standardized only by a trained chemist; if the services of such a chemist are not available, the standard solution should be obtained from a reliable chemical supply firm.

[14] Adopted, Vol. 21, 1920, pp. 358, 1387.

For stock solutions of the three chemicals made 200 cc. each to be kept separately until used:

(1) 1 per cent Potassium Ferricyanide (2 gm. dissolved in 200 cc. water).
(2) 1 per cent Potassium Iodide (2 gm. dissolved in 200 cc. water).
(3) 5 per cent Soluble Starch (10 gm. dissolved in 200 cc. water).

Mix the weighed starch with a little of the measured cold water and then pour into the remaining water boiling hot and continue to boil until the starch is in solution. Starch solution will not keep for many days and must not be used when it begins to sour.

To make a test for zinc-chloride preparation, simply pour 10 cc. each (or equal amounts) of the three stock solutions into atomizer and spray the cross-section of the tie evenly all over, if zinc-chloride is present a deep blue stain will result showing clearly the depth of penetration.

DETERMINATION OF ZINC IN TREATED TIMBERS[15]

NOTE—*It is suggested that this method be applied by a Chemist.*

Taking Samples

(1) The tools necessary for taking samples are a cross-cut saw and a one-inch auger. These should be wiped perfectly clean each time before taking a sample, in order to avoid contaminating the samples.

(2) The timbers from which samples are to be taken for analysis should be selected before the charge is loaded, and carefully weighed individually. They should be of average size and comparatively free from knots. After treatment they should be weighed and then piled until the dripping has stopped, when the samples may be taken.

(3) For ordinary determinations, timbers such as ties should be sawed at two points, viz., two feet from the end and at the center of the tie. These sections should be designated Section No. 1 and Section No. 2, respectively. In special cases where it may be necessary to cut a tie into several sections, the exact distance from the end to each section should be given.

(4) When a large number of ties are to be analyzed, it will be sufficient to cut but one section two feet from the end, thereby saving the six-foot piece for a narrow-gage tie.

(5) After the sections have been cut, three samples should be taken from each section, as follows: No. 1, one-half inch from outside; No. 3, at the center of the section; No. 2, half-way between No. 1 and No. 3. The samples are taken by boring a hole 2 inches deep with a one-inch bit, saving all the borings. Each sample should be properly labeled, as Tie

---

[15] Adopted, Vol. 9, 1908, pp. 712-714, 768; Vol. 11, Part 2, 1911, pp. 746, 747, 860.

No. —, Section No. —, Sample No. —, and a list made showing the location, date, number of run, kind of treatment and weight of each tie before and after treatment.

Method of Determining Zinc-Chloride in Samples

(6) Three grammes of dry borings should be weighed into a 250 cc. flask and three cc. concentrated sulphuric acid added. The flask should be gently heated on a sand bath or hot plate until the wood becomes thoroughly charged. A few drops of concentrated nitric acid should then be added. When the brown fumes have disappeared, a few more drops should be added, and the addition continued, a few drops at a time (toward the last the amount should be increased), until the organic matter is all destroyed. When this point is reached, the liquid will remain colorless on further heating. The flask should then be allowed to cool and diluted with 100 cc. of water (the water should be added carefully at first). As a rule, the residue in the flask will be completely dissolved, but if there should be a slight sediment, it may be disregarded. Ammonium hydroxide should be added until distinctly alkaline, and allowed to cool. If there is a precipitate of iron hydroxide, or if there has been any undissolved sediment in the flask, it should be filtered; if not, it should be poured into a 400 cc. beaker and 5 cc. ammonium sulphide added and allowed to stand over night. It should then be filtered into an 11 cm. filter paper, washing thoroughly with water containing ammonium sulphide, and dried. It should then be incinerated in a porcelain crucible and roasted until the zinc-chloride is converted to zinc oxide. The weight should be divided by three and the result multiplied by 1.674, which will give the number of grammes of zinc-chloride contained in one gramme of the wood examined, or the number of pounds per pound. To convert this result into pounds of zinc-chloride per cubic foot of wood, multiply by the weight in pounds of one cubic foot of the wood.

FORMS FOR REPORTING INSPECTION[16]

Two forms for reporting inspection of treatment are shown. Form "A" provides a record of the treatment and the determination of the absorption of the preservative by gage readings. Form "B" provides a record of the determination of the absorption by weighing.

These forms are intended as general guides for reporting and keeping records of the inspection of the treatment of timbers, and may be varied to suit any special kind of treatment.

The following is explanatory of the gage readings, designed by letter on Form "A":

Reading "A"—Is the reading of the measuring tank gage before the oil is put into the cylinder.

---

[16] Adopted, Vol. 14, 1913, pp. 713-716, 1165, 1166.

Reading "B"—Is the tank gage reading when the cylinder is completely filled.

Reading "C"—Is the tank gage reading when the pumping of the oil into the cylinder is stopped.

Reading "D"—Is the tank gage reading after all the oil from the charge is returned to the measuring tank.

Reading "A" minus "D," corrected for temperatures, gives the number of gallons used in the charge.

Reading "B" minus "C" gives the number of gallons pumped into the timber after the cylinder is filled and is used to give the gross absorption for high processes where oil is taken out of the timber by an initial air pressure, or by a final vacuum, or both. There will be a discrepancy in this gross absorption, due to the amount of oil absorbed by the timber while cylinder is being filled.

Form A.

M. W. 1700

____
(Name of Railroad)

______________________________ Department

______________________________ Plant

______________________________ Inspector

Date															
Kind of Treatment															
Retort Number															
Charge Number															
Liquid Used															
Percent of Chloride															
Steam or Air Admitted															
Vacuum Applied															
Liquid Admitted															
Pump Started															
Treatment Ended															
Steam or Air Pressure, Lbs.															
Vacuum, Inches															
Pressure of Liquid, Lbs.															
Measuring Tank Number															
Gallons per Tank Foot															
Reading A.															
Temperature A. Degrees Fahrenheit															
Reading B.															
Temperature B. Degrees Fahrenheit															
Reading C															
Temperature C. Degrees Fahrenheit															
Reading D.															
Temperature D. Degrees Fahrenheit															
Gals Pumped Into Timber per Charge B. minus C.															
Gallons Pumped Into Timber per Tie															
Pounds Pumped Into Timber per Cu. Ft.															
Total Gallons Used 100° Fahrenheit A. minus D.															
Gals per Cu. Ft. of Timber															
Gallons per Tie															
Lbs. per Cu. Ft. of Timber															
Lbs. of Chloride per Cu. Ft. Timber															
Material Treated.															

Form B.

M. W 1701

Date __________ ____________________ (Name of Railroad) Date __________

Kind of Treatment __________ __________ Plant Kind of Treatment __________

Run No. ______ Kind of Timber __________ Kind of Timber __________ Run No. ______

Tram Number	No. of Ties	Gross Weight Before Treatment	Weight of Tram	Weight of Ties Before Treatment	Gross Weight After Treatment	Weight of Ties After Treatment	Gain Per Tie	Tram Number	No. of Ties	Gross Weight Before Treatment	Weight of Tram	Weight of Ties Before Treatment	Gross Weight After Treatment	Weight of Ties After Treatment	Gain Per Tie

____________________ Inspector

Lbs. of Oil Per Tie __________ % of Chloride in Solution __________

Total Gals. Oil @ 100° Fahr. __________ Total Lbs. Liquid Used __________

Gals. Absorbed per Tie __________ Lbs. Chloride per Tie __________

____________________ Inspector

Lbs. of Oil Per Tie __________ % of Chloride in Solution __________

Total Gals. Oil @ 100° Fahr. __________ Total Lbs. Liquid Used __________

Gals. Absorbed per Tie __________ Lbs. Chloride per Tie __________

Appendix B

(2) SPECIFICATIONS FOR PRESERVATIVE TREATMENT OF DOUGLAS FIR

W. H. Kirkbride, Chairman, Sub-Committee; Andrew Gibson, R. S. Belcher, J. F. Pinson, J. W. Williams.

Your Committee submits the following proposed specifications for the Treatment of Douglas Fir:

I. INTRODUCTION

1. The physical structure of Douglas Fir causes it to be refractory to preservative treatment, this quality varying with the conditions under which the timber is grown. The heartwood offers great resistance to the injection of preservative; the sapwood can be treated more readily, but since the natural timber contains only a thin shell of sapwood, the general treatment is difficult. Furthermore, since sawed timber may be entirely heartwood, or may contain only a very small amount of sapwood, it follows that this type of material is more difficult to treat than piling, which contains the full amount of original sapwood.

Perforating or Incising

2. The refractory quality of Douglas Fir has led to the development of the principle of perforating or incising the timber mechanically as an aid to injection of preservatives. The advantages of this procedure have been conclusively demonstrated. Thus far the practice has been confined to tie and pole material. The incisions are so made and spaced that the preservative entering the wood unites between adjacent incisions and produces a more uniform and deeper penetration than would otherwise be possible.

Piling Sapwood

3. In order to obtain an adequate treatment, all piling material should have a minimum sapwood thickness equal to the depth of penetration desired. (See General Specification Requirements, Section 8, Penetration.)

Seasoning Before Treatment

4. In accordance with the general recommendations of this Association for all timber, Douglas Fir should be air-seasoned before treatment wherever possible. If this is done, artificial seasoning is avoided, the treating cycle is materially shortened, and a better treatment is secured. The proper amount of such seasoning will vary with climatic conditions and must be determined for each locality by actual tests.

Material stored for seasoning should be piled in accordance with the recommended practice of this Association.

Artificial Seasoning

5. If air-seasoning cannot be secured, the material must be artificially seasoned in order to accomplish treatment. The method of such seasoning will depend upon the kind of treatment. In cases where artificial seasoning is to be secured by boiling the material in the preservative oil, it is important that the specified allowable temperatures be not exceeded, to avoid injury of the timber. In treatments where zinc-chloride is used, the only method of artificial seasoning is that of steaming, and this procedure is not recommended by the Association.

Machining, Cutting, Framing

6. With the exception noted below for processes in which zinc-chloride is used as a preservative, all machining, cutting or framing of timber to be treated should be accomplished before treatment as far as practicable, to minimize subsequent cutting through the treated shell and exposure of untreated wood.

Preservatives

7. The following preservatives are commonly used for the treatment of Douglas Fir:

Creosote.
Creosote-Petroleum Mixture.
Creosote-Coal-Tar Solution.
Creosote-Zinc-Chloride Emulsion.
Zinc-Chloride.

Preservative Treatments

8. Douglas Fir is commonly treated by the following preservative processes:

Full Cell Process.
Empty Cell Process with Final Vacuum.
Empty Cell Process with Initial Air and Final Vacuum.
Creosote-Zinc Chloride Emulsion Process.
Zinc-Chloride Process.

The selection of treatment is largely determined by the intended use of the treated material. All the above preservatives and treatments have been applied to timber for general inland purposes. Use of timber treated by the Zinc-Chloride Process is limited by conditions of humidity. The Full Cell Process with straight creosote as the preservative is the only treatment recommended by the Association for the preservation of piling, and the timber to be used in sea water exposed to the action of marine borers.

Final Retention of Preservatives

9. The amount of preservative to be retained by the timber is optional with the Railroad, within the limitations of the various processes and necessary minimums specified by the Association. The amount required

will depend largely upon the intended use of the treated material. The following amounts are recommended:

For Douglas Fir Ties and Structural Timber

(For ties and moderate size structural timbers having dimensions over 6 inches and under 12 inches. A greater amount of preservative should be injected for timbers having dimensions less than 6 inches; a smaller amount can be injected for timbers in which the smaller dimension is more than 12 inches.)

(a) Treatment by Full Cell Process with Creosote, Creosote-Petroleum Mixture or Creosote-Coal-Tar Solution—not less than 10 lb. of preservative per cu. ft. of timber.

(This amount is necessary to secure a minimum adequate penetration. A treatment of 10 lb. by the Full Cell Process will give about the same penetration as a 6 lb. treatment by the Empty Cell Process.)

(b) Treatment by Empty Cell Process with Creosote, Creosote-Petroleum Mixture or Creosote-Coal-Tar Solution—6 to 8 lb. of preservative per cu. ft. of timber.

(c) Treatment by Creosote-Zinc-Chloride Emulsion Process—3 lb. creosote and 0.4 to 0.5 lb. dry zinc chloride per cu. ft. timber.

(d) Treatment by Zinc-Chloride Process—0.5 lb. dry zinc-chloride per cu. ft. timber.

For Douglas Fir Piling Not Used in Sea Water

Treatment with Creosote—not less than 10 lb. creosote per cu. ft. timber.

For Douglas Fir Structural Timber and Piling Used in Sea Water

Treatment by Full Cell Process with Straight Creosote—not less than 12 lb. creosote per cu. ft. timber.

Seasoning After Treatment

10. To secure the maximum benefits of the preservative process it should not be used immediately after being treated. Tie material should be seasoned a minimum of 60 days after treatment.

II. GENERAL SPECIFICATION REQUIREMENTS

(For All Methods of Treatment)

Quality of Timber

1. The timber shall conform to the specifications of this Association.

Physical Condition—Machining, Cutting, Framing, Trimming

2. For Ties.—All machining, such as boring for spikes and adzing, shall be done before treatment. Ties shall be bored, adzed, incised and branded as specified by the Railroad.

For Structural Timber.—All boring (see exception for processes using zinc-chloride in Introduction, Section 6), cutting and framing shall be accomplished, so far as practicable, before treatment, and as specified by the Railroad.

For Piling.—All piling shall have bark and inner skin removed, knots cut flush and butts and tips trimmed squarely. Piling previously stored in sea water shall have barnacles and similar forms of sea life removed. Piling showing attack of insects or marine borers shall be rejected.

Seasoning Before Treatment

3. Timber shall be air-seasoned or artificially seasoned before injection of the preservative under pressure, as desired by the Railroad. Such seasoning shall be accomplished in accordance with the specifications of this Association.

Moisture Content

4. Timber shall be considered thoroughly seasoned when its moisture content is 20 per cent or less of its oven-dry weight.

All material treated in any one charge shall have approximately the same moisture content.

Preservative

5. The preservative desired by the Railroad shall conform to the specifications of this Association.

Preservative Treatment

6. The preservative treatment desired by the Railroad shall conform to the specifications of this Association. (See Specifications for Preservative Treatments.)

Final Retention of Preservative

7. The amount of preservative to be retained by the timber shall be specified by the Railroad.

Piling not used in sea water shall have a minimum final retention of 10 lb. of creosote per cubic foot of timber. Structural timber and piling used in sea water and subject to the action of marine borers (treated by the Full Cell Process with creosote) shall have a minimum final retention of 12 lb. of creosote per cubic foot of timber.

The quantity of creosote oil retained shall be calculated on the basis of 100 degrees Fahr. from reading of working tank gages and scales or from weights of at least one-tenth of the material on a suitable track scale before and after treatment, checked as may be desired by the Railroad's representative.

Penetration

8. The penetration of preservative shall be as specified by the Railroad.

For piling the penetration shall correspond to the specified final retention of preservative, as follows:

MINIMUM SAPWOOD AND PENETRATION FOR PILING

(Treated by Full Cell Process with Straight Creosote)

Amount of preservative to be retained	*Minimum sapwood and penetration*
10 lb. creosote per cu. ft.	½ inch
12 lb. creosote per cu. ft.	¾ inch
14 lb. creosote per cu. ft.	1 inch
16 lb. creosote per cu. ft.	1¼ inch

In order to determine the penetration of the oil, borings should be made with an increment borer in at least six pieces in each cylinder load. The holes should be plugged with creosote plugs at least one-sixteenth inch larger than the diameter of the hole.

General Conditions

9. All holes bored for test purposes shall be plugged with treated plugs furnished by the Treating Company.

All timber must be handled with care, particularly after treatment, to avoid damaging the edges or breaking through the treated shell and exposing untreated wood. Sharp pointed tools, such as cant hooks, peavies, pickaroons and crowbars, must only be used in the ends of timbers. Injured material shall be rejected.

The Treating Company shall maintain the necessary thermometers and gages to indicate and record accurately the conditions at all stages of treatment, and all equipment shall be maintained in a condition satisfactory to the Railroad.

The Treating Company shall permit the Railroad inspectors or representatives to make all necessary tests of materials and equipment pertaining to work covered by these specifications, and shall co-operate in making such tests.

The Treating Company shall provide for the use of the Railroad inspectors or representatives all necessary chemicals and facilities for making tests required by these specifications.

The Railroad inspectors or representatives shall have access to all parts of the treating plant and to all records pertaining to work covered by these specifications.

III. PRESERVATIVE TREATMENTS

(To be inserted in General Specification Requirements)

Full Cell Process

(For use with Straight Creosote, Creosote-Petroleum
Oil Solution or Creosote-Coal-Tar Solution)

FOR TIES AND STRUCTURAL TIMBER

Artificial Seasoning

1. When the timber has not been air-seasoned, it may be artificially seasoned in the treating cylinder by boiling in the preservative oil under a vacuum at temperatures ranging from 180 deg. Fahr. to 200 deg. Fahr., as follows:

After the timber is placed in the treating cylinder, preservative heated to not less than 170 degrees Fahr. shall be admitted until the timber is completely immersed. The connections between the condenser and vapor drum on the treating cylinder shall then be opened and steam admitted through the heating coils and so regulated that the temperature in the treating cylinder is caused to rise as fast as the condensation will permit, until a temperature of not exceeding 200 deg. Fahr. is reached. At the beginning of the boiling period, in order to eliminate the possibility of the oil surging and entering the vapor lines and condenser, the vacuum produced should not exceed 15 inches. After the temperature has been raised not exceeding 200 degrees Fahr., the vacuum shall be increased to at least 20 inches and so maintained until the condensation passing off from the timber and collecting in the hot well of the condenser does not exceed 0.1 of a lb. per cubic foot of timber per hour.

Preparatory Bath

2. In the case of thoroughly air-seasoned timber, it is not necessary to boil under a vacuum, but because of the refractory nature of Douglas Fir, it must be held in a hot oil bath at temperatures from 180 degrees to 190 degrees Fahr. for a period of 6 to 8 hours, in order to obtain the necessary absorption without running into extremely high pressures.

Treating Operation

3. At the completion of the seasoning or bath periods, the treating cylinder shall be completely filled with preservative heated to not less than 170 degrees nor more than 190 degrees Fahr. The pressure in the cylinder shall then be gradually raised over a period not less than 1 hour and 30 minutes to pressure not less than 125 nor more than 175 pounds per square inch depending upon the dimension of the material. This operation shall be continued until the timber has absorbed sufficient preservative to insure the specified final retention.

The temperature of the preservative during the pressure period shall be not less than 170 degrees Fahr. nor more than 200 degrees Fahr. After the proper injection of preservative has been secured, the cylinder shall be speedily emptied of preservative, and a vacuum of 22 inches or more promptly created and maintained for a period not more than 1 hour nor more than 2 hours, so that the timber can be removed from the cylinder free of dripping preservative.

Final Retention of Preservative

(See General Specification Requirements, section 7.)

4. The amount of preservative finally retained by the timber shall be determined from readings of working tank gages or scales, or by weighing sufficient representative timber, before and after treatment, with proper correction for loss in moisture content.

Penetration

(See General Specification Requirements, section 8.)

5. Representative timber from each charge shall be tested for penetration. In determining penetration, light discoloration of the wood from treatment shall not be considered.

For Piling

Specifications for treatment of piling by the Full Cell Process are the same as given above for ties and structural timber with the exception that temperatures up to 220 degrees Fahr. will be permitted.

Rueping Process

(For use with Creosote, Creosote-Petroleum Mixture
or Creosote-Coal-Tar Solution.)

Artificial Seasoning

1. When the timber has not been air-seasoned, it may be artificially seasoned in the treating cylinder by boiling in the preservative oil under a vacuum at temperatures ranging from 180 degrees Fahr. to 200 degrees Fahr. as follows:

After the timber is placed in the treating cylinder, preservative heated to not less than 170 degrees Fahr. nor more than 200 degrees Fahr. shall be admitted until the timber is completely immersed. The connections between the condenser and vapor drum on the treating cylinder shall then be opened and steam admitted through the heating coils and so regulated that the temperature in the treating cylinder is caused to rise as fast as the condensation will permit, until a temperature of about 190 degrees Fahr. is reached. At the beginning of the boiling period, in order to eliminate the possibility of the oil surging and entering the vapor lines and condenser, the vacuum produced should not exceed 15 inches. After the temperature has been raised to 190 degrees Fahr. the vacuum shall be increased to 20 inches and so maintained until the condensation passing off from the timber and collecting in the hot well of the condenser does not exceed 0.1 of a lb. per cubic foot of timber per hour.

Preparatory Bath

2. In the case of thoroughly air-seasoned timber, it is not necessary to boil under a vacuum, but because of the refractory nature of Douglas Fir, it may be held in a hot oil bath at temperatures from 180 degrees to 190 degrees Fahr. for a period of 6 to 8 hours, in order to obtain the necessary absorption without running into extremely high pressures.

After completion of the seasoning or bath periods, the preservative shall be immediately drained completely from the treating cylinder. If a vacuum has been used, the cylinder shall be drained immediately upon breaking the vacuum.

Treating Operation

3. As soon as the treating cylinder has been completely drained, the timber shall be subjected to an air pressure of sufficient intensity and duration to provide for the specified final retention. The preservative shall then be introduced, the air pressure being maintained constant until the cylinder is filled. The pressure of the preservative shall then be gradually raised until it is not less than 100 lb. per square inch greater than the air pressure at which the treating cylinder was refilled. This pressure shall be held until sufficient preservative has been introduced to give the specified final retention.

Pressures in excess of 200 lb. per square inch will not be permitted. The temperature of the preservative during the pressure period shall be not less than 170 degrees Fahr. nor more than 200 degrees Fahr. Upon completion of the pressure period, the treating cylinder shall be speedily emptied of preservative and a vacuum of not less than 22 inches promptly created and maintained for a period not to exceed one hour nor more than 2 hours, so that the timber can be removed from the treating cylinder free of dripping preservative.

Final Retention of Preservative

(See General Specification Requirements, Section 7.)

4. The amount of preservatives finally retained by the timber shall be determined from readings of working tank gages or scales, or by weighing sufficient representative timber, before and after treatment, with proper correction for loss in moisture content.

Penetration

(See General Specification Requirements, Section 8.)

5. Representative timber from each charge shall be tested for penetration. In determining penetration, light discoloration of the wood from treatment shall not be considered.

Lowry Process

(For use with Creosote, Creosote-Petroleum Mixture
or Creosote-Coal-Tar Solution.)

Treatment of Douglas Fir by the Lowry Process is substantially the same as that of the Rueping Process with the exception that initial air pressure is omitted.

Creosote-Zinc-Chloride Emulsion Process

1. Except when ordered otherwise by the railroad, the timber to be treated shall be air-seasoned until the moisture in it will not prevent injection of the specified amount of preservative.

Treating Operation

2. The timber shall be steamed in the treating cylinder for at least 1 hour at a pressure not less than 15 nor more than 20 lb. per square inch. After releasing the steam pressure and condensation, a vacuum of at least 22 inches shall be created.

Without breaking the vacuum, the preservative shall be introduced until the cylinder is completely filled. The pressure shall then be gradually raised over a period not less than 1 hour and 30 minutes to a pressure not less than 125 nor more than 175 lb. per square inch. This pressure shall be maintained until the required absorption has been obtained.

The temperature of the preservative before introduction and during the entire pressure period shall be not less than 170 degrees Fahr. nor more than 200 degrees Fahr. During the entire pressure period the preservative solution shall be agitated mechanically to keep it in emulsion.

After the injection of preservative is completed, the cylinder shall be emptied of preservative and a vacuum of 22 inches or more maintained until the timber can be removed from the cylinder free of dripping preservative.

Final Retention of Preservative

(See General Specification Requirements, section 7.)

3. The amount of solution finally retained by the timber shall be determined from readings of working tank gages or scales, or by weighing sufficient representative timber before and after treatment.

Penetration

(See General Specification Requirements, Section 8.)

4. At least once each day the Railroad's representative shall determine penetration by analysis. The "Iodine-Potassium Ferricyanide Starch" color reaction test to determine the penetration by its visibility will generally be satisfactory.

Zinc-Chloride Process

Seasoning Before Treatment

1. Except when ordered otherwise by the Railroad, the timber to be treated shall be air-seasoned until the moisture in it will not prevent injection of the specified amount of preservative.

Preservative Solution

2. The preservative solution shall be no stronger than necessary to obtain the required retention of preservative with the largest volumetric absorption that is practicable, and shall be thoroughly mixed before use. Its strength shall not exceed 5 per cent and shall be determined by analysis. Chemical titration, using a silver-nitrate solution with potassium-chromate indicator, will usually be satisfactory.

Treating Operation

3. Air-seasoned material shall be steamed in the treating cylinder for not less than 1 hour nor more than 2 hours, at a pressure of not more than 20 lb. per square inch, the cylinder being provided with vents to relieve it of stagnant air and insure proper circulation of the steam, and being drained to prevent condensate from accumulating in sufficient quantity to reach the timber. After steaming is completed, a vacuum of at least 22 inches shall be created and maintained until the timber is as dry and as free from air as practicable.

Before the preservative is introduced, the cylinder shall be drained of condensate, and if the vacuum is broken, a second one as high as the first shall be created. The preservative shall be introduced without breaking the vacuum until the cylinder is filled. The pressure shall be gradually raised and maintained at not less than 125 lb. per square inch or more than 175 lb. maximum until the required quantity of preservative is injected into the timber, or until less than 5 per cent of the total quantity required has been injected during the latter half of 1 hour throughout which the rate of injection has persistently decreased while the pressure has been held continuously at 165 or more lbs. per square inch.

The temperature of the preservative during the pressure period shall be not less than 150 degrees Fahr. nor more than 190 degrees Fahr. and with an average of at least 170 degrees Fahr. After the cylinder is emptied of the preservative solution, a vacuum shall be created and maintained until the timber can be removed from the cylinder free of dripping preservative.

Final Retention of Preservative

(See General Specification Requirements, Section 7.)

4. The amount of solution finally retained by the timber shall be determined from readings of working tank gages or scales, or by weighing sufficient representative timber before and after treatment.

Penetration

(See General Specification Requirements, Section 8.)

5. At least once each day the Railroad's representative shall determine penetration by analysis. The "Iodine-Potassium Ferricyanide Starch" color reaction test to determine the penetration by its visibility will generally be satisfactory.

Appendix C

(3) SERVICE TEST RECORDS

Z. M. Briggs, Chairman, Sub-Committee; G. F. Eberly, J. E. Fanning, H. J. Force, C. F. Ford, Andrew Gibson, R. H. Howard, J. F. Pinson, W. R. Rhodes, Dr. H. von Schrenk, F. C. Shepherd, J. H. Waterman.

1. The Committee presents this year a revised and extended table of cross-tie renewals per mile of all tracks on 24 railroads. A column has been added for each road, showing five-year averages of renewals, ending each year; and at the bottom, an estimate of the percentage of treated ties now in track. The final columns, showing averages of renewals on all roads for each year, have been calculated on the basis of weighted averages, taking mileage into account. It is interesting to note that tie renewals per mile were gradually increasing from 226 in 1904, to 263 in 1915, but since that time have decreased to 174 in 1924.

2. The Forest Products Laboratory has revised its table of completed service records of ties this year, and this table is printed in full. The last complete table was published in the Proceedings for 1922, Vol. 23, pages 910-933.

3. Members of the Committee have found useful the curve showing a relation between the percentages of ties of any group renewed, and the average life of the ties of that group, which was developed by the Forest Products Laboratory and printed in our 1919 Proceedings, page 138. For greater convenience, we have reduced the curve to a table, which is presented herewith. It is suggested, however, that a table showing a relation between renewals and average life in years, instead of percentages, would be still more useful. This would make an extended table, and probably should be based on a larger number of service records than the original curve. The Committee expects to work on this during the coming year, with the assistance of the Forest Products Laboratory.

SPECIAL TESTS NOW IN PROGRESS

4. For the information of members of the Association, we would call special attention to tests of cross-ties now in progress on various railroads, as follows:

Chicago, Burlington & Quincy Railroad

Experimental ties were laid in 1000-tie stretches. A large variety of woods, treated with creosote, with zinc, with a mixture of creosote and zinc, and also untreated, are represented. The climate conditions vary from the semi-arid region of Wyoming to 50 inches rainfall in Illinois. These tests are now in their 16th year, and an elaborate report is made every year by the Superintendent of Timber Preservation. A summary of the results of the 1924 inspection is printed in Wood Preserving News for January, 1925.

Baltimore & Ohio Railroad

Two important tests are under way, one at Herring Run, Md., consisting of 3300 ties laid out of face in 1914, and one west of Blanchester, Ohio, consisting of 5230 ties laid in 1911. A summary of the results of the 1924 inspection is printed in the Proceedings of the American Wood Preservers' Association.

Pennsylvania Railroad System

Service tests are being made on several divisions, in 1000-tie stretches, on which ties are being renewed in the usual way, the new ties being numbered and marked with dating nails, and accurate records kept of each tie. These tests were started in 1919, and no ties have been removed to date, except some untreated sap white-oak ties, which gave only four years' life.

Union Pacific System

A test of about 7500 fir ties, treated and untreated, has been in progress since 1908 at Dodson, Oregon. This test is reported in the Proceedings of the American Wood Preservers' Association for 1925. Extensive test tracks have also been installed on new lines from Hammett to Reverse, Idaho, in 1923, and from Rogerson, Idaho, to Wells, Nevada, in 1924.

Atchison, Topeka & Santa Fe Railway

In addition to numerous test sections on various lines, this road now uses dating nails in all ties put in, and brands ties at the treating plants as they go through the adzing machine.

Chicago, Milwaukee & St. Paul Railway

This company has tests in progress since 1902, covering zinc-treated, Card process and untreated ties. Results of the 1923 inspection are given in the Proceedings of the American Wood Preservers' Association for 1925.

Northern Pacific Railway

There are 66,000 ties in test tracks. These include cottonwood and hemlock ties laid in 1910, and tamarack ties laid in 1917, from which renewal data will soon be available; also, 18 test tracks on various divisions, started in 1919.

Missouri Pacific Railroad

Seven test sections were started in 1921, of about 7½ miles each, in which test ties marked with dating nails are placed in the ordinary course of renewals. About 95,000 ties of various woods and treatments are now under test. The test sections represent various traffic conditions, different weights of rail and kinds of ballast. The rainfall varies from 57 inches on the Gulf Coast to 17 inches in Eastern Colorado.

Record of Completed Service Tests of Ties.

Species	Dimensions	Form	Preparation	Preservative	Process	Absorption	No. of ties	Railroad	Location	Date set	Track condition					Date 100% removed	Average life		Cause of removal
											Tie plates		Kind of spikes	Ballast¹	Traffic tons per year				
						Lbs. per cu. ft.					Kind	Size inches					Years	Reference¹	
Ash	---	---	---	None	Untreated	---	56	C.B. & Q.	Lines East	1909	Partly plated	---	Cut	Cin.,Gr.&B.C.	---	1918	4.6	F.P.L.	Mostly decay
Beech	---	---	---	None	Untreated	---	108	C.B. & Q.	Lines East	1909	Partly plated	---	Cut	Cin.,Gr.&B.C.	---	1920	4.1	F.P.L.	Mostly decay
Beech	---	---	---	None	Untreated	---	100	G.C. & S.F.	Beaumont Division	1902	None	---	Cut	Sand	Heavy	1905	3.0	R.R.	---
Beech	---	---	---	Zinc chloride	Burnett	---	13,834	Pennsylvania	Western Division	1902	---	---	---	---	---	1918	8.9	Pub.	---
Beech	---	---	---	Zinc chloride	Burnett	---	9,937	Pennsylvania	Western Division	1901	---	---	---	---	---	1916	11.1	Pub.	---
Beech	---	Sawed	---	Zinc creosote	Allardyce	22.0 creo., .30 zinc	50	G.C. & S.F.	Beaumont Division	1902	None	---	Cut	Sand	Heavy	1908	6.0	R.R.	---
Beech	---	---	---	Zinc tannin	Wellhouse	.88	100	G.C. & S.F.	Beaumont Division	1902	None	---	Cut	Sand	Heavy	1912	10.0	R.R.	---
Birch, red	---	---	---	None	Untreated	---	50	C.B., & Q.	Lines East	1910	Yes	---	Cut	Gravel	---	1918	4.5	F.P.L.	Decay
Birch, red	---	---	---	None	Untreated	---	89	C.B. & Q.	Lines East	1909	Plated '13	---	Cut	Cinders	---	1914	2.9	F.P.L.	Decay
Birch, yellow	6"x7"x8'	Hewed	Green	None	Untreated	---	100	C. & N. W.	Calamus, Ia.	1914	None	---	Cut	Stone	---	1919	5.0	R.R.	Decay
Catalpa	7"x8"x8½'	---	---	None	Untreated	---	122	Pennsylvania	Urbana, Ohio.	1907	Goldie	---	Screw '07- Cut '16	Gravel	14,119,000	1921	11.0	F.P.L.	Mostly decay
Cedar	---	---	---	None	Untreated	---	1000	C. & N. W.	Elmhurst, Ill.	1903	50% Wolhaupter	4x6	---	Stone	---	1917	13.0	F.P.L.	Plate cut
Cedar	6"x8"x8'	Hewed	---	None	Untreated	---	11,516	C.R.I. & P.	---	1900	None	---	Cut	Gr. & Cin.	Light	1923	19.4	F.P.L.	---
Cedar	6"x8"x8'	Hewed	Seasoned	None	Untreated	---	2001	C.R.I. & P.	Vinton, Ia.	1898	---	5x7½	Cut	Gravel	4,745,000	1917	17.2	F.P.L.	Various
Chestnut	7"x8"x8½'	Hewed	Green	Creosote	Full cell	---	95	D. L. & W.	Boonton, N. J.	1907	D.L. & W. Std.	7x10¼	Screw	Stone	---	1922	14.2	F.P.L.	Shattered and rail cut
Cottonwood	---	---	---	None	Untreated	---	56	C.B. & Q.	Lines East	1909	Partly plated	---	Cut	Cin.,Gr.&B.C.	---	1915	2.6	F.P.L.	Decay
Cypress	---	---	---	None	Untreated	---	353	G.H. & S.A.	Bay View & San Leon,Tex.	1905	Glendon	---	---	Gravel	---	1917	11.7	F.P.L.	Decay
Cypress	---	---	---	None	Untreated	---	342	G.H. & S.A.	Bay View & San Leon,Tex.	1905	None	---	---	Gravel	---	1917	11.4	F.P.L.	Decay
Douglas fir (Coast)	7"x9"x8'	Sawed	Green	None	Untreated	---	264	Northern Pac.	Maywood, Wash.	1906	Sellers & N.P. Std.	---	Cut	Gravel	Heavy	1921	9.1	F.P.L.	Decay
Douglas fir (Coast)	7"x9"x8'	Sawed	Green	None	Untreated	---	100	Northern Pac.	Maywood, Wash.	1906	N.P.Std. 1916	---	Cut	Gravel	Heavy	1917	7.8	F.P.L.	Decay
Douglas fir (Coast)	7"x9"x8'	Sawed	Seasoned	None	Untreated	---	350	Northern Pac.	Maywood, Wash.	1906	Sellers '06-N.P.Std.'16	---	Cut	Gravel	Heavy	1921	8.8	F.P.L.	Decay
Douglas fir (Coast)	7"x9"x8'	Sawed	Seasoned	None	Untreated	---	284	Northern Pac.	Maywood, Wash.	1906	Sellers '06-N.P.Std.'16	---	Cut	Gravel	Heavy	1924	9.1	F.P.L.	Decay
Douglas fir (Coast)	7"x9"x8'	Sawed	Seasoned	None	Untreated	---	100	Northern Pac.	Maywood, Wash.	1906	Sellers '06-N.P.Std.'16	---	Cut	Gravel	Heavy	1920	8.8	F.P.L.	Decay
Douglas fir (Coast)	7"x9"x8'	Sawed	Seasoned	None	Untreated	---	99	Northern Pac.	Maywood, Wash.	1906	N.P.Std. '16	---	Cut	Gravel	Heavy	1919	7.9	F.P.L.	Decay
Douglas fir (Coast)	7"x9"x8'	Sawed	Seasoned	None	Untreated	---	96	Northern Pac.	Maywood, Wash.	1906	Sellers '06-N.P.Std.'16	---	Screw '06-Cut '16	Gravel	Heavy	1918	8.9	F.P.L.	Decay
Douglas fir (Coast)	7"x9"x8'	Sawed	Seasoned	None	Untreated	---	91	Northern Pac.	Maywood, Wash.	1906	Sellers '06-N.P.Std.'16	---	Screw '06-Cut '16	Gravel	Heavy	1920	9.3	F.P.L.	Decay
Douglas fir (Coast)	7"x9"x8'	Sawed	Seasoned	None	Untreated	---	58	Northern Pac.	Maywood, Wash.	1906	N.P.Std. '16	---	Screw '06-Cut '16	Gravel	Heavy	1917	8.3	F.P.L.	Decay
Douglas fir(Mountain)	7"x9"x8'	Hewed	Green	None	Untreated	---	108	Northern Pac.	Plains, Mont.	1907	Sellers	---	Cut and screw	Gravel	8,270,506	1916	7.5	F.P.L.	Decay and other causes
Douglas fir(Mountain)	7"x9"x8'	Hewed	Green	None	Untreated	---	95	Northern Pac.	Plains, Mont.	1907	Wolhaupter & Sellers	---	Screw-out 1914	Gravel	8,270,506	1916	7.4	F.P.L.	Decay and other causes
Douglas fir(Mountain)	7"x9"x8'	Hewed	Green	None	Untreated	---	94	Northern Pac.	Plains, Mont.	1907	Wolhaupter	---	Cut	Gravel	8,270,506	1915	7.1	F.P.L.	Decay and other causes
Douglas fir(Mountain)	7"x9"x8'	Hewed	Green	None	Untreated	---	92	Northern Pac.	Plains, Mont.	1907	Sellers	---	Cut	Gravel	8,270,506	1916	7.3	F.P.L.	Decay and other causes
Douglas fir(Mountain)	7"x9"x8'	Hewed	Green	None	Untreated	---	91	Northern Pac.	Plains, Mont.	1907	Sellers	---	Cut	Gravel	8,270,506	1915	7.2	F.P.L.	Decay and other causes
Douglas fir(Mountain)	7"x9"x8'	Hewed	Green	None	Untreated	---	90	Northern Pac.	Plains, Mont.	1907	Sellers	---	Screw	Gravel	8,270,506	1915	7.3	F.P.L.	Decay and other causes
Douglas fir(Mountain)	7"x9"x8'	Hewed	Seasoned	None	Untreated	---	90	Northern Pac.	Plains, Mont.	1907	Wolhaupter	---	Cut	Gravel	8,270,506	1916	7.0	F.P.L.	Decay and other causes
Douglas fir(Mountain)	7"x9"x8'	Hewed	Seasoned	None	Untreated	---	90	Northern Pac.	Plains, Mont.	1907	Sellers	---	Cut	Gravel	8,270,506	1916	7.3	F.P.L.	Decay and other causes
Douglas fir(Mountain)	7"x9"x8'	Hewed	Seasoned	None	Untreated	---	90	Northern Pac.	Plains, Mont.	1907	Sellers	---	Cut	Gravel	8,270,506	1916	7.3	F.P.L.	Decay and other causes
Douglas fir(Mountain)	7"x9"x8'	Hewed	Seasoned	None	Untreated	---	90	Northern Pac.	Plains, Mont.	1907	Sellers	---	Screw and cut	Gravel	8,270,506	1916	7.4	F.P.L.	Decay and other causes
Douglas fir(Mountain)	7"x9"x8'	Hewed	Seasoned	None	Untreated	---	90	Northern Pac.	Plains, Mont.	1907	Sellers	---	Screw	Gravel	8,270,506	1916	7.6	F.P.L.	Decay and other causes
Douglas fir(Mountain)	7"x9"x8'	Hewed	Seasoned	None	Untreated	---	89	Northern Pac.	Plains, Mont.	1907	N.P. #21	---	Cut	Gravel	8,270,506	1916	7.3	F.P.L.	Decay and other causes
Douglas fir	---	Hewed	---	None	Untreated	---	1340	Gr.Northern	Butte Division	1911	Goldie & J.G. 6x8½	6½x8½	Cut	Gravel	---	1922	8.0	F.P.L.	Decay
Douglas fir	---	Sawed	---	None	Untreated	---	850	Gr.Northern	Belt to Gerber	1911	---	---	---	---	---	1922	7.8	F.P.L.	Decay
Douglas fir	7"x8"x8'	Mostly sawed	Seasoned	None	Untreated	---	50	Northern Pac.	Thompson Falls, Mont.	1915	N.P.Std.	---	Cut	Gr. and sand	8,270,506	1923	7.8	F.P.L.	Decay
Douglas fir	7"x9"x8'	Sawed	Partly seasoned	Zinc chloride	Burnett	.24	1941	Southern Pac.	Various	1897	Servis & Wolhaupter	---	Cut	Gr.St. & dirt	Heavy	1910	10.7	F.P.L.	Various
Douglas fir	7"x9"	Sawed	---	Zinc chloride	Burnett	---	85	Southern Pac.	Edenvale, Calif.	1913	Yes	8x8¼	Cut	---	---	1920	7.0	F.P.L.	Mechanical wear
Elm, white	---	---	---	None	Untreated	---	88	C.B. & Q.	Lines East	1909	Partly plated	---	Cut	Cin.,Gr.&B.C.	---	1918	4.5	F.P.L.	Mostly decay
Gum	---	Hewed	Seasoned	None	Vulcanized	---	100	Norfolk Southn.	Norfolk Division M.P.6-7	1897	---	---	---	---	---	1905	2.9	F.P.L.	---
Gum	---	Sawed	Seasoned	None	Vulcanized	---	100	Norfolk Southn.	Norfolk Division M.P.6-7	1897	---	---	---	---	---	1906	4.5	F.P.L.	---
Gum	---	Hewed	Seasoned	Zinc tannin	Wellhouse	---	100	Norfolk Southn.	Norfolk Division M.P.6-7	1897	---	---	---	---	---	1918	16.6	F.P.L.	---
Gum	---	Sawed	Seasoned	Zinc tannin	Wellhouse	---	100	Norfolk Southn.	Norfolk Division M.P.6-7	1897	---	---	---	---	---	1918	14.4	F.P.L.	---
Gum, red	---	---	---	None	Untreated	---	98	C.B. & Q.	Lines East	1909	Partly plated	---	Cut	Cin.,Gr.&B.C.	---	1918	3.8	F.P.L.	Mostly decay
Gum, red	---	---	---	None	Untreated	---	53	C.B. & Q.	Lines West	1909	Yes	---	Cut	Cin.,Gr.&B.C.	---	1919	4.6	F.P.L.	Mostly decay
Gum, red	---	Sawed	---	Creosote	Full cell	12.5	112	G.H. & S.A.	Bay View & San Leon,Tex.	1905	Partly plated	---	Partly screw	---	---	1922	11.2	F.P.L.	---
Gum, red	6"x8"x8'	Sawed	---	Creosote	Full cell	14.4	88	G.H. & S.A.	Bay View & San Leon,Tex.	1905	---	---	Partly screw	---	---	1922	13.1	F.P.L.	---
Gum, red	7"x9"x8'	Hewed	---	Diamond Wood Pres	---	.21 (gallons)	500	G.H. & S.A.	Ft.Hancock & Iser,Tex.	1907	Glendon	---	Cut	Slag	---	1922	13.3	F.P.L.	---
Gum, red	6"x8"x8'	Sawed	---	Zinc chloride	Burnett	.27	129	G.H. & S.A.	Bay View & San Leon,Tex.	1905	Partly plated	---	Screw and cut	---	---	1917	6.6	F.P.L.	---

¹Note: B.C.= Burnt clay; Cin. = Cinders; Gr. = Gravel; St. = Stone; F.P.L.=Average life computed by Forest Products Laboratory; R.R.=Records and average life reported by railroads; Pub.=Data obtained from published reports.

rvative

ar creoso
ar creoso
ar creoso
ar creoso
ar creoso

ar creoso
ar creoso
loride
loride
eosote

all salts

ar creoso
ar creoso
ar creoso
ar creoso
ar creoso

ar creoso
ar creoso
ar creoso
ar creoso
ar creoso

ar creoso
ar creoso
ar creoso
hloride
reosote

annin
annin
all salts
crude oil
hloride

hloride

hloride

ius carbo
all salt
all salts
eaumont

te
tine
hloride
hloride
hloride

hloride
reosote
reosote
annin

age life

Record of Completed Service Tests of Ties (Continued)

Species	Dimensions	Form	Preparation	Preservative	Process	Absorption	No. of ties	Railroad	Location	Date set	Track condition					Date 100% re-moved	Average life		Cause of removal
											Tie plates		Kind of spikes	Ballast[1]	Traffic tons per year		Years	Reference	
						Lbs. per cu. ft.					Kind	Size inches							
[illegible]	6"x8"x8'	Sawed	---	Zinc chloride	Burnett	30	115	G.H. & S.A.	Bay View & San Leon,Tex.	1905	Partly plated	---	Screw and cut	---	---	1917	6.6	F.P.L.	---
[illegible]	---	---	---	None	Untreated	---	[illegible]8	C.B. & Q.	Lines East	1909	Partly plated	---	Cut	Cin.,Gr.&B.C.	---	1916	2.9	F.P.L.	Decay
[illegible]	6"x8"x8'	Sawed	---	Creosote	Full cell	---	113	G.H. & S.A.	Bay View & San Leon,Tex.	1905	Partly plated	---	Partly screw	---	---	1922	11.8	F.P.L.	---
[illegible]	6"x8"x8'	Sawed	Seasoned	Creosote	Full cell	13.[illegible]	88	G.H. & S.A.	Bay View & San Leon,Tex.	1905	Partly plated	---	Partly screw	---	---	1918	11.5	F.P.L.	---
[illegible]	6"x8"x8'	Sawed	---	Zinc chloride	Burnett	.2[illegible]	113	G.H. & S.A.	Bay View & San Leon,Tex.	1905	Partly plated	---	Screw and cut	---	---	1917	6.0	F.P.L.	---
[illegible]	6"x8"x8'	Sawed	---	Zinc chloride	Burnett	.23	85	G.H. & S.A.	Bay View & San Leon,Tex.	1905	Partly plated	---	Screw and cut	---	---	1917	7.1	F.P.L.	---
Hemlock	---	---	---	None	Untreated	---	87	C.B. & Q.	Lines East	1909	Partly plated	---	Cut	Cin.,Gr.&B.C.	---	1916	4.3	F.P.L.	Decay
Hemlock	6"x8"x8'	Hewed	Seasoned	None	Untreated	---	169	C. & N.W.	Janesville, Wis.	1907	None	---	Cut	Gravel	Light	1917	6.5	F.P.L.	Decay
Hemlock	---	---	---	None	Untreated	---	101	G.C. & S.F.	Beaumont Division	1902	None	---	Cut	Sand	Heavy	1904	2.0	F.P.L.	---
Hemlock	7"x9"x8'	Sawed	Green	None	Untreated	---	103	Northern Pac.	Maywood, Wash.	1906	None	---	Cut	Gravel	Heavy	1914	7.5	F.P.L.	Decay
Hemlock	7"x8"x8'	Hewed	Green	None	Untreated	---	100	Northern Pac.	Maywood, Wash.	1906	Sellers	---	Cut	Gravel	Heavy	1915	7.8	F.P.L.	Decay
Hemlock	6"x8"x8'	Hewed	---	Zinc chloride	Burnett	.50	16,167	C.R.I. & P.	Plessis & Sibley, Ia.	1900	None	---	---	Gr. and cin.	---	1923	16.9	F.P.L.	Other than decay
Hemlock	---	---	---	Zinc chloride	Burnett	---	5909	Pennsylvania	Western Division	1897	---	---	---	---	---	1916	10.1	Pub.	---
Hemlock	---	---	---	Zinc chloride	Burnett	---	4786	Pennsylvania	Chicago Division	1897	---	---	---	---	---	1911	10.1	Pub.	---
Hemlock	---	---	---	Zinc chloride	Burnett	---	1048	Pennsylvania	Western Division	1899	---	---	---	---	---	1916	9.7	Pub.	---
Hemlock	---	---	---	Zinc chloride	Burnett	---	1000	Pennsylvania	Chicago Division	1899	---	---	---	---	---	1913	11.6	Pub.	---
Hemlock	---	---	---	Zinc chloride	Burnett	---	698	Pennsylvania	Chicago Division	1896	---	---	---	---	---	1908	11.4	Pub.	---
Hemlock	---	---	---	Zinc chloride	Burnett	---	521	Pennsylvania	Western Division	1900	---	---	---	---	---	1915	9.0	Pub.	---
Hemlock	---	---	---	Zinc chloride	Burnett	---	438	Pennsylvania	Western Division	1898	--	---	---	---	---	1915	9.7	Pub.	---
Hemlock	---	---	---	Zinc chloride	Burnett	---	275	Pennsylvania	Chicago Division	1898	---	---	---	---	---	1910	8.4	Pub.	---
Hemlock	---	---	---	Zinc chloride	Burnett	---	200	Pennsylvania	Western Division	1892	---	---	---	---	---	1907	10.9	Pub.	---
Hemlock	---	Hewed	---	Zinc chloride	Burnett	.62	100	G.C. & S.F.	Beaumont Division	1902	None	---	Cut	Sand	Heavy	1913	8.8	F.P.L.	---
Hemlock	---	Hewed	---	Zinc tannin	Wellhouse	---	11,990	C. & N. W.	Belle Plains, Ia.	1905-06	Wolhaupter	---	Cut	---	---	1918	12.5	P.R.	Other than decay
Hemlock	---	Hewed	---	Zinc tannin	Wellhouse	.55	100	G.C. & S.F.	Beaumont Division	1902	None	---	Cut	Sand	Heavy	1913	10.0	F.P.L.	---
Hickory, pignut	---	---	---	None	Untreated	---	55	C.B. & Q.	Lines East	1909	Partly plated	---	Cut	Cin.,Gr.&B.C.	---	1921	5.4	F.P.L.	Mostly decay
Juniper	---	Hewed	Seasoned	Creosote	Full cell	---	75	Norfolk Southn.	Norfolk Division M.P.6-7	1897	---	---	---	---	---	1918	20.2	F.P.L.	---
Juniper	---	Hewed	Seasoned	None	Untreated	---	50	Norfolk Southn.	Norfolk Division M.P.6-7	1897	---	---	---	---	---	1908	8.1	F.P.L.	---
Juniper	---	Hewed	Seasoned	None	Untreated	---	100	Norfolk Southn.	Norfolk Division M.P.6-7	1897	---	---	---	---	---	1917	15.3	F.P.L.	---
Juniper	---	Hewed	Seasoned	None	Untreated	---	100	Norfolk Southn.	Norfolk Division M.P.6-7	1897	---	---	---	---	---	1918	13.7	F.P.L.	---
Juniper	---	Hewed	Seasoned	None	Untreated	---	100	Norfolk Southn.	Norfolk Division M.P.6-7	1897	---	---	---	---	---	1918	13.6	F.P.L.	---
Juniper	---	Hewed	Seasoned	None	Untreated	---	120	Norfolk Southn.	Norfolk Division M.P.6-7	1897	---	---	---	---	---	1918	13.4	F.P.L.	---
Juniper	---	Hewed	Seasoned	None	Untreated	---	125	Norfolk Southn.	Norfolk Division M.P.6-7	1897	---	---	---	---	---	1910	11.2	F.P.L.	---
Juniper	---	Hewed	Seasoned	None	Untreated	---	200	Norfolk Southn.	Norfolk Division M.P.6-7	1897	---	---	---	---	---	1917	12.6	F.P.L.	---
Larch, western	7"x9"x8'	Hewed	Green	None	Untreated	---	96	Northern Pac.	Plains, Mont.	1907	Wood '07-Wolhaupter '16	---	Screw '07-Cut '16	Gravel	8,270,506	1915	6.6	F.P.L.	Decay and other causes
Larch, western	7"x9"x8'	Hewed	Green	None	Untreated	---	92	Northern Pac.	Plains, Mont.	1907	Sellers	---	Screw	Gravel	8,270,506	1916	7.4	F.P.L.	Decay and other causes
Larch, western	7"x9"x8'	Hewed	Green	None	Untreated	---	91	Northern Pac.	Plains, Mont.	1907	Wolhaupter	---	Cut	Gravel	8,270,506	1915	6.9	F.P.L.	Decay and other causes
Larch, western	7"x9"x8'	Hewed	Green	None	Untreated	---	91	Northern Pac.	Plains, Mont.	1907	Sellers	---	Cut	Gravel	8,270,506	1915	7.1	F.P.L.	Decay and other causes
Larch, western	7"x9"x8'	Hewed	Green	None	Untreated	---	91	Northern Pac.	Plains, Mont.	1907	Sellers	---	Screw and cut	Gravel	8,270,506	1915	7.1	F.P.L.	Decay and other cause
Larch, western	7"x9"x8'	Hewed	Green	None	Untreated	---	90	Northern Pac.	Plains, Mont.	1907	Sellers	---	Cut	Gravel	8,270,506	1915	6.9	F.P.L.	Decay and other cause
Larch, western	7"x9"x8'	Hewed	Seasoned	None	Untreated	---	90	Northern Pac.	Plains, Mont.	1907	Sellers	---	Cut	Gravel	8,270,506	1915	7.0	F.P.L.	Decay and other causes
Larch, western	7"x9"x8'	Hewed	Seasoned	None	Untreated	---	91	Northern Pac.	Plains, Mont.	1907	N.P. #21	---	Cut	Gravel	8,270,506	1915	7.0	F.P.L.	Decay and other causes
Larch, western	---	Hewed	Seasoned	None	Untreated	---	90	Northern Pac.	Plains, Mont.	1907	Sellers	---	Cut	Gravel	8,270,506	1915	7.1	F.P.L.	Decay and other causes
Larch, western	7"x9"x8'	Hewed	Seasoned	None	Untreated	---	90	Northern Pac.	Plains, Mont.	1907	Sellers	---	Screw and cut	Gravel	8,270,506	1916	7.1	F.P.L.	Decay and other causes
Larch, western	7"x9"x8'	Hewed	Seasoned	None	Untreated	---	90	Northern Pac.	Plains, Mont.	1907	Sellers	---	Screw	Gravel	8,270,506	1916	7.5	F.P.L.	Decay and other causes
Larch, western	7"x9"x8'	Hewed	Seasoned	None	Untreated	---	90	Northern Pac.	Plains, Mont.	1907	Wolhaupter	---	Cut	Gravel	8,270,506	1915	7.8	F.P.L.	Decay and other causes
Larch, western	7"x8"x8'	Mostly sawed	Seasoned	None	Untreated	---	50	Northern Pac.	Thompson Falls, Mont.	1915	N. P. Std.	---	Cut	Gr. & sand	8,270,506	1923	7.3	F.P.L.	Decay and other causes
Maple, hard	---	---	---	None	Untreated	---	52	C.B. & Q	Lines East	1909	Partly plated	---	Cut	Cin.,Gr.&B.C.	---	1916	3.8	F.P.L.	Decay
Maple, hard	6"x7"x8'	Hewed	Green	None	Untreated	---	100	C. & N. W.	Calamus, Ia.	1914	None	---	Cut	Stone	---	1919	5.0	R.R.	Decay
Maple, soft	---	---	---	None	Untreated	---	57	C. B. & Q.	Lines East	1909	---	---	---	Cin.,Gr.&B.C.	---	1923	3.1	F.P.L.	Decay
Oak, black	6"x8"x8'	---	---	Barschall salts	Hasselman	---	118	G.C. & S.F.	Beaumont Division	1902	None	---	Cut	Sand	Heavy	1908	3.3	F.P.L.	---
Oak, black	6"x8"x8'	---	---	Zinc tannin	Wellhouse	.53	86	G.C. & S.F.	Beaumont Division	1902	None	---	Cut	Sand	Heavy	1915	9.0	F.P.L.	---
Oak, red	---	---	---	None	Untreated	---	60	C. B. & Q.	Lines West	1909	Plated	---	Cut	Cin.,Gr.&B.C.	---	1915	5.0	F.P.L.	Mostly decay
Oak, red	---	---	---	None	Untreated	---	103	C. B. & Q.	Lines East	1909	Partly plated	---	Cut	Cin.,Gr.&B.C.	---	1923	4.8	F.P.L.	Mostly decay
Oak, red	6"x8"x8'	---	---	None	Untreated	---	93	G.C. & S.F.	Beaumont Division	1902	None	---	Cut	Sand	Heavy	1910	2.8	F.P.L.	---
Oak, red	7"x9"x8'	Hewed	---	Dimond Wood Pres.	---	.15(gallons)	500	G.H. & S.A.	Ft.Hancock & Iser, Tex.	1907	Glendon	---	Cut	Slag	---	1922	14.1	F.P.L.	---

[1] Note: B.C. = Burnt clay; Cin. = Cinders; Gr. = Gravel; F.P.L.=Average life computed by Forest Products Laboratory; P.R.=Records and average life reported by railroads; Pub.=Data obtained from published reports.

vative

oil
oil-ZnCl
ne

creosote
oride
oride
osote
nin

Wood Pres.
oride
oride
oride

l salts

osote
nin

osote
oride

nin
nin

l salts

oride
oride
nin

e life cc

Record of Completed Service Tests of Ties (Continued)

Species	Dimensions	Form	Preparation	Preservative	Process	Absorption	No. of ties	Railroad	Location	Date set	Track condition					Date 100% removed	Average life		Cause of removal
											Tie plates		Kind of spikes	Ballast[1]	Traffic tons per year		Years	Reference[1]	
						Lbs. per cu. ft.					Kind	Size inches							
Oak, red	---	---	---	Wood tar creosote	Dipped	---	2910	Pennsylvania	Camden, N. J.	1896	---	---	---	---	---	1914	6.4	R.R.	Decay
Oak, red	---	---	---	Wood tar creosote	Dipped	---	591	Pennsylvania	Camden, N. J.	1896	---	---	---	---	---	1914	5.5	R.R.	Decay
Oak, red	---	---	---	Wood tar creosote	Dipped	---	297	Pennsylvania	Camden, N. J.	1896	---	---	---	---	---	1914	5.3	R.R.	Decay
Oak, red	---	---	---	Wood tar creosote	Dipped	---	250	Pennsylvania	New York & Philadelphia	1895	---	---	---	---	---	1914	5.7	R.R.	Decay
Oak, red	---	---	---	Wood tar creosote	Dipped	---	250	Pennsylvania	New York & Philadelphia	1695	---	---	---	---	---	1914	4.5	R.R.	Decay
Oak, red	---	---	---	Wood tar creosote	---	---	180	Pennsylvania	Camden, N. J.	1895	---	---	---	---	---	1914	4.0	R.R.	Decay
Oak, red	---	---	---	Wood tar creosote	---	---	55	Pennsylvania	Baltimore, Md.	1896	---	---	---	---	---	1914	5.3	R.R.	Decay
Oak, red	6"x8"x8'	Sawed	Steamed	Zinc chloride	Burnett	---	86	G.C. & S.F.	Beaumont Division	1902	None	---	Cut	Sand	Heavy	1915	9.1	F.P.L.	---
Oak, red	---	---	---	Zinc chloride	Burnett	---	135	Pennsylvania	Western Division	1697	---	---	---	---	---	1916	10.7	Pub.	---
Oak, red	7"x8"x8'	Hewed	Seasoned	Zinc creosote	Low pressure	---	250	G.H. & S.A.	LaFayette & Scott, La.	1906	Q. & W.	---	Cut	Gravel	---	1917	10.2	F.P.L.	---
Oak, white	---	---	---	None	Untreated	---	50	C. & N. W.	Janesville, Wis.	1907	None	---	Cut	Gravel	---	1920	10.1	F.P.L.	Decay
Oak, white	6"x8"x8'	Hewed	---	None	Untreated	---	280	C. M. & St.P.	Braymer, Mo.	1911	None	---	Cut	Burnt clay	Heavy	1923	9.8	F.P.L.	Decay
Oak, white	6"x8"x8'	---	---	None	Untreated	---	197	G.C. & S.F.	Beaumont Division	1902	None	---	Cut	Sand	Heavy	1913	7.1	F.P.L.	---
Oak, white	---	Hewed	Seasoned	None	Untreated	---	300	Norfolk Southn.	Norfolk Div.-Test mile	1697	---	---	---	---	---	1910	8.6	F.P.L.	---
Oak, white	6"x8"x8'	---	---	Barschall salts	Hasselman	---	196	G.C. & S.F.	Beaumont Division	1902	None	---	Cut	Sand	Heavy	1913	5.8	F.P.L.	---
Oak, white	---	---	---	Wood tar creosote	Brush	---	597	Pennsylvania	Baltimore, Md.	1897-96	---	---	---	---	---	1914	9.0	R.R.	Decay
Oak, white	---	---	---	Wood tar creosote	Brush	---	551	Pennsylvania	Camden, N. J.	1894-95	---	---	---	---	---	1914	5.8	R.R.	Decay
Oak, white	---	---	---	Wood tar creosote	Brush	---	541	Pennsylvania	Baltimore, Md.	1897-98	---	---	---	---	---	1914	9.5	R.R.	Decay
Oak, white	---	---	---	Wood tar creosote	Brush	---	386	Pennsylvania	Baltimore, Md.	1897	---	---	---	---	---	1914	8.0	R.R.	Decay
Oak, white	---	---	---	Wood tar creosote	Brush	---	232	Pennsylvania	Baltimore, Md.	1898	---	---	---	---	---	1914	10.0	R.R.	Decay
Oak, white	---	---	---	Wood tar creosote	Brush	---	204	Pennsylvania	Baltimore, Md.	1897	---	---	---	---	---	1914	9.0	R.R.	Decay and other causes
Oak, white	---	---	---	Wood tar creosote	Brush	---	72	Pennsylvania	Baltimore, Md.	1898	---	---	---	---	---	1914	9.0	R.R.	Decay
Oak, white	---	---	---	Wood tar creosote	Dipped(hot)	---	620	Pennsylvania	Camden, N. J.	1896-97	---	---	---	---	---	1914	5.5	R.R.	Decay
Oak, white	---	---	---	Wood tar creosote	Dipped	---	175	Pennsylvania	New York & Philadelphia	1897-98	---	---	---	---	---	1914	4.0	R.R.	Other than decay
Oak, white	---	---	---	Wood tar creosote	Dipped(hot)	---	348	Pennsylvania	New York & Philadelphia	1896-97	---	---	---	---	---	1914	4.0	R.R.	Decay
Oak, white	---	---	---	Wood tar creosote	Dipped(hot)	---	86	Pennsylvania	Camden, N. J.	1897	---	---	---	---	---	1914	5.5	R.R.	Other than decay
Oak, white	---	---	---	Wood tar creosote	Dipped(cold)	---	70	Pennsylvania	New York & Philadelphia	1895	---	---	---	---	---	1914	5.5	R.R.	Decay
Oak, white	---	---	---	Wood tar creosote	---	---	104	Pennsylvania	New York & Philadelphia	1892	---	---	---	---	---	1914	7.0	R.R.	Decay
Oak, white	6"x8"x8'	---	Steamed	Zinc chloride	Burnett	.35	100	G.C. & S.F.	Beaumont Division	1902	None	---	Cut	Sand	Heavy	1909	6.7	F.P.L.	---
Oak, white	6"x8"x8'	---	Steamed	Zinc creosote	Allardyce	.24 zinc - 3.0 creo.	100	G.C. & S.F.	Beaumont Division	1902	None	---	Cut	Sand	Heavy	1914	9.1	F.P.L.	---
Oak, white	6"x8"x8'	---	Steamed	Zinc tannin	Wellhouse	.35	101	G.C. & S.F.	Beaumont Division	1902	None	---	Cut	Sand	Heavy	1913	10.7	F.P.L.	---
Oak, white	6"x8"x8'	---	Steamed	Zinc tannin	Wellhouse	.33	100	G.C. & S.F.	Beaumont Division	1902	None	---	Cut	Sand	Heavy	1914	8.8	F.P.L.	---
Pine	---	---	---	Barschall salts	Hasselman	14.60	72	G.C. & S.F.	Beaumont Division	1902	None	---	Cut	Sand	Heavy	1913	3.7	F.P.L.	---
Pine	---	Hewed	---	Ebano crude oil	Full cell	14.65	321	G.C. & S.F.	Beaumont Division	1910	---	---	---	---	---	1915	3.1	F.P.L.	---
Pine	---	Sawed	---	Zinc chloride	Burnett	---	101	G.C. & S.F.	Beaumont Division	1905	---	---	---	---	---	1918	7.1	F.P.L.	---
Pine	---	Sawed	---	Zinc chloride	Burnett	---	77	G.C. & S.F.	Beaumont Division	1905	---	---	---	---	---	1917	7.3	F.P.L.	---
Pine, Bull	---	---	---	None	Untreated	---	242	G.C. & S.F.	Beaumont Division	1902	---	---	---	---	---	1908	2.5	F.P.L.	---
Pine, Bull	---	---	---	Zinc chloride	Burnett	---	249	G.C. & S.F.	Beaumont Division	1902	---	---	---	---	---	1912	9.0	F.P.L.	---
Pine, loblolly	---	---	---	None	Untreated	---	110	C. B. & Q.	Lines East	1909	Partly	---	Cut	Cin., Gr., &B.C	---	1919	4.9	F.P.L.	Mostly decay
Pine, loblolly	6"x7"x8'	Hewed	Green	None	Untreated	---	100	C. & N. W.	Calamus, Ia.	1914	Sellers	---	Cut	Gravel	---	1920	6.0	R.R.	Decay
Pine, loblolly	---	---	---	None	Untreated	---	100	G.C. & S.F.	Beaumont Division	1902	None	---	Cut	Sand	Heavy	1904	2.0	R.R.	---
Pine, loblolly	---	Hewed	---	Avenarius carbol.	---	.97	84	G.C. & S.F.	Beaumont Division	1906	---	---	---	---	---	1912	2.3	F.P.L.	---
Pine, loblolly	---	Sawed	---	Barschall salts	Hasselman	---	100	G.C. & S.F.	Beaumont Division	1902	None	---	Cut	Sand	Heavy	1908	4.2	F.P.L.	---
Pine, loblolly	---	---	---	Barschall salts	Hasselman	---	99	G.C. & S.F.	Beaumont Division	1902	None	---	Cut	Sand	Heavy	1906	3.8	F.P.L.	---
Pine, loblolly	---	---	---	ZnCl&Beaumont oil	---	.35ZnCl-3.2 Beau.oil	81	G.C. & S.F.	Beaumont Division	1902	None	---	Cut	Sand	Heavy	1910	8.0	R.R.	---
Pine, loblolly	---	Hewed	Seasoned	Creosote	Pressure	---	1000	Georgia	Barnett, Ga.	1906	None	---	Cut	Cinders	---	1924	15.5	F.P.L.	Decay and other causes
Pine, loblolly	---	---	Seasoned	Spirittine	---	3.3	100	G.C. & S.F.	Beaumont Division	1902	None	---	Cut	Sand	Heavy	1909	2.5	F.P.L.	---
Pine, loblolly	---	Hewed	---	Zinc chloride	Burnett	.36	927	G.C. & S.F.	Beaumont Division	1905	---	---	---	---	---	1917	5.2	F.P.L.	---
Pine, loblolly	---	Hewed	---	Zinc chloride	Burnett	.60	574	G.C. & S.F.	Beaumont Division	1905	---	---	---	---	---	1917	5.8	F.P.L.	---
Pine, loblolly	---	Sawed	---	Zinc chloride	Burnett	.39	339	G.C. & S.F.	Beaumont Division	1905	---	---	---	---	---	1914	6.7	F.P.L.	---
Pine, loblolly	---	---	---	Zinc chloride	Burnett	.35	100	G.C. & S.F.	Beaumont Division	1902	None	---	Cut	Sand	Heavy	1910	7.6	F.P.L.	---
Pine, loblolly	---	Hewed	---	Zinc creosote	Allardyce	2.4 creo.- .25 zinc	1000	G.C. & S.F.	Beaumont Division	1904	---	---	---	---	---	1919	8.4	F.P.L.	---
Pine, loblolly	---	---	Steamed	Zinc creosote	Allardyce	3.0 creo.- .24 zinc	50	G.C. & S.F.	Beaumont Division	1902	None	---	Cut	Sand	Heavy	1909	6.9	F.P.L.	---
Pine, loblolly	---	---	---	Zinc tannin	Wellhouse	.33	100	G.C. & S.F.	Beaumont Division	1902	None	---	Cut	Sand	Heavy	1914	7.2	F.P.L.	---
Pine, longleaf	7"x9"x8½'	Hewed	Seasoned	None	Untreated	---	50	Atlantic C.L.	Waycross, Ga.	1915	Flange	---	Cut	Gravel	---	1920	4.0	F.P.L.	---

[1] Note: B.C. = Burnt Clay; Cin. = Cinders; Gr. = Gravel; F.P.L.=Average life computed by Forest Products Laboratory; R.R.=Records and average life reported by railroads; Pub.=Data obtained from published reports.

Record of Completed Service Tests of Ties (Continued).

Species	Dimensions	Form	Preparation	Preservative	Process	Absorption	No. of ties	Railroad	Location	Date set	Track condition					Date 100% re-moved	Average life		Cause of removal
						Lbs. per cu.ft.					Tie plates Kind	Tie plates Size inches	Kind of spikes	Ballast[1]	Traffic tons per year		Years	Reference[1]	
Pine longleaf	6"x8"x8'	---	---	None	Untreated	---	2100	C.M. & St.P.	Rio, Wis.	1899	---	---	Cut	---	---	1917	12.1	F.P.L.	Decay and other causes
Pine longleaf	6"x8"x10'	Sawed	Seasoned	None	Untreated	---	216	C.M. & St.P.	Hubbleton, Wis.	1908	None	---	---	Cinders	---	1922	12.5	F.P.L.	Decay and other causes
Pine longleaf	---	---	---	None	Untreated	---	154	C.M. & St.P.	---	1899	None	---	---	Cinders	---	---	12.0	Pub.	---
Pine longleaf	6"x7"x8'	---	---	None	Untreated	---	93	G.C. & S.F.	Beaumont Division	1902	None	---	Cut	Sand	Heavy	1909	2.5	F.P.L.	---
Pine longleaf (heart)	7"x8"x8'	Sawed	---	None	Untreated	---	434	G.H. & S.A.	Bay View & San Leon, Tex.	1905	---	---	---	---	---	1917	4.9	F.P.L.	---
Pine longleaf (heart)	7"x8"x8'	Sawed	---	None	Untreated	---	382	G.H. & S.A.	Bay View & San Leon, Tex.	1905	---	---	---	---	---	1913	4.3	F.P.L.	---
Pine longleaf (heart)	7"x9"x8'	Sawed	---	None	Untreated	---	184	G.H. & S.A.	Bay View & San Leon, Tex.	1905	---	---	---	---	---	1915	4.2	F.P.L.	---
Pine longleaf	---	Hewed	---	Beaumont oil	Open tank	5.7	100	G.C. & S.F.	Beaumont Division	1902	None	---	Cut	Sand	Heavy	1909	4.9	F.P.L.	---
Pine longleaf	---	---	---	Beaumont oil-ZnCl	Two movement	3.5 oil - .35 zinc	100	G.C. & S.F.	Beaumont Division	1902	None	---	Cut	Sand	Heavy	1914	10.5	F.P.L.	---
Pine longleaf	---	--	---	Spirittine	---	3.3	100	G.C. & S.F.	Beaumont Division	1902	None	---	Cut	Sand	Heavy	1912	6.6	F.P.L.	---
Pine longleaf	---	---	---	Wood tar creosote	Brush	---	96	Pennsylvania	Baltimore, Md.	1897	---	---	---	---	---	1914	7.0	R.R.	Other than decay
Pine, longleaf	---	---	---	Zinc chloride	Burnett	---	68	N.Y.N.H. & H.	Rowayton, Conn.	1901	Yes	5x8	Cut	Stone	---	1916	14.4	F.P.L.	Decay
Pine longleaf	6"x12"x8-½'	Sawed	---	Zinc chloride	Burnett	---	57	N.Y.N.H. & H.	Rowayton, Conn.	1901	Yes	5x8	Cut	Stone	---	1914	13.0	R.R.	Decay
Pine longleaf	---	---	---	Zinc creosote	Allardyce	22.0 creo. - .3 zinc	50	G.C. & S.F.	Beaumont Division	1902	None	---	Cut	Sand	Heavy	1913	9.7	F.P.L.	---
Pine longleaf	6"x8"x8'	Sawed	Steamed	Zinc tannin	Wellhouse	.33	100	G.C. & S.F.	Beaumont Division	1902	None	---	Cut	Sand	Heavy	1921	8.7	F.P.L.	---
Pine, sap	7"x9"x8'	Hewed	---	Diamond Wood Pres.	---	.11 (gallons)	500	G.H. & S.A.	Ft. Hancock, Tex.	1907	Glendon	---	Cut	Slag	---	1922	10.3	F.P.L.	---
Pine sap	7"x9"x8'	Hewed	---	Zinc chloride	Burnett	.40	334	G.H. & S.A.	Bay View & San Leon, Tex.	1905	None	---	---	---	---	1915	5.9	F.P.L.	---
Pine sap	7"x9"x8'	Hewed	---	Zinc chloride	Burnett	.40	334	G.H. & S.A.	Bay View & San Leon, Tex.	1905	---	---	Screw	---	---	1913	5.6	F.P.L.	Decay and other causes
Pine, sap	7"x9"x8'	Hewed	---	Zinc chloride	Burnett	.40	333	G.H. & S.A.	Bay View & San Leon, Tex.	1905	Glendon	---	---	---	---	1917	5.9	F.P.L.	---
Pine shortleaf	---	---	---	None	Untreated	---	100	G.C. & S.F.	Beaumont Division	1902	None	---	Cut	Sand	Heavy	1907	3.1	F.P.L.	---
Pine shortleaf	---	Sawed	---	Barschall salts	Hasselman	---	98	G.C. & S.F.	Beaumont Division	1902	None	---	Cut	Sand	Heavy	1912	4.5	F.P.L.	---
Pine shortleaf	6"x7"x8'	Sawed	---	Creosote	Full cell	---	3202	N.Y.N.H. & H.	Greenwich, Conn.	1907	Shoulder	---	Screw	Stone	12,000,000	1922	12.2	F.P.L.	Other than decay
Pine, shortleaf	---	Sawed	---	Zinc creosote	---	22.0 creo.-.30 zinc	50	G.C. & S.F.	Beaumont Division	1902	None	---	Cut	Sand	Heavy	1913	6.8	F.P.L.	---
Pine, shortleaf	---	---	---	Zinc tannin	Wellhouse	.33	100	G.C. & S.F.	Beaumont Division	1902	None	---	Cut	Sand	Heavy	1914	7.2	F.P.L.	---
Pine, southern yellow	---	---	---	Creosote	Creo-resinate	---	125	Pennsylvania	Jamesburg, N. J.	1901	---	---	---	---	---	1914	10.0	R.R.	Decay and other causes
Pine, southern yellow	---	---	---	Creosote	Creo-resinate	---	125	Pennsylvania	Seaside, N. J.	1901	---	---	---	---	---	1914	10.0	R.R.	Decay and other causes
Pine, southern yellow	7"x9"x8'	Hewed	---	Creosote	Full cell	12.0	285	G.H. & S.A.	LaFayette & Scott, La.	1906	Q. and W.	---	Cut	Gravel	---	1923	12.3	F.P.L.	---
Pine, southern yellow	7"x8"x9'	Hewed	---	Creosote	Full cell	---	285	Louisana Westn.	LaFayette & Scott, La.	1906	Q. and W.	---	Cut	Gravel	---	1923	11.4	F.P.L.	Other than decay
Pine, southern yellow	---	Hewed	Seasoned	None	Untreated	---	100	Southern Pac.	LaFayette & Scott, La.	1907	Servis & Wolhaupter	---	---	Gravel	---	1910	2.7	R.R.	---
Pine, southern yellow	---	Hewed	Seasoned	None	Vulcanized	---	100	Norfolk Southn.	Norfolk Division M.P.6-7	1897	---	---	---	---	---	1900	2.1	F.P.L.	---
Pine, southern yellow	---	Sawed	Seasoned	None	Vulcanized	---	100	Norfolk Southn.	Norfolk Division M.P.6-7	1897	---	---	---	---	---	1908	4.3	F.P.L.	---
Pine, western yellow	---	Sawed(Triang.)	---	None	Untreated	---	1970	Gr.Northern	Butte Division	1911	Goldie	6½x8½	Cut	Gravel	---	1923	8.0	F.P.L.	Decay and other causes
Pine, western yellow	---	Hewed	---	None	Untreated	---	1051	Gr. Northern	Butte Division	1911	Goldie	---	Cut	Gravel	---	1921	6.8	F.P.L.	Decay
Pine, southern yellow	---	Hewed	---	Zinc creosote	Allardyce	---	200	G.H. & S.A.	Ft.Hancock, Tex.	1894	---	---	Cut	Gravel	---	1921	20.5	F.P.L.	Decay
Pine, western yellow	7"x9"x8'	Sawed	Unseasoned	Zinc fluoride	---	.29	195	Southern Pac.	West Oakland, Calif.	1906	Flat	---	Cut	Crushed rock	Heavy	1915	8.6	F.P.L.	Decay
Pine, southern yellow	---	Hewed	Seasoned	Zinc tannin	Wellhouse	---	100	Norfolk Southn.	Norfolk Division M.P.6-7	1897	---	---	---	---	---	1918	16.6	F.P.L.	---
Pine, southern yellow	---	Sawed	Seasoned	Zinc tannin	Wellhouse	---	100	Norfolk Southn.	Norfolk Division M.P.6-7	1897	---	---	---	---	---	1918	15.8	F.P.L.	---
Poplar	---	---	---	None	Untreated	---	55	C. B. & Q.	Lines East	1909	Partly plated	---	Cut	Cin.,Gr.&B.C.	---	1921	4.8	F.P.L.	Mostly decay
Sycamore	---	---	---	None	Untreated	---	56	C. B. & Q.	Lines East	1909	Partly plated	---	Cut	Cin.,Gr.&B.C.	---	1916	2.7	F.P.L.	Mostly decay
Tamarack	6"x8"x8'	---	---	Barschall salts	Hasselman	---	98	G.C. & S.F.	Beaumont Division	1902	None	---	Cut	Sand	Heavy	1910	3.8	F.P.L.	---
Tamarack	---	---	---	None	Untreated	---	87	C. P. & Q.	Lines East	1909	Partly plated	---	---	Cin.,Gr.&B.C.	---	1918	4.7	F.P.L.	Decay
Tamarack	---	Hewed	Seasoned	None	Untreated	---	125	C. & N. W.	Janesville, Wis.	1907	None	---	Cut	Gravel	Light	1917	6.2	F.P.L.	Decay
Tamarack	6"x7"x8'	Hewed	Green	None	Untreated	---	100	C. & N. W.	Chadron, Nebraska	1914	Sellers	---	Cut	Gravel	---	1920	6.0	R.R.	Decay
Tamarack	6"x7"x8'	Hewed	Green	None	Untreated	---	100	C. & N. W.	Verdi, Minnesota	1914	None	---	Cut	Gravel	---	1920	6.0	R.R.	Decay
Tamarack	---	---	---	None	Untreated	---	94	Northern Pac.	Yellowstone Division	1911	Yes	6x8½	---	Gravel	---	1924	9.3	F.P.L.	Decay
Tamarack	---	Sawed & hewed	---	None	Untreated	---	2894	Gr. Northern	Newport, Washington	1908	---	---	Cut	Gravel	Heavy	1918	6.7	F.P.L.	Decay and other causes
Tamarack	---	Sawed(Triang.)	---	None	Untreated	---	1425	Gr. Northern	Butte Division	1911	Goldie	6½x8½	Cut	Gravel	---	1923	7.0	F.P.L.	Decay and other causes
Tamarack	---	Hewed	---	None	Untreated	---	1231	Gr. Northern	Butte Division	1911	Goldie G-58, J.G.58	---	Cut	Gravel	---	1923	7.6	F.P.L.	Decay
Tamarack	---	---	---	None	Untreated	---	148	Northern Pac.	Lake Superior Division	1910-15	N.P.	7x9	---	Sand & cin.	---	1915	8.0	F.P.L.	Decay
Tamarack	---	Sawed(Triang.)	---	Zinc chloride	Burnett	.50	2708	Gr. Northern	White Fish, Montana	1904	Goldie #58	---	---	Gravel	---	1920	10.0	F.P.L.	Decay and other causes
Tamarack	---	---	---	Zinc chloride	Burnett	.50	200	Pennsylvania	Western Division	1892	---	---	---	---	---	1902	8.8	Pub.	---
Tamarack	---	---	Steamed	Zinc tannin	Wellhouse	.58	100	G.C. & S.F.	Beaumont Division	1902	None	---	Cut	Sand	Heavy	1912	10.0	R.R.	---

[1] Note: B.C. = Burnt clay; Cin. = Cinders; Gr. = Gravel; F.P.L.=Average life computed by Forest Products Laboratory; R.R.=Records and average life reported by railroads; Pub.=Data obtained from published reports.

U. S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE
FOREST PRODUCTS LABORATORY
MADISON, WISCONSIN
October 8, 1925.

CROSS TIE RENEWALS PER MILE OF ALL TRACK MAINTAINED 1900-

Committee 11, A W P A
XVII AREA

Year	A T & S F Miles	A T & S F Ties	A T & S F 5 Yr Avg Ties	B & O Miles	B & O Ties	B & O 5 Yr Avg Ties	C B & Q Miles	C B & Q Ties	C B & Q 5 Yr Avg Ties	C & E I Miles	C & E I Ties	C & E I 5 Yr Avg Ties	C C C & St L Miles	C C C & St L Ties	C C C & St L 5 Yr Avg Ties
1900	[illegible]	[illegible]								[illegible]	[illegible]				
01	[illegible]	[illegible]		[illegible]	[illegible]					1 107	[illegible]				
02	[illegible]	224	229	[illegible]	[illegible]					1 126	224				
03	[illegible]	[illegible]	216	[illegible]	32					1 128	135				
04	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]					1 125	133	[illegible]			
05	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				1 134	[illegible]	[illegible]	[illegible]	[illegible]	
06	[illegible]	97	234	[illegible]	[illegible]	[illegible]				1 479	149	163	3 277	242	
07	[illegible]	[illegible]	[illegible]	[illegible]	254	233				1 493	217	161	3 738	[illegible]	
08	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				1 507	199	161	[illegible]	375	
09	[illegible]	233	267	[illegible]	[illegible]	[illegible]				1 514	121	159	3 801	138	327
1910	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				1 522	200	177	3 834	384	310
11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				1 520	35	174	3 925	342	309
12	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				1 972	29	169	3 960	318	313
13	[illegible]	93	[illegible]	[illegible]	[illegible]	[illegible]				2 002	249	187	3 973	282	314
14	[illegible]	[illegible]	[illegible]	[illegible]	201	[illegible]	[illegible]	[illegible]		2 046	202	203	4 010	269	326
15	[illegible]	[illegible]	[illegible]	[illegible]	379	254	12 654	227		2 055	255	214	4 001	277	307
16	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	12 955	203		1 892	244	236	4 021	222	272
17	[illegible]	55	167	[illegible]	238	267	13 225	192		1 871	187	235	4 090	202	249
18	[illegible]	34	80	[illegible]	34	254	[illegible]	124	209	1 850	56	211	4 110	205	233
19	[illegible]	[illegible]	73	[illegible]	243	[illegible]	13 365	162	196	1 867	141	199	4 173	201	219
1920	[illegible]	[illegible]	164	[illegible]	255	248	13 355	178	186	1 865	102	168	4 177	156	195
21	[illegible]	49	123	[illegible]	229	[illegible]	13 365	177	181	1 863	63	132	4 210	194	192
22	[illegible]	58	153	[illegible]	[illegible]	[illegible]	13 420	[illegible]	176	1 654	131	121	4 228	143	180
23	[illegible]	[illegible]	146	[illegible]	227	236	13 530	183	171	1 662	158	119	3 972	191	177
24	[illegible]	5	143	[illegible]	132	218	13 530	153	158	1 651	92	109	3 948	139	165
25															
26															
27															
28															
29															
1930															
% treated of 1922	88				75			92			99			87	
ties used 1923					75						99			80	
1924					87						99			91	
1925															
% treated of 1924	70				60						98			83	
ties in track 1925															

Year	C M & St P Miles	C M & St P Ties	C M & St P 5 Yr Avg Ties	C R I & P Miles	C R I & P Ties	C R I & P 5 Yr Avg Ties	D L & W Miles	D L & W Ties	D L & W 5 Yr Avg Ties	Gt Northern Miles	Gt Northern Ties	Gt Northern 5 Yr Avg Ties	Ill Central Miles	Ill Central Ties	Ill Central 5 Yr Avg Ties
1900							[illegible]	[illegible]		6 242	225				
01	[illegible]	[illegible]					[illegible]	[illegible]		[illegible]	229				
02	[illegible]	23					2 212	[illegible]		6 917	84				
03	8 529	148					2 211	223		7 038	189				
04	9 125	12					[illegible]	[illegible]	[illegible]	7 159	[illegible]	202			
05	9 263	97	[illegible]				[illegible]	[illegible]	[illegible]	7 416	[illegible]	190			
06	9 447	116	[illegible]				2 377	203	224	7 643	125	169			
07	9 709	34	[illegible]				2 422	240	232	8 021	241	180			
08	9 946	176	[illegible]	[illegible]	[illegible]		2 439	277	243	8 376	248	192			
09	10 001	202	[illegible]	9 311	276		2 475	235	244	8 637	349	205			
1910	10 043	203	158	9 311	246		[illegible]	[illegible]	[illegible]	8 819	293	231			
11	10 135	159	167	9 311	265		[illegible]	[illegible]	[illegible]	8 990	262	259	8 978	231	
12	10 135	163	181	9 605	209	256	2 619	231	227	9 150	228	256	9 438	267	
13	10 590	205	187	9 911	221	243	2 644	281	228	9 595	237	254	9 570	286	
14	10 837	190	185	10 118	243	237	2 627	255	232	9 689	232	250	9 571	266	
15	11 021	183	181	10 044	249	237	2 663	279	253	10 104	229	238	9 652	253	272
16	11 072	251	199	10 044	222	229	2 656	195	248	10 074	250	233	9 761	228	260
17	11 100	135	193	10 065	183	224	2 663	157	233	10 513	344	238	9 922	179	242
18	11 107	228	197	10 274	155	210	2 671	121	201	10 676	250	241	10 003	161	211
19	11 112	242	208	10 274	155	193	2 675	147	180	10 620	253	245	10 068	198	[illegible]
1920	11 087	146	200	10 290	190	182	2 677	159	156	10 632	213	242	10 083	[illegible]	[illegible]
21	11,100	161	182	10 319	169	171	2 675	166	150	10 667	184	229	10 125	260	210
22	11 060	189	195	10 323	151	165	2 678	137	146	10 689	191	218	10 155	249	224
23	11 762	225	192	10 424	140	162	2 679	102	142	10 697	220	212	10 357	199	231
24	11,898	204	195	10 371	118	134	2 676	85	130	10 723	201	202	10,529	170	226
25															
26															
27															
28															
29															
1930															
% treated of 1922					92			81			32			78	
ties used 1923		90			90			67			35			62	
1924					98			91			50				
1925															
% treated of 1924		60			80			82			40				
ties in track 1925															

Year	K C Sou Miles	K C Sou Ties	K C Sou 5 Yr Avg Ties	Lehigh Valley Miles	Lehigh Valley Ties	Lehigh Valley 5 Yr Avg Ties	Mich Cent Miles	Mich Cent Ties	Mich Cent 5 Yr Avg Ties	M K & T Miles	M K & T Ties	M K & T 5 Yr Avg Ties	Minn & St L Ry Miles	Minn & St L Ry Ties	Minn & St L Ry 5 Yr Avg Ties	N Y C (East) Miles	N Y C (East) Ties	N Y C (East) 5 Yr Avg Ties
1900				2 807	394		3 453	[illegible]										
01				2 854	301		[illegible]	[illegible]		310	[illegible]					6 172	[illegible]	
02				2 973	108		3 093	282		2 491	121					6 296	[illegible]	
03				2 893	307		3 136	237		2 580	437					6 292	[illegible]	
04				2 911	211	[illegible]	3 182	141	[illegible]	2 741	460					6 436	[illegible]	
05				2 990	196	255	3 354	144	[illegible]	2 980	387	412				[illegible]	[illegible]	[illegible]
06				3 060	155	195	[illegible]	174	192	[illegible]	344	[illegible]				6 716	176	[illegible]
07				3 070	184	211	3 527	110	[illegible]	3 085	358	397				6 915	263	213
08				3 153	172	184	3 559	110	136	3 232	[illegible]	369				7 211	225	216
09				3 171	195	180	3 602	272	[illegible]	[illegible]	[illegible]	349	808	310		7 258	220	212
1910	1,196	462		3 191	177	177	3 609	176	168	3 401	149	362	818	257		[illegible]	249	227
11	1,246	432		3 199	141	174	3 615	284	191	3 647	466	386	[illegible]	396		7 545	[illegible]	237
12	1,251	294		3 245	164	170	[illegible]	[illegible]	[illegible]	3 722	401	395	843	385		7 562	219	[illegible]
13	1,261	351		3 277	267	189	3 659	307	249	3 907	342	405	851	300	342	7 766	254	235
14	1,273	355	379	3 313	232	196	3 738	284	[illegible]	3 958	124	396	856	305	353	7 800	271	241
15	1,289	354	357	3 320	69	193	3 765	331	[illegible]	4 021	329	372	858	231	347	8 000	243	244
16	1,289	338	338	3 384	286	218	[illegible]	[illegible]	238	[illegible]	382	355	857	299	326	8 054	207	240
17	1,290	240	328	3 408	178	252	3 822	[illegible]	302	4 002	235	322	897	145	278	8 099	197	235
18	1,290	237	305	3 396	173	232	3 928	197	280	4 140	209	295	903	168	240	8 248	199	[illegible]
19	1,290	273	288	3 393	195	224	3 974	144	252	4 196	220	276	903	80	183	8 255	190	[illegible]
1920	1,302	290	276	3 399	116	190	[illegible]	126	210	[illegible]	302	271	906	167	170	8 230	163	[illegible]
21	1,308	310	270	3 401	133	159	3 852	154	170	4 245	233	241	907	146	141	8 377	220	196
22	1 303	249	272	3 413	77	139	3 869	222	169	4 251	183	231	910	146	141	8 471	199	196
23	1 324	227	270	3 414	91	[illegible]	3 846	216	172	4 275	179	225	811	144	137	8 393	201	192
24	1 323	225	260	3 421	109	105	3 846	[illegible]	84	4 367	213	222	[illegible]	53	151	8 231	173	192
25																		
26																		
27																		
28																		
29																		
1930																		
% treated of 1922		51			73			90			93			99			66	
ties used 1923		50			96			56			90			97			83	
1924		70			95						100						81	
1925																		
% treated of 1924		55			70						63						52	
ties in track 1925																		

Year	N Y C (West) Miles	N Y C (West) Ties	N Y C (West) 5 Yr Avg Ties	Nor Pacific Miles	Nor Pacific Ties	Nor Pacific 5 Yr Avg Ties	Penna Miles	Penna Ties	Penna 5 Yr Avg Ties	Soo Line (M St P & S Ste M) Miles	Soo Line Ties	Soo Line 5 Yr Avg Ties	Southern Pac (Atlantic System) Miles	Southern Pac (Atlantic System) Ties	Southern Pac (Atlantic System) 5 Yr Avg Ties	Southern Pac (Pacific System) Miles	Southern Pac (Pacific System) Ties	Southern Pac (Pacific System) 5 Yr Avg Ties
1900				6 275	411		14,799	294					3 501	[illegible]				
01				6 322	[illegible]		[illegible]	29					3 691	[illegible]				
02				6 493	311		15 981	273					[illegible]	243				
03				6 636	314		16,751	244					3 817	[illegible]				
04				6 916	200	314	17 330	217	264				4 153	[illegible]	264			
05	[illegible]	[illegible]		7 036	[illegible]	[illegible]	[illegible]	279	[illegible]				[illegible]	[illegible]				
06	3 588	257		7 253	290	294	18,527	241	[illegible]				[illegible]	[illegible]	[illegible]			
07	3 683	261		7 512	346	301	18,845	267	250				4 347	258	[illegible]			
08	[illegible]	266		7 938	291	289	18,963	138	240				[illegible]	244	[illegible]			
09	4 357	250	256	8 258	296	[illegible]	19,016	262	249				4 401	259	[illegible]			
1910	4 669	250	257	8 430	292	293	19 508	240	[illegible]				4 413	289	278			
11	4 770	260	257	8 761	264	294	20 083	235	240				4 504	267	263			
12	4 944	265	258	8 858	287	282	20 219	290	245				4 519	299	272			
13	5 015	295	264	9 282	317	295	20 441	261	258	4 973	258		4 556	271	277			
14	5 036	242	264	9 422	306	297	20 578	292	265	5 113	287		4 619	295	284			
15	5 010	301	273	9 636	276	294	20 686	314	278	5 279	256		4 694	384	303			
16	5 013	273	275	9 678	247	267	20 829	287	289	5 289	196		4 767	361	322			
17	5 069	270	270	9 789	292	288	22 524	212	273	5 308	[illegible]	[illegible]	4 806	196	303			
18	5 131	249	267	9 783	230	270	23 0[illegible]	174	256	5 331	207	235	4 874	218	292	10 434	259	
19	5 175	189	256	9 783	220	253	23 500	211	240	5 331	266	[illegible]	4 885	267	288	10 306	269	
1920	5 185	193	253	[illegible]	242	246	25 0[illegible]	202	217	5 335	239	[illegible]	4 929	329	287	10 492	272	
21	5 188	196	217	[illegible]	211	243	25 112	232	206	5 502	342	[illegible]	4 992	341	292	10 606	257	
22	5 194	196	203	9 920	167	218	25 132	232	210	5 514	301	[illegible]	4 949	319	317	10 563	243	260
23	[illegible]	147	183	9 798	177	207	25 2[illegible]	211	218	5 520	323	304	4 958	291	[illegible]	[illegible]	206	253
24	[illegible]	129	170	9 765	163	196	25 348	177	211	5 520	336	318	[illegible]	[illegible]	[illegible]	10 869	196	253
25																		
26																		
27																		
28																		
29																		
1930																		
% treated of 1922		79			38			68			22			80			43	
ties used 1923		83			18			74			17			85			52	
1924		91			38						17			66			64	
1925																		
% treated of 1924		85			52			44			9			44			57	
ties in track 1925																		

Year	Union Pacific Miles	Union Pacific Ties	Union Pacific 5 Yr Avg Ties	C R R of N J Miles	C R R of N J Ties	C R R of N J 5 Yr Avg Ties	Miles	Number of Roads	Weighted Average Ties	Weighted Average 5 Yrs
1900	3 088	261		1 316	219		53,076	11	267	
01	3 098	242		1 331	273		73,825	15	255	
02	[illegible]	129		1 340	263		83,024	15	237	
03	[illegible]	[illegible]		1 354	246		85,033	15	231	
04	[illegible]	[illegible]	[illegible]	1 373	275	[illegible]	87,779	15	226	243
05	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	97,543	17	234	237
06	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	100,642	17	226	231
07	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	103,034	17	251	234
08	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	115,1[illegible]	18	239	235
09	[illegible]	[illegible]	294	[illegible]	[illegible]	[illegible]	[illegible]	19	257	241
1910	5 083	257	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	20	238	242
11	5 291	246	268	1,491	204	[illegible]	[illegible]	[illegible]	255	248
12	5 485	171	239	1,531	220	234	137 083	21	247	247
13	5 617	231	232	1,569	240	235	144,967	22	257	251
14	5 676	248	233	1,612	224	226	159,796	23	250	249
15	5 685	238	227	1,633	189	215	161,604	23	263	254
16	5 722	253	228	1,665	156	206	163,095	23	252	254
17	5 815	196	233	[illegible]	127	[illegible]	[illegible]	23	202	245
18	5 994	191	225	[illegible]	127	[illegible]	[illegible]	24	196	233
19	6 024	185	[illegible]	[illegible]	132	[illegible]	179,851	24	204	223
1920	6 035	206	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	24	206	[illegible]
21	[illegible]	184	[illegible]	[illegible]	[illegible]	[illegible]	182,456	24	209	203
22	[illegible]	203	[illegible]	[illegible]	42	139	182,988	24	198	203
23	6 227	145	155	[illegible]	116	137	184,358	24	183	200
24	6 282	215	201	[illegible]	33	137	187,231	24	174	194
25										
26										
27										
28										
29										
1930										
% treated of 1922		100			98					
ties used 1923		100			98					
1924		98			99					
1925										
% treated of 1924		64								
ties in track 1925										

Note: Horizontal lines show beginning of extensive use of treated ties

5 year average column is 5 years ending year shown

In conclusion the Committee wishes to repeat from its 1922 report, that in addition to proper treatment of ties attention should be given to good drainage, suitable ballast, weight of rail according to the traffic, large tie plates, and in general well-maintained track, if the maximum service is to be realized from the cross-ties.

STATEMENT BASED ON TIE RENEWAL CURVE OF FOREST PRODUCTS LABORATORY.

Per Cent Renewed	Per Cent of Life	Per Cent Renewed	Per Cent of Life	Per Cent Renewed	Per Cent of Life
1	45	36	86	71	106
2	50	37	87	72	107
3	55	38	87	73	107
4	60	39	88	74	108
5	63	40	88	75	108
6	65	41	89	76	109
7	66	42	89	77	109
8	68	43	90	78	110
9	69	44	90	79	110
10	70	45	91	80	111
		46	91	81	112
11	70	47	92	82	112
12	71	48	92	83	113
13	72	49	93	84	114
14	73	50	93	85	115
15	74	51	94	86	115
16	75	52	94	87	116
17	75	53	95	88	117
18	76	54	96	89	118
19	77	55	97	90	119
20	77	56	97	91	120
21	78	57	98	92	122
22	78	58	98	93	125
23	79	59	99	94	127
24	80	60	99	95	130
25	80	61	100	96	135
26	81	62	100	97	140
27	81	63	101	98	150
28	82	64	102	99	170
29	82	65	102	100	190
30	83	66	103		
31	83	67	103		
32	84	68	104		
33	84	69	104		
34	85	70	105		
35	86				

Note—Estimates of life should not be based on less than 10 per cent renewals.

Appendix D

(4) MARINE PILING INVESTIGATIONS

Dr. H. Von Schrenk, Chairman, Sub-Committee; Wm. G. Atwood, H. C. Bell, J. R. W. Davis, Andrew Gibson, J. E. Pinson F. C. Shepherd.

The pertinent files of the Committee on Marine Piling Investigations of the National Research Council were turned over to this Sub-Committee during the year and the National Research Council also notified the Government departments that this Sub-Committee had succeeded to the work and bespoke the same degree of cooperation which had been previously given to the council. The Council also sent a similar notification to the "Committee on the Deterioration of Structures in Sea Water" of the Institution of Civil Engineers of Great Britian. The Chairman of this Sub-Committee called on the Secretary of the British Committee in London and arranged for the same cooperation which had existed with the National Research Council.

This Committee having no funds available for research and being under the necessity of working entirely with contributed services, found itself unable to continue the extremely valuable biological work which had been carried on by the Council. It was impossible to do more than to carry on the long-time tests which had already been started and to initiate one series of new tests for which the specimens were prepared and furnished by the Chemical Warfare Service. A final report on the studies of this very efficient Government organization is also in preparation and will be submitted to this Committee for publication when completed.

The tests now underway may be divided into three general classes as follows:

(I) Tests of various timbers, principally tropical, for which the specimens had been collected and placed under the direction of the Committe on Marine Piling Investigation, National Research Council, and similar experiments being made under the direction of the Engineer of Maintenance of the Panama Canal and a joint Army and Navy Board at Manila. Several tests of different methods of protection by the same agencies are also included in this group.

(II) Tests of specimens impregnated by the Chemical Warfare Service with materials which their studies had shown to offer the greatest prospect for success.

(III) Tests of specimens impregnated with various creosotes and fractions of creosote which had been treated by several agencies. In this group are also included the piles removed from the "Long Wharf" of the Southern Pacific and redriven in other locations and a few miscellaneous tests being carried on by various railroads.

These tests have been underway for periods ranging from a few months to several years and it is hoped that this Committee will be able to submit annual reports on their conditions.

PART 1—The report of the Committee of the National Research Council. "Marine Structures—Their Deterioration and Preservation," devotes pages 77 to 86 inclusive to a study of the service record of various timbers for which claims of immunity from marine borer attack had from time to time been made. The conclusions were that the records obtained for cottonwood justified further test and that none of the foreign timbers showed promise of immunity under the most severe conditions, with the possible exception of angelique and manbarklak from Dutch or British Guiana or turpentine wood from Australia and Tasmania. The Forestry Department of the Dutch province of Surinam furnished samples of the two former and the Government of Australia specimens of the latter for test. These specimens were distributed to the harbors having the most active borers in waters of varying temperatures.

Tests of cottonwood were made by the Southern Pacific at Galveston, Texas, and San Francisco, Cal., and the Northern Pacific Railway at Seattle, with the following results:

> GALVESTON—"Since my report of January 10, 1925, which indicated no signs of teredo having attacked piece of cottonwood submerged September 4, 1924, have just had this test removed July 25th, and it was found to be practically eaten up.
>
> "The observation made January 10th and July 25th indicate that the teredo are a little slow in getting started, but after they get into the cottonwood they make about the same progress they do in untreated pine."

The San Francisco report is as follows:

> TESTS AT OAKLAND, 1923-24—"In August, 1923, several 4-ft. lengths of cottonwood were submerged for test purposes at the Southern Pacific Company Biological station at Oakland Pier. While this was about a month too late for the heavy breeding season of teredo, the specimens were found to be immediately attacked by both teredo and limnoria, that of the latter being general. The final inspection of October 10th, 1924, showed extremely heavy attack by limnoria, and additional attack by teredo and bankia, some of the latter having attained a length of 18 inches.
>
> "In October, 1923, 30 cottonwood piles were placed at 7 wharf locations in Oakland and carefully observed at about 3-months intervals. These were placed too late for the 1923 breeding season of teredo. However, they were immediately attacked by limnoria. The final inspection of October 10, 1924, showed extremely heavy attacks by limnoria, the erosion being to a depth of about 1¾ inches. Attack by teredo and bankia was found in a minor degree, probably due to the fact that the limnoria had taken complete possession of the pile surface and created a thick layer of soft torn fibres in which the young teredo and bankia could not establish themselves and begin boring.
>
> "The evidence of these tests shows that such piling would be completely destroyed in from 2 to 3 years and that if obtainable, could in no way be justified for use in marine structures where Douglas Fir is available."

The Northern Pacific tests gave similar results.

The distribution and condition of the specimens of the three tropical timbers under test follow:

New York, New Haven & Hartford Railroad

Specimens of angelique and manbarklak were placed at Slades Ferry, Conn., July 17, 1923, and one specimen of turpentine wood was placed at Slades Ferry and another at Warren, R. I., on July 14, 1924. None of these pieces showed any attack whatever on October 16, 1925.

Atchison, Topeka & Santa Fe Railway

Specimens of angelique and manbarklak placed November 11, 1922, were lost sometime before July of the following year.

A specimen of turpentine wood placed July 9, 1924, showed no attack on December 17, 1924, and a very slight attack in the bark and sapwood on August 5, 1925.

Southern Pacific Company

Angelique and manbarklak placed in Galveston harbor July 11, 1923, showed no attack in October, 1925.

A manbarklak specimen was placed at San Francisco January 5, 1924.

Florida East Coast Railway

An angelique specimen was placed at St. Augustine July 31, 1923, and no attack was shown on October 6, 1925.

Manbarklak placed at Key West, August 5, 1923, showed very slight attack in December, 1924, but in October, 1925, the entire surface of the specimen was heavily attacked by limnoria and there was considerable evidence of an attempted attack by molluscan borers which had not succeeded in penetrating to any appreciable depth.

Turpentine wood placed at Key West, June 10, 1924, showed no attack on October 21, 1925.

San Antonio & Aransas Pass Railway

A specimen of turpentine wood was placed at Harbor Island, Texas, in July, 1924. No report of inspection received.

Seaboard Air Line

A specimen of turpentine wood was placed at Seddon Island, Fla., June 4, 1924. No inspection report received.

Newport News Shipbuilding & Dry Dock Co.

Specimens of angelique and manbarklak were placed at Newport News, Va., July 10, 1923, but have been lost.

Naval Air Station, Pensacola, Fla.

Specimens of turpentine wood were placed June 13, 1924. A slight attack in the bark and sapwood was shown in December, 1924, but this attack had made no progress on October 1, 1925.

U. S. District Engineer, Charleston, S. C.

Specimens of turpentine wood were placed at Castle Pinckney in Charleston harbor June 24, 1924. They showed a slight attack in bark and sapwood in December, but no heavier attack in October, 1925. They are covered with barnacles (Fig. 1).

Panama Canal Zone

Because of the failure of the greenheart used in the locks, the Canal Zone Government installed a number of test specimens on September 13, 1923. The following statement of their condition was furnished by the Governor as a result of inspections made October 12, 1925. The test is being made at the Pacific end of the Miraflores locks.

Name of wood	*Source*	*Conditions*
Almendro	Panama	Several small teredo found from 1½ to 2 inches long.
Apitong (creosoted)	Philippine Is.	Small block attached to almendro. No attack.
Malabayabas	Philippine Is.	Unattacked.
Yellow Pine	U.S.	Riddled.
Greenheart	Demerara	Attack almost as heavy as on Yellow Pine.
Foengo	Dutch Guiana	No attack.
Anoura	Dutch Guiana	No attack.
Spensi Hoedoe	Dutch Guiana	No attack.
Ingi Barki	Dutch Guiana	One teredo 1 inch long.
Basra Locus (angelique)	Dutch Guiana	No attack.
Manbarklak	Dutch Guiana	2 teredo 1½ inches long.

Army and Navy at Cavite, P. I.

These tests are similar to those at Panama with most of the specimens indigenous timbers, but inspection reports have not been received.

FIG. 1

Specimens of Turpentine Wood at Castle Pinckney, S. C., immersed June 24, 1924. Photographed October, 1925.

Naval Station, Pearl Harbor, H. I.

Two "scupper nailed" pieces were installed in September, 1923. On one of these steel nails were used and on the other copper. No reports received.

Superintendent of Lighthouses, Key West, Fla.

Two piles one sheathed with copper sheets .021 inches thick and the other with monel metal of about the same thickness were placed May 23, 1923. The inspection of September 29, 1925, showed the copper to be in excellent condition. The portion above high water was covered with a thin coat of verdigris, between wind and water with verdigris and a whitish marine growth and below low tide by marine growth. The monel was sound and in good condition, but showed slight corrosion where barnacles had been attached.

Superintendent of Lighthouses, New Orleans, La.

Two piles similar to the above were placed February 21, 1923 for the copper and May 23d for the monel. The last inspection reported was in December, 1924. The copper was in excellent condition but the monel was somewhat pitted.

Seaboard Air Line

A "scupper nailed" test piece protected with steel roofing nails was placed under test at Seddon Island, Fla., June 17, 1923. No inspection report received.

Part II—The studies of the Chemical Warfare Service as reported in "Marine Structures—Their Deterioration and Preservation," showed a high rate of toxicity for copper carbonate and several derivatives of the war gas "Lewsite." Some other materials which also showed high toxicity were eliminated from consideration either because of their high cost or because they could not be readily used for impregnation. Three materials were finally fixed on as offering the greatest promise from the standpoints of efficiency and economic availability and test pieces were treated with them. These test pieces were round posts about 5 inches in diameter and 2 feet long with 1-inch holes bored in them before treatment.

The specimens were treated in the experimental plant of the Chemical Warfare Service at the Edgewood Arsenal with following materials:

No. 1. 1 per cent ammoniacal solution of copper carbonate.
No. 2. 1 per cent Diphenalymine chlorarsine in creosote.
No. 3. 0.75 per cent Diphenalymine chlorarsine and 0.5 per cent phenyldichlorarsine in fuel oil.

It was recommended that they be suspended in the same manner as the test pieces in the Forest Products tests at Gulfport and Pensacola (Fig. 2) or by chains.

Twelve locations were selected for the tests, care being taken to make the tests in both warm and cold water and to have all of them at locations where the two-year tests of the National Research Council had shown great activity by the borers, and in most cases the presence of several species.

The treatment was not completed until the summer of 1925, the first specimens having been shipped to Manila by a transport sailing the last of March.

This series of tests is located as follows:

New York, New Haven & Hartford Railroad

Warren, R. I. Installed May 5, 1925. Neither the control piece or the treated specimens showed any attack on October 16, 1925.

Atchison, Topeka & Santa Fe Railway

Port Bolivar, Texas. No reports.

Southern Pacific Railway

San Francisco, Cal.

FIG. 2

Manner of Suspending Chemical Warfare Service Test Pieces at Coco Solo, C. Z.

Florida East Coast Railway

The specimens were not placed in the water at Key West until September 21, 1925. Sufficient time has not elapsed to make a report of any value.

Naval Air Station, Pensacola, Fla.

Specimens were installed June 8, 1925. On October 1st the control blocks showed a very light attack by borers though they were covered by marine growth. The treated pieces were not attacked and had very little marine growth adhering to them.

Navy Yard, Pearl Harbor, H. I.

One set of specimens was placed on the Torpedo Pier No. 3 and the other on the Coaling Plant Wharf August 17, 1925. They have not been immersed long enough to make a report of any value.

Puget Sound Navy Yard, Bremerton, Wash.

One set of specimens was placed on Pier 4, October 14, 1924, and the other on Pier 8, November 3, 1925.

Naval Air Station, Coco Solo, C. Z.

One set of specimens was hung from the dock in front of the officers' quarters July 23, 1925, and the other from the boat house on August 11, 1925. Both sets were inspected October 6, 1925. The control pieces were covered with barnacles but were not attacked by borers; the treated pieces had neither barnacles nor borers (Fig. 2).

U. S. District Engineer, Charleston, S. C.

Specimens were installed at Castle Pinckney in Charleston Harbor, May 12, 1925. The inspection of October 14, 1925, showed that the control pieces were covered with marine growth and riddled by borers while the treated pieces (Fig. 3) not only were not attacked but had much less growth adhering to them, the one containing the copper carbonate having none at all.

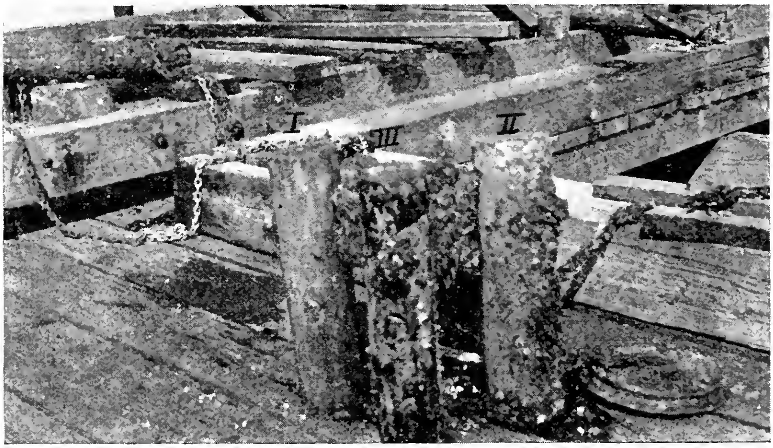


FIG. 3

Test frame immersed at Castle Pinckney, S. C., showing absence of marine growth on some of the treated specimens.
No. 1 is treated with copper carbonate.
No. 2 reinforced creosote.
No. 3, fuel oil and toxic.

Superintendent of Lighthouses, San Juan, P. R.

Test frames were immersed at San Juan, July 1, 1925, and inspected October 5, 1925. All the impregnated pieces were entirely free from borers and marine growth while the control pieces were covered with marine growth but were not attacked by borers.

Naval Station, Cavite, P. I.

"(a) Under date of June 2, 1925, the test pieces were placed in water 70 feet from shore, in approximately 30 feet of water at mean low tide; suspended about 3 feet from the bottom; and in a locality where the attacks of the borer appear heavy."

"(b) Seventy-nine days later (August 19, 1925) the first inspection was made, and it was noted that a few shells adhered to the treated pieces, but there was no destructive action. The untreated wood (native lauan) was partly covered with shells, but no boring attacks were noted."

"(c) Forty-nine days later (October 7, 1925) another inspection was made, and later on October 12, 1925, at which inspection it was noted that, test piece No. 1 had a greenish color, but showed no signs of borer attack; nor were there shells attached. Piece No. 2 had a dark color; showed no signs of borer attack, but had a few shells attached. Piece No. 3 showed a tarry exudation, but no signs of borer, and had but few shells attached. The untreated native wood at this last inspection was completely covered with shells, and upon close inspection was found to be full of holes."

FIG. 5

Specimens in Seattle Harbor, April 30, 1925, to October 15, 1925. Left, creosote; center, untreated; right, 50-50 crude oil and creosote.

Chemical Warfare Service, Beaufort, N. C.

Specimens were installed June 13, 1925, and inspected October 27th. Control pieces showed very heavy attack by borers and were covered by marine growth while treated pieces were free from attack and had only a few barnacles adhering to them on the ends.

PART III—The various series of tests under this classification have been initiated for the purpose of trying to find out which constituents or fractions of creosote give protection and which, if any, are unnecessary.

The Forest Products Laboratory commenced their tests in 1911 (see pages 140-143, "Marine Structures—Their Deterioration and Preservation"). These experiments are tests of the various fractions of creosote and of creosote of a known composition with the addition of naphthaline, tar, fuel oil and other substances. The 1923 inspection is reported in the book above mentioned and further reports will be made from time to time.

The Northern Pacific is making some experiments at Seattle with various preservatives and coatings.

They report one series of tests of Douglas fir blocks impregnated with 5 per cent Cresylicacid and 95 per cent crude oil. These blocks were

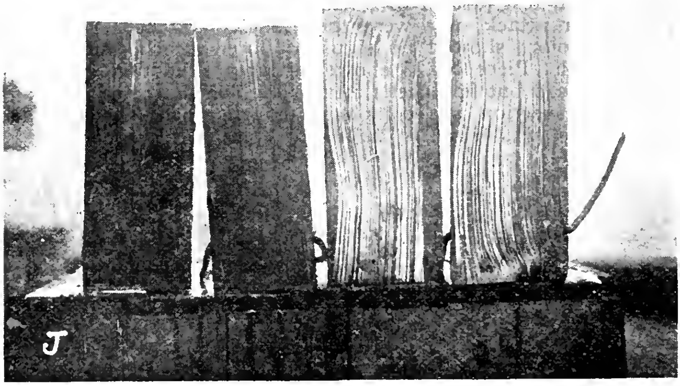


Fig. 6

Immersed April 30, 1925, to October 15, 1925. Crude oil treated block on left, creosote on right.

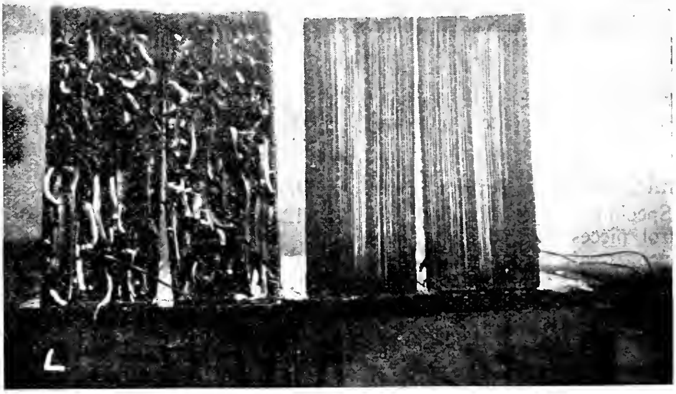


Fig. 7

Immersed January 23, 1925, to October 15, 1925. Untreated on left, 50-50 crude oil creosote treatment on right.

immersed May 29, 1924, and were totally destroyed before September 18, 1925, and if anything the attack on them seemed to be heavier than on untreated timber.

Other blocks were treated with a 50-50 mixture of crude oil and creosote, others with A.R.E.A. No. 1 creosote and still others with California crude oil. The creosote and 50-50 treated blocks were immersed April 30, 1925, and removed October 15th and those treated with crude oil were in the water from January 23, 1925, to October 15th. The treated blocks, even those having nothing but crude oil in them, were not attacked while the control blocks were heavily attacked (Figs. 5, 6 and 7).

It is interesting to note that the impregnation with crude oil in this case gave immunity for at least 9 months, and since no attack is probable

P = Pine; F = Fir

BARRETT MANUFACTURING COMPANY MATERIAL

Station B. Pier 7, San Francisco—No attack except lightly by Limnoria

Gate No.	Specimen No.	Treatment	Date Placed	Condition November 3, 1925
B 4	P 1	Coke oven original oil	Jan. 1923	P 1 intact.
	P 2	Coke, solids removed		P 2, 3, 4 slightly eroded by limnoria on ends; sides intact.
	3	Coke, acids removed		
	4	Coke, bases removed		
B 5	P 5	Coke, minus residue above 360° C	Jan. 1923	All slightly eroded by limnoria on ends. P 5 also on sides next to end. P 8 ditto. P 5 but slightly worse.
	6	Coke, minus frac. 230°-270° C		
	7	Coke, minus frac. up to 230° C		
	8	Coke, minus frac. 270°-360° C		
B 6	P 9	Vertical retort original oil	Jan. 1923	All slightly eroded by limnoria on ends; sides intact.
	P 10	Vertical, minus solids		
	P 11	Vertical, minus acids		
	P 12	Vertical, minus bases		
B 7	P 13	Vertical, minus residue above 360° C	Jan. 1923	All slightly eroded by limnoria on ends; merest traces on sides.
	14	Vertical, minus frac. 230°-270° C		
	15	Vertical, minus frac. up to 230° C		
	16	Vertical, minus frac. °270-°360 C		
B 8	F 1 2 3 4	Coke oven oils duplicating B 4 in identical order	Jan. 1923	All slightly eroded on ends. On sides attack confined to line across specimens where gate had rubbed against a submerged brace.
B 9	F 5 6 7 8	Coke oven oils duplicating B 5 in identical order	Jan. 1923	All slightly eroded on ends; traces only on sides.
B 10	F 9 10 11 12	Vertical retort oils duplicating B 6 in identical order	Jan. 1923	All show slight erosion on both ends and sides.
B 11	F 13 14 15 16	Vertical retort oils duplicating B 7 in identical order	1922	Erosion on all ends, not severe but deeper than on preceding. On sides generally light, but deeper in scattered spots. P 13 and 16 worse than B 14 and 15.

before June in this location the protection would be good for at least 18 months.

The Forest Products Laboratory initiated a series of tests in San Francisco Bay in which the material used for impregnation was either whole creosote, single fractions, or whole creosote from which single fractions had been subtracted or to which single fractions had been added. (Page 144, "Marine Structures.")

Still another series of tests was started by the National Research Council with the assistance of Dr. von Schrenk and S. R. Church, of the Barrett Co.'s laboratories. The preparation of the various creosotes used and the impregnation of the test pieces is fully described on pages 144-148, "Marine Structures." These specimens were inspected November 3, 1925, with the results shown below.

Station C. Crockett, Calif.—Teredo only borer active at this station

Gate No.	Specimen No.	Treatment	Date Placed	Condition November 3, 1925
C 4	P 17 18 19 20	Coke oven oils duplicating B 4 in identical order..................	1922	This gate lost by breaking of chain.
C 5	21 22 23 24	Coke oven oils duplicating B 5 in identical order..................	1922	All sound; untreated frame blocks riddled by *Toredo navalis.*
C 6	25 26 27 28	Vertical retort oils duplicating B 6 in identical order................	1922	Ditto C 5.
C 7	29 30 31 32	Vertical retort oils duplicating B 7 in identical order................	1922	P 32, half on one side practically destroyed by teredo; other half some attack, but fairly sound. P 29, 30, 31 show embryo attack, but apparently discontinued with no development.

Arent Laboratories Material

Gate No.	Specimen No.		Date Placed	Condition November 3, 1925
B 12	P 33 F 17	Antimony trichloride with untreated pine controls............ Untreated Fir control..............	1922	Completely destroyed by limnoria in 16½ months, the treated pieces failing even quicker than untreated controls. Test discontinued on July, 1924, inspection.
C 8	P 33 F 17	Duplicates of B 12.................	1922	Specimens lost during repair of pier.

This test has not been under way long enough to permit drawing definite conclusions but a few years more should show very instructive results.

1925 REPORT ON RE-DRIVEN 1919 AND 1920 CREOSOTED PILES FROM SOUTHERN PACIFIC OAKLAND WHARVES.

The following tables, I-A to I-D, give the 1925 condition of four sets of test piles driven in 1919 and 1920 at Seattle, Tiburon in San Francisco Bay, San Pedro and San Diego. Each set originally consisted of seven piles, including the following:

3—Old Creosoted Fir Piles, originally driven in 1890......Table I-A
1—Old Creosoted Fir Pile, originally driven in 1901......Table I-B
2—New Freshly Creosoted Fir Piles......................Table I-C
1—New Untreated Fir Pile..............................Table I-D

The untreated piles were destroyed in 3 or 4 years, as shown in Table I-D, leaving six piles in each set.

The set at San Diego was exposed for test by the Atchison, Topeka & Santa Fe Railway in their wharf No. 63, until this wharf was dismantled in July of this year. They are to be redriven in the vicinity by the Southern Pacific Co., and the test continued.

TABLE I-A—TEST PILES

CREOSOTED FIR PILES FROM SOUTHERN PACIFIC COMPANY OLD LONG WHARF, DOCK "A," OAKLAND. ORIGINALLY DRIVEN IN 1890. PULLED IN 1919 AND REDRIVEN ELSEWHERE. EXPOSED TO MARINE BORER ATTACK THIRTY-FIVE YEARS TO DATE.

Mark	Redriven for Test			1925 Inspection	
	Date	Railroad	Location	Remarks	Borers
A-6	1920	N. P. Ry. Co.	Seattle	No attack to date	
A-8	1920	N. P. Ry. Co.	Seattle	No attack to date	
A-32	1920	N. P. Ry. Co.	Seattle	No attack to date	
A-19	1919	N.W.P.R.R.Co.	Tiburon*	No attack	
A-28	1919	N.W.P.R.R.Co.	Tiburon*	No attack	
A-29	1919	N.W.P.R.R.Co.	Tiburon	No attack	
A-5	1919	S. P. Co.	San Pedro	Slight Limnoria erosion in two spots	Limnoria
A-20	1919	S. P. Co.	San Pedro	Slight Limnoria erosion	Limnoria
A-34	1919	S. P. Co.	San Pedro	Slight Limnoria erosion	Limnoria
A-2	1920	A.T.& S.F.Ry.Co.	San Diego	General surface attack between tides	Limnoria
A-7	1920	A.T.& S.F.Ry.Co.	San Diego	Attack through crack and hole eaten inside 6 in. x 8 in. and 3½ ft. long. Also general surface attack between tides	Limnoria
A-33	1920	A.T.& S.F.Ry.Co.	San Diego	General surface attack in checks and on surface between tides	Limnoria

*San Francisco Bay.

TABLE I-B—TEST PILES

CREOSOTED FIR PILES FROM SOUTHERN PACIFIC COMPANY OLD LONG WHARF, DOCK "E," ORIGINALLY DRIVEN IN 1901. PULLED IN 1919 AND REDRIVEN ELSEWHERE. EXPOSED TO MARINE BORER ATTACK TWENTY-FOUR YEARS TO DATE.

Mark	Redriven for Test			1925 Inspection	
	Date	Railroad	Location	Remarks	Borers
E-46	1920	N. P. Ry. Co......	Seattle......	No attack to date...............	....
E-42	1919	N.W.P.R.R.Co....	Tiburon*....	Attacked, 2 holes................	Limnoria
E-38	1919	S. P. Co...........	San Pedro...	No attack to date...............	....
E-50	1920	A.T.& S.F.Ry.Co.	San Diego...	General Surface attack, 1 in.-2 in. deep in checks between tides...	Limnoria

*San Francisco Bay.

TABLE 1-C—TEST PILES

FRESHLY CREOSOTED FIR PILES, EXPOSED TO MARINE BORER ATTACK FIVE YEARS TO DATE

Mark	Redriven for Test			1925 Inspection	
	Date	Railroad	Location	Remarks	Borers
47	1920	N. P. Ry. Co......	Seattle......	No attack to date..............	....
48	1920	N. P. Ry. Co......	Seattle......	Attacked in checks.............	Limnoria
43	1919	N.W.P.R.R.Co....	Tiburon*....	No attack.......................	....
44	1919	N.W.P.R.R.Co....	Tiburon*....	No attack.......................	....
40	1919	S. P. Co...........	San Pedro...	No attack to date..............	....
41	1919	S. P. Co...........	San Pedro...	No attack to date..............	....
51	1920	A.T.& S.F.Ry.Co.	San Diego...	General attack in checks, 1 in. deep between tides............	Limnoria

Mark	Redriven for Test			1925 Inspection	
	Date	Railroad	Location	Remarks	Borers
52	1920	A.T.& S.F.Ry.Co.	San Diego...	Slight surface attack. Several small holes deep...............	Limnoria

*San Francisco Bay.

TABLE 1-D—TEST PILES

UNTREATED FIR PILES, EXPOSED TO MARINE BORER ATTACK FOUR YEARS

Mark	Redriven for Test			1925 Inspection	
	Date	Railroad	Location	Remarks	Borers
49	1920	N. P. Ry. Co......	Seattle......	Broken off at mud line, 1923.....	Limnoria Bankia
45	1919	N.W.P.R.R.Co....	Tiburon*....	Broken off at mud line, 1923......	Limnoria Bankia Teredo navalis
39	1919	S. P. Co...........	San Pedro...	Broken off at mud line, 1924......	Limnoria Bankia
53	1920	A.T.& S.F.Ry.Co.	San Diego...	Broken off at mud line, 1923......	Limnoria (Probably Bankia)

*San Francisco Bay.

BIOLOGICAL STUDIES

The Honorary Advisory Council for Scientific and Industrial Research and the Biological Board of Canada, and the Department of Zoology of the University of British Columbia in cooperation with railroad and public works officials have been making studies of the distribution of borers on both coasts.

The report on the work on the east coast is presented in Report No. 15 of Research Council of Canada and was prepared by R. H. McGonigle, B.A.

In the introduction Mr. McGonigle states that the work was initiated because of the interest created by the work on this side of the international line. He further says: "It is a survey of the Atlantic Coast for marine borers to obtain a measure of the amount of damage done, and to ascertain their relation to the hydrography of the coastal waters."

The following hydrographic data were obtained for each place:

"(1) Rise or fall of the tide—by measuring the level at hourly intervals.

"(2) Salinity—Samples were taken at low tide and again at high tide, from the surface and bottom. If the wharf went dry at low tide a sample was taken on the ebb and another on the flood, just as the water reached the lowest part of the wharf.

"(3) Temperature—the temperature was taken for each of the above samples and in addition for samples ten feet from the surface if the depth exceded ten feet.

"(4) Hydrogen-ion concentration—ascertained for surface and bottom samples."

Information regarding the borers was obtained by inspection of existing structures and by inquiry. For the purpose of making pile inspections in deep water an instrument like a periscope was developed. This instrument is illustrated in the paper and offers a much cheaper means of inspection than by diver. The following harbors were inspected, with the results shown:

Welchpool, Campobello, N. B. Limnoria only, piles last 6 or 7 years.
St. Andres, N. B. Limnoria, only light attack.
St. Johns, N. B. No borers.
Kingsport, N. S. Very light attack by limnoria.
Port George, N. S. Limnoria only, attack heavy.
Annapolis, N. S. Limnoria only, attack light.
Digby, N. S. Limnoria only, piles last 18 or 20 years.
Weymouth, N. S. No borers.
Yarmouth, N. S. One teredo found, limnoria attack light.
Barrington Head, N. S. A very few limnoria.
Clarks Harbor, N. S. Limnoria only. Piles last 10 to 16 years.
Shelburne, N. S. Comparatively light limnoria attack.
McNutt's Island, Shelburne, N. S. Limnoria. Piles last 8 or 10 years.
Liverpool, N. S. A very few limnoria.
Port Mouton, N. S. Limnoria only, medium attack.
Lunenburg, N. S. Limnoria only were found, attack medium, but teredo were reported.

Hubbards Cove, N. S. Both teredo and limnoria; teredo attack very heavy in some parts of the harbor. Piles last 2 years.

Halifax, N. S. Both teredo and limnoria occur, but the former is negligible. Piles last 8 or 9 years.

Bedford, N. S. Teredo and limnoria, very light attack.

Jeddore, N. S. Limnoria only; fairly heavy attack.

Lower Ship Harbor, N. S. Teredo reported, but not seen; limnoria attack fairly heavy.

East River, Sheet Harbor, N. S. Teredo and limnoria present, but unimportant.

Marie Joseph, N. S. Fairly heavy attack by both teredo and limnoria. Piles last about 6 years. One teredo burrow 30 inches long was found.

Goldboro, Isaac Harbor, N. S. Both teredo and limnoria present. Piles are said to last about 15 years.

Whitehead, N. S. Teredo and limnoria present. Piles are said to last about 15 years.

Canso, N. S. Teredo and limnoria present, the latter more destructive. Piles last from 2 to 10 years.

Port Mulgrave, N. S. Both borers present, but attack very light.

St. Peters, N. S. Both borers present, but normal attack light. Heavy teredo attack reported in some years.

Grand Narrows, N. S. Both borers present and teredo very destructive. Piles driven in August were destroyed in the same season.

Louisburg, N. S. Both borers present, but neither very destructive.

North Sydney, N. S. Both borers present and teredo very destructive. Piles last from 1 to 3 years.

Port aux Basquis, Newfoundland. Both borers present and limnoria very destructive. Piles last about 5 years.

Port Hood, N. S. Both borers present and active; two species of teredo probably present. Piles last only a few years.

Pictov, N. S. Both borers present, but not especially destructive. The railroad wharf collapsed after 20 years' service.

Charlottetown, P. E. I. Both borers very active. Piles last from 1 to 5 years.

North Rustico, P. E. I. Heavy attack by both teredo and limnoria; about the same as Charlottetown.

Summerside, P. E. I. Teredo very active; limnoria less so. Piles last from 2 to 5 years.

Pointe du Chien, N. B. Limnoria present and teredo more destructive than at any other harbor investigated.

Chatham, N. B. No borers found, though evidence of the presence of teredo was found, both up and down stream.

Bathhurst, N. B. No borers found, though there was some evidence of the presence of teredo.

Petit Rocher, N. B. Heavy attack by both toredo and limnoria.

Dalhousie, N. B. No borers found.

Gaspe, P. Q. A few limnoria; no teredo.

Rimouski, P. Q. Fairly heavy limnoria attack.

Isle Verti and Levis, P. Q. No borers found and evidence indicates that they are unknown in the St. Lawrence above Rimouski.

The writer of this report is of the opinion that the hydrogen-ion concentration is a factor of no importance in the distribution of the borers.

Limnoria was found to be destructive in harbors where the temperature was from 33 deg. Fahr. to 37 deg. Fahr., and in a number of others where the temperature was little higher.

Teredo were found most active in harbors with temperatures ranging from 55 deg. Fahr. to 64 deg. Fahr., but it is possible that other factors have as much, or more, influence on their distribution.

The west coast experiments are reported by Dr. C. McLean Fraser, F.R.S.C., in the Transactions of the Royal Society of Canada.

The method used was similar to that of the National Research Council, except that the test boards carried 12 instead of 24 blocks. Salinity and temperature observations were made at many of the test board locations.

Testboards were located as follows:

Victoria, Inner Wharf.
Belmont Wharf, Esquimault.
Bamfield.
Rivers Inlet.
Ogden Point, Victoria Wharf, Outer Harbor.
Quantsino Sound.
Digby Island.

Limnoria were found at all these locations and *Bankia setacea* at all except Bamfield and Digby Island.

Dr. Fraser thus summarizes his report:

> "The examination of test blocks of Douglas fir set out along the coast of British Columbia by the Federal Department of Public Works indicates that while the range of temperature and specific gravity is evidently a suitable range for the growth of *Bankia setacea* and *Limnoria lignorum* (*Xylophaga washingtona* is also an agent in the Rivers inlet area), these factors, temperature and specific gravity, are not the most potent factors affecting the rapidity and extent of infection within this area. A comparison of infection in areas of somewhat similar salinity and temperature range shows a wide variation.
>
> "Although entrance of the larvæ of *Bankia* may be most intensive during the spring and early summer months, it must take place at all times of the year. No area more favorable for *Bankia* growth than that formed by the inlets adjacent to Queen Charlotte Sound has yet been investigated.
>
> "*Limnoria* thrives throughout the year. The extent of the season in which the larvæ are hatched out was not determined, but it must extend over a large portion of the year also. Species of barnacles, muscles, annelids, other isopods, etc., are commonly found associated with *Limnoria,* either because the tunnelled wood forms a better surface for attachment or the tunnels themselves serve for protection. The presence of these may have, indirectly, a deleterious effect on the wood."

Conclusions

Test of cottonwood indicates that probably the bark furnishes the protection and that when this is broken the timber itself has no more resistance than any other.

Angelique and manbarklak are not as yet proven to be immune. None of the specimens of angelique have been attacked, but two of those of manbarklak have been.

None of the specimens of turpentine wood have shown attack beyond the bark and the very thin layer of sapwood. This agrees with the service records previously obtained for this timber.

The period of test for the Chemical Warfare Service specimen is too short to expect any result, but it is interesting to note that the two cheap materials, copper carbonate and fuel oil with a toxic, are as yet unattacked and in most cases little or no marine growth is attached to the specimens.

The failure of the borers to attack the untreated control pieces in most of these test frames is very interesting. It is very unfortunate that funds are not available for scientific studies to find the reasons for these and other very important facts regarding the action of the borers. Money expended on such studies would very probably make possible the development of more efficient protection.

No conclusions can yet be developed from the experiments reported in Part III, but these tests should in time produce valuable information as to the most effective type of creosote.

FIFTH REPORT OF THE COMMITTEE OF THE INSTITUTION OF CIVIL ENGINEERS ON "DETERIORATION OF STRUCTURES OF TIMBER, METAL AND CONCRETE EXPOSED TO THE ACTION OF SEA-WATER"

In April of this year the British Committee on investigations of deterioration of structures in sea-water issued their fifth (interim) report, consisting of 65 pages and 12 illustrations and plans. The report is composed of a series of progress reports on the following subjects: "Fifth Interim Report of the Committee for the year ending 31st March, 1924;" "Report on the Comparative Corrosion of Steel at Colombo, Halifax, Plymouth and Auckland;" "Report on the Investigations to Protect Timber Against Teredo;" "Report on Examination of Raft and Test Pieces at Plymouth, November, 1923;" "Remarks on Dr. Harington's Report;" "General Report on the Creosoting and Impregnation of Timbers with Poisons; also on the Mechanical Tests of Foreign Timbers;" "Report on the Painting of Steel Plates," "Report on the Arrangements Made to Expose the Paint Specimens to the Action of Sea-Water and of the Atmosphere at Southampton;" "Report on the Salinity of the Water in the Hamoaze;" "Report on Certain Defects Noticed in Admiralty Reinforced Concrete Structures;" "Report on Arrangements Made for the Exposure of Certain Blocks of Poisoned Timber at Colombo;" "Report on the Condition of Specimens of Timber Exposed to the Action of the Sea at Leith Docks;" Abstracts of Reports Received from Correspondents—

Report of Tests on Native and Other Timbers;
Report on Some Specimens of Shelly Tubes of Teredo, from Solomon Islands;
Report on Specimen of Rock Perforated by a Species of Clam in the Vicinity of Cape Breton, Nova Scotia;
Report on Marine Piling Investigations of the National Research Council;
Report of an Occurrence of Deterioration in a Sample of Concrete;
Report on the Disintegration of Cement in Sea-Water.

In the sections devoted to timber, Dr. Harington's report "deals with final examination of raft and test pieces of timber, treated and untreated, which were put out at Plymouth in September, 1920." These timbers were treated with creosote alone and four sets treated respectively with creosote and thymol, carbazole, chlorodinitrobenzene and dinitronaphthalene. The conclusions reached were that while the experiment was not quite satisfactory, due to the method of impregnation, nevertheless, it showed a very much higher degree of protection for the creosotes to which the various substances had been added than creosote alone, in the following order of efficiency, carbazole, dinitronaphthalene and chlorodinitrobenzene.

The above report can be obtained by purchase from H. M. Stationery Office, Adastral House, Kingsway, London, W. C. 2, the price being 3s. 6d.

During the past summer the Chairman of this Committee had the pleasure of discussing the general problem of marine borer protection with the Secretary of the English Committee, Mr. P. M. Crosthwaite, towards the end of establishing the closest possible relations between the two Committees.

Recommendations

It is recommended that the Committee continue the studies now under way.

Appendix E

(5) SPECIFICATIONS FOR PRESERVATIVE TREATMENT OF SIGNAL TRUNKING AND CAPPING

C. F. Ford, Chairman, Sub-Committee; Dr. H. von Schrenk, R. S. Belcher, E. W. Hammond, Frank Ringer.

PURPOSE

1. (a) The purpose of these specifications is to provide for preservative treatment of trunking and capping for the protection of insulated signal wires and cables.

ORDERING AND REQUISITIONING

2. (a) Orders and requisitions shall specify method of treatment, design, kind of wood, and quantity (of unsurfaced lumber, board measure) of trunking and capping required.

MATERIAL

3. (a) **Kinds of Wood.**—Cedar, cypress, Douglas fir, larch, black gum and yellow pine are acceptable woods for signal trunking and capping for use after pressure preservative treatment.

DESIGN

4. (a) Trunking and capping shall be in accordance with American Railway Association drawings 1176 or 1177, or as specified by the Purchaser.

(b) Trunking and capping shall be shipped in lengths of from eight (8) to twenty (20) feet, but not less than fifty (50) per cent of each shipment shall be sixteen (16) to twenty (20) feet in length and eighty-five (85) per cent shall be ten (10) feet or more.

MANUFACTURE

5. (a) It shall be straight, well grooved and surfaced on all exterior planes, with ends sawed square.

(b) It shall be thoroughly seasoned (not over twenty (20) per cent moisture).

GENERAL QUALITY

6. (a) All trunking and capping shall be free from any defects which may impair its durability, strength and water tightness, such as

(1) Decay other than "blue stain."
(2) Grain with slant greater than one (1) in fifteen (15).
(3) Unspecified or plugged holes.
(4) Large, loose or numerous knots or knots in groups.
(5) Shake.
(6) Injurious pitch pockets or splits.
(7) Excessive wane.
(8) Excessive warp.
(9) Any combination of defects exceeding in damaging effect any single maximum defect that is allowable.

INSPECTION

7. (a) Trunking and capping will be inspected at points of shipment or destination in suitable and convenient places satisfactory to the Purchaser.

(b) Inspectors representing the Purchaser shall have free entry at all times, while work on the contract of the Purchaser is being performed, to all parts of the Manufacturer's works which concern the manufacture of the trunking and capping ordered. The Manufacturer shall afford the Inspector, free of cost, all reasonable facilities to satisfy him that the trunking and capping supplied is in accordance with this specification.

(c) Inspectors will make a reasonably close examination of each piece of trunking and capping, which shall be judged independently without regard for the decisions on others in the same lot.

(d) **Decay.**—"Blue stain" only will be allowed.

(e) **Knots.**—A large knot is one more than one (1) inch in diameter in capping or two (2) inches in diameter in trunking. Numerous knots are any number equaling a large knot in damaging effect. Knots in groups are any aggregation of knots equaling a large knot in damaging effect. Loose knots are any not fixed in the piece by growth or position.

(f) **Pitch Pockets.**—Injurious pitch pockets are any exceeding six (6) inches in length or one-quarter (¼) inch in depth, within any five (5) square feet of surface.

(g) **Splits.**—Injurious splits are any exceeding six (6) inches in length or one-quarter (¼) inch in depth within any five (5) square feet of surface.

(h) **Wane.**—Wane is bark or lack of wood from any cause on corners.

(j) **Warp.**—Trunking and capping are excessively warped when a straight line along any corner from end to end of the piece is anywhere away from the piece more than one-tenth (1/10) inch per foot of its length.

(k) **Dimensions.**—All dimensions specified for trunking and capping are minimum requirements. An excess of one-quarter (¼) inch in outside dimensions and one-eighth (⅛) inch in groove dimensions are maximum tolerances. Exactness of dimensions will be determined by accurate measurements anywhere along trunking and capping as desired by the Railroad's Inspector.

(l) **Workmanship.**—Trunking and capping are not well sawed, and trunking is not well grooved, when their surfaces are not even.

PRESERVATIVE TREATMENT

GENERAL REQUIREMENTS

8. (a) **Kind of Preservative.**—The preservative used shall be A.R.E.A. Grade 1 Creosote Oil.

(b) **Retention of Preservative.**—No charge shall contain less than ninety (90) per cent, nor more than one hundred and ten (110) per cent of the quantity of preservative that may be specified. The amount of preservative retained shall be calculated on the basis of preservative at 100 degrees F., from readings of working tank gages, or scales, or from weights before and after treatment of loaded trams on suitable track scales, checked as may be desired by the Purchaser's representative. Volume corrections shall be based on American Wood Preservers' Association Table of Factors to be used for Determining the Volume of Creosote at 100 deg. Fahr. when the Oil is at Temperatures Ranging from 60 degrees to 225 deg. Fahr.

(c) **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 condition satisfactory to the Purchaser. 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.

METHOD OF TREATMENT

9. (a) Trunking and capping may be treated by one of the following processes as selected by the Purchaser:

(1) Full Cell Process (to be used only where wires are to be laid in Petroleum Asphaltum).
(2) Empty Cell Process with Initial Air.
(3) Empty Cell Process without Initial Air.

MANNER OF TREATMENT

10. (a) The ranges of pressure, temperature and time duration shall be controlled so as to result in maximum penetration by the quantity of preservative injected, which shall permeate all of the sapwood, and as much of the heartwood as practicable. The vacuum requirements stipulated are those at sea level and necessary corrections shall be made for altitude.

TREATING OPERATIONS—Full Cell Process

11. (a) Timber shall be subjected to a vacuum of sufficient intensity and duration to insure that the wood is as dry and free from air as practicable, and to permit a retention of not less than twelve (12) nor more than fourteen (14) lb. of preservative per cubic foot of wood.

(b) The preservative shall be introduced between 165 degrees Fahr. and 200 degrees Fahr. and the cylinder filled without breaking the vacuum. The pressure shall then be raised to and maintained at a minimum of 100 pounds per square inch or until the quantity of preservative required to insure the final retention stipulated is injected into the wood or until the Purchaser's representative is satisfied that the largest volumetric injection that is practicable has been obtained. The temperature of the preservative during the pressure period shall be not less than 150 degrees Fahr. nor more than 200 degrees Fahr., and shall average at least 180 degrees Fahr. After the pressure is completed the cylinder shall be emptied speedily of preservative, and a vacuum of not less than twenty-two (22) inches promptly created and maintained until the wood can be removed from the cylinder free of dripping preservative.

EMPTY CELL PROCESS WITH INITIAL AIR ("RUEPING PROCESS")

12. (a) Timber shall be subjected to air pressure of sufficient intensity and duration to provide under a vacuum the ejection of surplus preservative and to insure a retention and proper distribution of an average of eight (8) lb. of preservative per cubic foot of wood.

(b) The preservative shall be introduced between 165 degrees Fahr. and 200 degrees Fahr., the cylinder pressure being maintained constant until the cylinder is filled with preservative. The pressure shall then be raised to and maintained at a minimum of 150 lb. per square inch or until there is obtained the largest practicable volumetric injection that can be reduced to the stipulated retention by quick high vacuum, or until the Purchaser's representative is satisfied that the largest volumetric injection that is practicable has been obtained. The temperature of the preservative during the pressure period shall be not less than 150 degrees Fahr. nor more than 200 degrees Fahr., and shall average at least 180 degrees Fahr. After pressure is completed the cylinder shall be emptied speedily of preservative, and a vacuum promptly created and maintained until the wood can be removed free of dripping preservative.

EMPTY CELL PROCESS WITHOUT INITIAL AIR ("LOWRY PROCESS")

13. (a) The amount of preservative retained shall be not less than eight (8) nor more than ten (10) lb. per cubic foot of wood.

(b) The preservative between 165 degrees Fahr. and 200 degrees Fahr. shall be introduced to the timber until the cylinder is filled. Pressure shall then be raised to and maintained at a minimum of 100 lb. per square inch or until there is obtained the largest practicable volumetric injection that can be reduced to the stipulated retention by a quick high vacuum, or until the Purchaser's representative is satisfied that the largest volumetric injection that is practicable has been obtained. The temperature of the preservative during the pressure period shall be not less than 150 degrees Fahr. nor more than 200 degrees Fahr. and shall average at least 180 degrees Fahr. After pressure is completed the cylinder shall be emptied speedily of preservative and a vacuum of not less than 22 inches promptly created and maintained for not less than thirty (30) minutes until the quantity of preservative injected is reduced to the required retention and the wood can be removed from the cylinder free of dripping preservative.

14. (a) As an excess of creosote oil is injurious to the rubber insulation of signal wires and cables, the trunking should be placed in the cylinder with the groove down and each cylinder charge, at the discretion of the Purchaser, may be given a final steaming of thirty (30) minutes to one (1) hour to remove all free creosote oil.

(b) Trunking and capping which has been given the preservative treatment should be air seasoned sixty (60) to ninety (90) days before wires are placed therein, which seasoning is optional with the Purchaser.

Appendix F

(6) TREATMENT WITH MIXTURE OF CREOSOTE AND PETROLEUM

R. S. Belcher, Chairman, Sub-Committee; H. C. Bell, H. von Schrenk, C. F. Ford, F. C. Shepard, E. B. Fulks, O. C. Steinmayer, W. H. Kirkbride, J. H. Waterman, L. J. Reiser, Galen Wood.

Your Committee on this subject presented for the 1924 report to the Convention a history of the use of creosote-petroleum mixtures in this country and in Europe, and the results obtained up to that time. Previous to making this report your Committee made an exhaustive inquiry during the previous one and one-half years, and endeavored to obtain the latest information both from foreign countries as well as from this country. The Committee made three inspection trips investigating creosote-petroleum ties at various points on the Santa Fe, and reports of length of service given by ties inspected.

For the 1925 Convention the Committee made another report on this subject which was in general a continuance of report made the previous year. During the year previous to making this report, the Committee again made inspection of 975 creosote-petroleum ties in the Cleveland Section of the Beaumont Division of the Santa Fe, and service given by these test ties up to date of report was tabulated in the Committee report. In this report your Committee arrived at certain conclusions: First, that creosote for mixture with petroleum shall be any of the Association's standard grades of creosote, but that creosote-coal-tar solution might be used with certain kinds of petroleum. Some indication was given in the conclusions as to the petroleum most suitable for admixture with creosote.

Your Committee recommended that this subject be continued, and during the past year the subject has not been lost sight of, but, on the contrary, the study has been continued, and effort made to reach conclusions as to tentative specifications and methods of analyses for petroleum suitable for admixture with standard grades of creosote and creosote-coal-tar solution, to define the limits of viscosity of creosote-petroleum mixtures, and to prepare tables for the measurement of petroleum.

To date we have not been able to complete any of the above, but think that the subject should be continued until such time as the Committee is able to submit data on these subjects.

Inasmuch as there has been little change in the 975 creosote-petroleum ties in the Cleveland Test Section, your Committee has not thought it worth while to bring up to date the data on these ties published in last year's report.

Appendix G

(7) TREATMENT WITH MIXTURE OF ZINC-CHLORIDE AND PETROLEUM

R. S. Belcher, Chairman, Sub-Committee; H. C. Bell, H. von Schrenk, C. F. Ford, F. C. Shepard, E. B. Fulks, O. C. Steinmayer, W. H. Kirkbride, J. H. Waterman, L. J. Reiser, G. Wood.

Much the same may be said of this subject as has been said under the subject of Creosote-Petroleum Mixture. Under conclusions given in report of last year it was stated that there are some certain operating difficulties encountered in the experimental work with zinc-chloride and petroleum which had not been up to that time very encouraging.

About 3500 ties were treated in this manner and have been placed in test track. This experimental work has been continued during the past year chiefly along the line of the zinc-petroleum emulsion treatment described in the last year's report.

This experimental treatment has been carried on during the past year in an experimental cylinder located at Somerville, Texas, and it has been found that with certain petroleums containing sufficient asphalt, emulsions may be made with which Southern yellow pine, oak and gum timber may be treated leaving up to three-quarters of a pound of zinc-chloride per cubic foot of timber in sappy Southern yellow pine and three to five-tenths pound in red oak and gum.

This zinc-chloride-petroleum emulsion treatment is now being tried out at Albuquerque, N. M., in standard size treating cylinders, but this work is only just under way, and results will not be available for this year's report.

REPORT OF SPECIAL COMMITTEE ON CLEARANCES

O. F. Dalstrom, *Chairman;*	F. E. Morrow,
J. R. W. Ambrose,	J. V. Neubert,
W. C. Barrett,	Arthur Ridgway,
W. T. Dorrance,	T. E. Rust,
E. B. Katte,	C. C. Westfall,
C. M. McVay,	F. B. Wiegand,

Committee.

To the American Railway Engineering Association:

Your Committee respectfully presents herewith report on the subject of Clearances.

The work has not been carried far enough to enable the Committee to submit recommendations for the action of the Association. The Committee therefore submits the following as a progress report, and recommends that it be received as information.

The Committee had one meeting in 1925, which was held in Chicago on July 10th. The meeting was attended by three members of the Committee, and by special representatives of four railways which had been invited to send representatives because of the special problems in clearances under consideration by those railways.

The Committee first made a brief review of the information available on clearances and a preliminary program was laid out for investigation and study of the subject, after which the Committee organized to handle the work. The plan of work, as outlined in the program, was first to collect and study the essential data. To do this effectively the subject was divided into four sub-divisions and a Sub-Committee appointed to study and report on each sub-division, as follows:

1. Clearances required for electrical zones.
   E. B. Katte, Chairman of Sub-Committee,
   F. B. Wiegand,
   W. T. Dorrance.
2. Limiting outline of clearance required for equipment.
   F. E. Morrow, Chairman of Sub-Committee,
   C. C. Westfall,
   Arthur Ridgway.
3. Limiting outline of clearance required for lading.
   J. V. Neubert, Chairman of Sub-Committee,
   C. M. McVay.
4. Clearances required for safety of trainmen.
   W. C. Barrett, Chairman of Sub-Committee,
   J. R. W. Ambrose,
   T. E. Rust.

Bulletin 284, February, 1926.

Three of the four Sub-Committees have made their first reports. These reports indicate that more information must be obtained and thoroughly studied before recommendations can be made by the Committee. During the past decade changes have been made in dimensions and types of equipment, in the sizes and weights of shipments, and in the clearances fixed by legislative acts of many states. The self-propelled gas-electric units that have come into use recently present special problems on clearances.

The Committee recommends the re-assignment of the subject in its present form.

Respectfully submitted,

THE SPECIAL COMMITTEE ON CLEARANCES,
O. F. DALSTROM, *Chairman.*

REPORT OF COMMITTEE XXII—ECONOMICS OF RAILWAY LABOR

C. C. Cook, *Chairman;*
Lem Adams,
M. C. Blanchard,
A. S. Butterworth,
H. A. Cassil,
G. C. B. Dunn,
John Evans,
J. A. Heaman,
E. B. Hillegass,
E. T. Howson,
P. B. Jeffries,
F. G. Jonah,
C. E. Johnston,
J. D. Keiley,
J. W. Kern, Jr.,
A. N. Reece, *Vice-Chairman;*
J. B. Mabile,
A. C. Mackenzie,
W. A. Murray,
G. M. O'Rourke,
R. L. Pearson,
W. L. Rohbock,
R. W. Ross,
R. L. Schmid,
F. S. Schwinn,
J. M. Sills,
F. M. Thomson,
Cale Wamsley,
C. E. Weaver,
B. A. Wood,
Committee.

To the American Railway Engineering Association:

Your Committee respectfully presents herewith report covering the following subjects:

(1) Revision of the Manual.
(2) Standard methods for performing maintenance of way work and establishment of units of measure of work performed (Appendix A).
(3) Extent to which it is practicable to stabilize employment in the maintenance of way department in the interest of efficiency, and the necessary measures (Appendix B).
(4) Methods of maintaining motor cars (Appendix C).
(5) Economy in use of labor-saving devices (Appendix D).
(6) Educating and training maintenance of way employees (Appendix E).

Action Recommended

1. None.

2. That the conclusions in Appendix A, relating to the discontinuance of the subject of Standard Methods for Performing Maintenance of Way Work and Establishment of Units of Measure of Work Performed, be approved and accepted as information.

3. That the report in Appendix B, on the Extent to which it is Practicable to Stabilize Employment in the Maintenance of Way Department in the Interest of Efficiency and the Necessary Measures thereto, be accepted as a progress report.

4. That the conclusions in Appendix C, relating to Methods of Maintaining Motor Cars, be approved for publication in the Manual.

Bulletin 285, March, 1926.

5. That Conclusion (1) in Appendix D, relating to the Economy in use of Labor-Saving Devices, be approved for publication in the Manual.

That Conclusions (2) and (3) in Appendix D, relating to the same subject, be accepted as information.

6. That the report in Appendix E, relating to Educating and Training Maintenance of Way Employees, be accepted as information.

Recommendations for Future Work

1. Revision of the Manual.
2. Study and report on the Extent to which it is Practicable to Stabilize Employment in the Maintenance of Way Department in the Interest of Efficiency and the Necessary Measures to Accomplish it.
3. Economy in the Use of Labor-Saving Devices.
4. Methods of Maintaining Motor Cars:
    (a) Rules for Care and Operation of Motor Cars.
    (b) Standardization of Motor Car Parts.
5. Equating Track Values for Labor Distribution.
6. Outline of Work for Ensuing Year.

Respectfully submitted,

THE COMMITTEE ON ECONOMICS OF RAILWAY LABOR,
C. C. COOK, *Chairman.*

Appendix A

(2) STANDARD METHODS FOR PERFORMING MAINTENANCE OF WAY WORK AND ESTABLISHMENT OF UNITS OF MEASURE OF WORK PERFORMED.

F. S. Schwinn, Chairman, Sub-Committee; G. C. B. Dunn, Col. F. G. Jonah, A. C. Mackenzie, R. L. Pearson, J. M. Sills.

The subject of "Standard Methods for Performing Maintenance of Way Work for the Purpose of Establishing Units of Measure of Work Performed" was first assigned to the Committee in 1920. A resumé of the Committee's work was given in the report published in the Proceedings of 1925.

It was the conclusion of the Committee that, with the forms and principles adopted and published in the 1922 Supplement to the 1921 Manual and as contained in the Proceedings of 1922, in combination with the various studies published in the 1924 Proceedings and those set out in that report and published in the 1925 Proceedings, it had demonstrated conclusively the practicability of these principles, which should enable any carrier to prepare the necessary data for comparison of work between gangs, districts or divisions, and by the use of the form suggested in compiling cost data on various items of maintenance of way work, that the cost of this work or different items of work, between different districts or divisions, might be readily compared, and that these results could be compared with results of similar work on other railroads, as the occasion might warrant, and that the relative quality and economy of the work could only be compared on such items of work where the conditions might be compared or the quality judged by inspection.

It was appreciated that there was wide diversity in conditions and considerable variation in the practices of different carriers, and the further necessity of following different practices in various parts of the country. The Committee felt that it would not be practicable to attempt to establish for general application standards of performance for each item of work, and that the studies of the Committee had been carried forward as far as it was desirable at this time.

The subject was reassigned to the Committee and the Committee has proceeded with further studies, considering the maintenance of way accounts and charges, in an effort to determine whether the maintenance expenses could be expressed in a form of some unit of cost per mile of line or per some uniform traffic unit, which would be representative of a fair and normal allowance for ordinary maintenance purposes, and for the several classes of railroads in the different sections of the country.

A questionnaire was circulated among carriers which called for a reporting of mileage and other necessary physical data required for the purpose of ascertaining amount of property maintained and also other statistical data covering speed of trains, freight car and passenger car mileage, as well as the maintenance of way charges by accounts for the years 1923 and 1924. Forty-one carriers, representing 120,205 miles of operated line, fairly well scattered throughout the country, furnished replies to this questionnaire. These replies have been tabulated and analyzed. From the physical data attached to the replies the different lines have been equated to an equated main line mileage, using as a basis the equivalents shown on page 685 of the Proceedings of 1922 and again published on page 932 of the 1925 Proceedings. For ready reference the table of equivalents is here again set out.

One mile of first main track equivalent to:

- 1.15 miles of second main track.
- 1.33 miles of third or fourth main track.
- 2.00 miles of branch line track.
- 2.00 miles of passing and thoroughfare track.
- 3.33 miles of yard tracks—
  - 12 main line switches.
  - 20 sidetrack switches.
  - 10 railroad crossings.
  - 12 city street crossings.
  - 25 to 50 country road crossings.
  - ½ mile of track pans.
  - 4 miles of ditches.

The railways reporting were also classified in accordance with the Classification of Railways, as published on page 16 of the 1921 Manual, and, which for ready reference, is here quoted:

CLASSIFICATION OF RAILWAYS

Class "A" includes all districts of a railway having more than one main track, or those districts of a railway having a single main track with a traffic that equals or exceeds the following:

Freight car mileage passing over districts per year per mile, 150,000; or, Passenger car mileage per year per mile of district, 10,000; with maximum speed of passenger trains of 50 miles per hour.

Class "B" includes all districts of a railway having a single main track with a traffic that is less than the minimum prescribed for Class "A," and that equals or exceeds the following:

Freight car mileage passing over districts per year per mile, 50,000; or Passenger car mileage per year per mile of district, 5,000; with maximum speed of passenger trains of 40 miles per hour.

Class "C" includes all districts of a railway not meeting the traffic requirements of Classes "A" or "B."

The maintenance charges were tabulated by accounts and classes of railroads under the several different regions, and studies and comparisons of this tabulation were made. These comparisons indicated a somewhat higher cost of maintenance per equated mile of Class "A" roads as compared with Class "B" roads, but the difference is not uniform. In general, the cost per thousand car miles per mile of line was greater on Class "B" roads than on Class "A" roads. The differences, however, do not follow any fixed rule; they are so variable that it is not possible to develop a uniform relationship.

A further study was made of the charges which are in part or in whole affected by use. While in general the charges under accounts affected by use are greater per equated mile on Class "A" roads than they are on Class "B" roads, and the charges per thousand car miles per mile of line are usually found to be greater on Class "B" roads than on Class "A" roads, no fixed relationship could be determined and no rule could be developed whereby such charges could be forecast. Further examination was made of the charges under Account 212, Ties. While this account is heavily affected by use, the comparisons indicate no fixed ratio as between the different classes of railroads and the charges appear to vary considerably in the different regions, this being undoubtedly due to the differences in climatic conditions and kinds of ties used.

Conclusions

It is the conclusion of the Committee that it is not possible to determine a fixed unit of cost of maintenance of way and structures accounts for any unit of property, such as the equated mile, or for any unit of use, such as thousand car miles. It is further the conclusion that it will be impossible to determine upon such unit of cost at any future time unless all railroads were to adopt the use of standard materials and standard practices, and even then there would exist differences reflecting the differences in location, climatic conditions and physical construction.

The Committee feels that it has exhausted this study as far as it is possible to do so at the present time, and it again respectfully recommends that it be relieved from further study of this subject.

Appendix B

(3) EXTENT TO WHICH IT IS PRACTICABLE TO STABILIZE EMPLOYMENT IN THE MAINTENANCE OF WAY DEPARTMENT IN THE INTEREST OF EFFICIENCY, AND THE NECESSARY MEASURES.

Lem Adams, Chairman, Sub-Committee; A. S. Butterworth, H. A. Cassil, J. A. Heaman, E. T. Howson, W. A. Murray, Cale Wamsley.

Your Committee feels that this subject should be divided into three separate and distinct sub-divisions:

First—The equalization of expenses.
Second—The determination of the extent to which the maintenance of uniform forces is justified, and
Third—The effect of uniform purchases of materials on their cost.

The Committee, in its report for last year, covered very fully the advantages of the equalization of expenses, and this report is found on pages 988 to 991, inclusive, in Volume 26, A.R.E.A. Proceedings. However, your Committee deemed it advisable to obtain data on the working of equalization. Therefore, it sent out a questionnaire to fifty representative railroads, embodying all classes of lines and territory in the United States. Out of these fifty questionnaires, we received replies from thirty-four.

Eighteen of these roads are using equalization in some form. Fifteen railroads do not resort to equalization at all and have never done so. One railroad equalized for two years (1922-1923), then discontinued the plan for two years, and now advise that they will return to the equalization of several of the Primary Accounts in 1926. It is particularly gratifying to learn that not one railroad, having taken advantage of the I.C.C. order permitting of the equalization of expenses, has condemned the practice or found it in any way unworkable, but, on the other hand, they give the plan the highest endorsement. One large Eastern system took up equalization in 1925, due to the scope and simplicity of accounting afforded in the new General Account No. 280.

Only one railroad, so far reported, equalizes for all accounts. One equalizes for ties only; seven equalize for ties and rail only; three for ties, rail and ballast; one for ties, rail and O.T.M.; three for ties, rail, ballast and O.T.M., and two for ties, new rail, O.T.M. for new rail, and labor applying new rail. (One of the latter railroads will extend the plan to ballast in 1926.) Sixteen of the eighteen railroads using the equalization plan make their spread over the entire twelve-months period, and two railroads make the spread over nine months only.

The railroads using the equalization plan are largely doing their major work in months best suited therefor. Out of the thirteen railroads reported as not resorting to equalization, six appear to favor the plan, but for various reasons do not use it, and two of these hope to get it authorized in 1926. Six advise that they do not think the equalization plan of any advantage.

From these reports there appears to be a strong majority of railroads favoring the adoption of the equalization of expenses for the two, three or four major Primary Accounts for maintenance of way work. The prevailing reason for such action is the advantages afforded by, and the evident economy from, doing work seasonally, and in most instances at a time of the year when traffic is light, thus causing the minimum interruption thereto and having a minimum of delay to their work therefrom. It also prevents the distortion of operating ratios and spreads the expense over the entire year for doing renewal work, which appears to be the correct condition, since the forces destructive to track are at work throughout the year.

From the experience of the railroads that are practicing the equalization of expenses, it does not appear that there are any material disadvantages to offset the numerous advantages. Therefore, your Committee wishes to endorse the practice as economically sound, and recommends its general adoption on our railroads, as we feel that by its application a more uniform force may be engaged in maintenance of way work and distributed over a greater portion of the year, thereby tending toward the stabilization of forces.

SUB-DIVISION NO. 2, THE DETERMINATION OF THE EXTENT TO WHICH THE MAINTENANCE OF UNIFORM FORCES IS JUSTIFIED

Your Committee has nothing to report, but is assembling information in connection therewith and proposes continuation of the study next year.

SUB-DIVISION NO. 3—THE EFFECT OF STABILIZATION OF EMPLOYMENT ON UNIFORM PURCHASES OF MATERIALS AND ON THEIR COSTS

The cost of maintenance of way work is divided between two major factors, labor and material. The effect of stabilization of forces is reflected largely and most directly in the labor costs. However, since the rate of use of materials varies with the number of men employed, any measure which tends to promote uniformity of employment will at the same time lead to the more uniform use of materials, and this in turn will tend to the more uniform distribution of their purchase and delivery throughout the year. To ascertain whether this will be reflected in the cost of these products, the Committee made inquiry of leading companies in widely separated branches of the engineering and maintenance of way supply field, inquiring specifically as to the following points:

1. To what extent is your business and that of your section of the railway supply industry seasonal? In other words, does your business tax your facilities seriously at times, and leave them only partially utilized at

others? At what periods of the year is your production at the maximum and the minimum?

2. To what extent do you regard this fluctuation as necessary and to what extent due to a "hand-to-mouth" policy of purchasing by the roads?

3. In the operation of your plants, are you able to use dull periods to accumulate stocks for later orders, or is it necessary to curtail operations and reduce forces? What is the effect of such curtailment on your production costs when your business again picks up?

4. To what extent would uniformity of purchasing aid you in reducing your cost of production?

5. Would you consider it practical to delay billing the roads for all or a portion of their orders taken into stock if the desire to avoid the accumulation of large stocks by the roads is a detriment to uniform buying?

6. In brief, do you believe that more uniform buying by the roads will be reflected in savings in the cost of their material?

Abstracts from these replies accompany this report. A study of them leads to the inevitable conclusion, which is in accord with experience elsewhere in industry, that minimum cost is secured through uniform production. Competition is such that reductions in manufacturing costs are reflected ultimately if not directly in prices charged the railways. Stabilization of forces, with the resulting increase in the uniformity of use of materials, should therefore lead to savings in the cost of these materials over and above the savings effected directly through the increased efficiency of the forces. These savings are estimated by some manufacturers to be as high as 10 per cent of their present cost of production.

ABSTRACTS OF REPLIES

From a Manufacturer of Frogs, Switches and Crossings

Our facilities are seldom seriously taxed to capacity, since in our line there is an over-capacity. Partially utilized facilities predominate, especially in the fall and the first part of the year, when there is delayed buying. Production usually is at a maximum in the early spring and early fall. The hand-to-mouth policy of purchasing is responsible largely for wide fluctuations. A consistent policy of normal replacements for maintenance and annual releases for improvements would materially reduce costs and resultant prices to the railroads.

As all of the railroads have special specifications, our material has to be built on order. We are thus unable to accumulate stocks during dull periods for later deliveries. The result is that we, of necessity, have to lay off labor trained in our line of work, which locates elsewhere, and we then have to train new hands.

It is difficult to state what uniformity of purchasing would accomplish in reducing our costs of production, but it certainly would result in large figures to both producer and buyer. It would be practical to delay billing or defer shipments with a time limit on orders to railroads which would anticipate their requirements, and thus obviate their accumulating large temporary stocks of materials.

From a Manufacturer of Track Material

Our business is seasonable. The facilities of our plants are taxed beyond their capacity at certain seasons of the year in taking care of the requirements of our customers. This means in order to take care of all the customers a large amount of expensive equipment is necessary. This equipment often runs at less than 40 or 50 per cent of its capacity through the balance of the year and at times is idle. There is no question but that better material can also be produced when the pressure is not so great, as when mill operations are normal.

I do not feel that the railroads, as a usual practice, buy "hand-to-mouth." A large proportion of the track work is done in the first six months of the year, and while the railroads may contract a long way ahead for their material, the actual shipments are not wanted until their work begins. Therefore, it is not a question of purchasing as much as it is a question of the possibility of extending their work over longer periods.

In the devices which we handle it is not practicable to accumulate stocks for later orders; in dull periods operations can be carried on only on a certain minimum basis by reduced forces. This can only be accomplished by accumulating orders for materials until these orders are large enough to warrant operations. The effect of such curtailment or shutdown is higher operating costs.

Considering the class of material we furnish, it would be impractical to make a general practice to delay billing for all or portions of orders taken from stock, for our manufactured products run into large sums of money.

Uniform production always means lower costs, and a more uniform product. It would be natural to assume that if each mill would operate at 75 per cent of a certain capacity through the entire year, rather than at 100 per cent through six months and be shut down three or four months, the cost of material would be reduced, and there is no question but this lower cost would in the end be reflected in the selling prices or the cost to the railroads.

From a Manufacturer of Track Tools

Our railroad business is seasonal. The past three years indicate that approximately two-thirds of the business is received in the first half of the year and one-third in the last half. During the first half of the year our capacity and facilities are frequently seriously overburdened and during the last half of the year our facilities are only partially utilized.

I believe that this fluctuation is unnecessary and could be avoided if the railroads would anticipate their requirements in our line, just as they anticipate their requirements for rail, rail splice bars, etc.

We are able to use dull periods to some extent and to accumulate stocks for later orders. In fact, if we did not have these we could not render even reasonable service during the busy periods. Our ability to do this, however, is limited to stocking our standard products, and as from 60 to 70 per cent of our products are made to railroad standards which differ from ours, we are compelled to enter production orders for this latter portion after the purchase orders are received.

Theoretically it is practical to delay billing a railroad for all or a portion of orders which they might place in anticipation of their requirements. We have in many instances accepted orders from railroads for our products and have made up the material and held it in our warehouse subject to shipping instructions. We have, however, usually stipulated that the complete order must be replaced for shipment prior to the end of the calendar year in which the order is placed. However, this plan has not proved satisfactory, for instances have occurred where we have carried stocks of such material in our warehouse in excess of two years. Delayed billing is practicable only if the railroads recognize the obligation which such orders impose.

Uniform buying by the railroads would give us greater uniformity in our operations and this would be reflected in a saving to the railroads, because our selling prices are based upon our costs.

From a Manufacturer of a Track Accessory

While there is a tendency toward winter track work among the Northern roads, by far the greater part of all track maintenance and construction is still done by those roads from March to August. The Southern roads do some of their track work in the winter months, but even they do a great deal of summer track work. The result is that those companies furnishing articles for track are called upon to ship material, beginning in March and terminating in August. Orders for this material are placed from January until July, there being a period of inactivity, both so far as orders and manufacturing are concerned in the period from September to January. Such a situation brings about the following unsatisfactory conditions: (1) To provide sufficient shipments during the active months, the manufacturer must have a plant of double the capacity than would be required if his shipments could be distributed over the entire year; in other words, he must have a plant to meet the shipping requirements for six busy months and then be closed down for the other six months. Such a condition creates a lack of economy in manufacture, which is shown in the cost of the product and paid for by the railroads. (2) It is impossible to build up an efficient working organization for the reason that a large percentage of the employees are only retained for a six-months period. (3) It often causes delays in shipment of material to customers, who in turn are delayed in their working programs. (4) Track work is often done without all material on hand, with the result that this material is placed in track at a later time at considerable added expense.

The railway companies could entirely eliminate the delivery congestion by placing orders for material with the manufacturers at least six months in advance, giving definite advice when material will be required for use. The manufacturer could then make up material and ship when it is required. Such procedure would entirely eliminate the closing down of the shop during the fall and early winter, as well as the congestion which exists in the spring and early summer. In many cases the manufacturer is unable to accumulate stocks for contemplated orders for the reason that railways give no assurance beforehand as to the type or quantity of material which will be bought, or as to a change of standard. A manufacturer cannot afford to take the risk which would be involved in making up material in anticipation of railway orders, when he has no assurance that he will be successful in securing the business.

If the railways were to pursue an orderly policy in the placement of their orders, and give the manufacturers plenty of time to arrange their manufacturing schedules, it would save at least 10 per cent in the manufacturing cost of the average product. Most manufacturers would prefer to manufacture material and defer billing rather than shut down their plants, or manufacture and hold in stock for a reasonable length of time. The railroads should understand that receiving material well in advance of actual requirements is of value to them and they should meet the manufacturer halfway in the matter of delayed billing or accumulation of stock. Large stocks in the railway supply field are always dangerous, as often railways, due to a sudden business depression, will delay programs, causing cancellation or holdup of orders, which would in turn cause great hardship on a manufacturer who accumulated a large stock.

From a Producer of Cross-Ties

Our business is seasonal. Ties can be manufactured to best advantage during the spring and summer months, for weather conditions are most favorable at that time. Any production that takes place during the fall and winter months is handicapped by wet weather in the woods and by conditions inherent to the timber itself. The tie business is also subject to periods of high and low activity of irregular lengths, usually covering more than a year. These latter are caused by active and inactive tie buying on the part of the railroads. The result is a serious taxing of facilities during the busy periods and a partial use of them at other times.

If it were the policy of the railroads to anticipate their requirements sufficiently in advance, the greater part of this fluctuation could be avoided; that is, advantage could be taken of favorable weather conditions in the woods to accumulate stock. Tie renewals can be anticipated closely by any railroad, so that the "hand-to-mouth" buying policy of the railroads is unnecessary.

It is impossible for any company in our line to forecast the business it will receive when the tie market becomes active. During the period of depression, therefore, it is necessary to curtail operations and to reduce forces. This results in increased costs and forced operating conditions when business again picks up, often with the added detrimental effect that the railroads find it impossible to get the grade of ties they want. Without doubt the cost of ties would be substantially lowered if it were the railroads' policy to anticipate requirements and place the orders a year or more in advance. There would be a saving in the actual cost of the delivered product and also better service, for the railroad could get what it needed at the time the product is needed. Experience has also shown that some concerns, during the stress of forced operations, lower quality and railroads, pressed for their requirements, accept ties which are below the grade for which they were purchased and are inferior in quality and manufacture. Such action not only affects the railroads from an ultimate economical standpoint, but is positively detrimental from a mechanical standpoint; furthermore, it works a hardship on all producers who maintain quality.

From a Manufacturer of Construction Equipment

From 60 to 75 per cent of our railway business is seasonal. During periods of great activity in railroad construction work our facilities are taxed to the utmost, the work dropping off as the season advances until we are obliged to reduce the number of our employees and the number of hours the plant is kept in operation. Our production is at the maximum during the spring and summer months, and at the minimum during the winter.

It seems to be the policy of some railroads to make purchases only when traffic is heavy, and, consequently, earnings large. Part of our equipment is used continuously so that there should be a fairly uniform volume of orders. That part of our equipment which is used in construction work is naturally dependent on the amount of work under way. This portion of our business probably could only be made more uniform by the railroads planning their extensions sufficiently far in advance so that contracts could be let in the fall or early winter, in order to give the contractors opportunity to place their orders for equipment to be built during the winter months.

We are able to use the dull periods to accumulate stocks for later orders only to a very limited extent and it is necessary for us to curtail operations and reduce forces. The effect of this curtailment increases production costs on account of the necessity of training new men for the work as well as increasing the overhead cost.

While we are unable to state to what extent uniformity of production would reduce production costs, except in very general terms, the amount would be considerable if we could keep the plant in operation to capacity during the entire year. We would therefore be inclined to consider favorably the billing for goods ordered during the dull periods for future use.

From a Manufacturer of Track Materials

Our business is not seasonal. We do business with nearly all of the railroads in the country and their requirements are so different that our business runs along fairly uniformly throughout the year. If there is any variation it is due to other than seasonal causes. We encounter very little "hand-to-mouth" buying. Fluctuation is due entirely to economic causes. Accumulation of stock is almost never possible, for there is too great diversity in different railroad requirements to even attempt standardization.

Uniformity of purchasing by the railroads is a goal which it is hardly reasonable to expect them to attain under the present burden of taxation and government regulation. The rich roads buy for a year's requirements at one time and the poorer ones buy when they have money. We would not undertake delay in billing our customers, for we know from experience that the practice is fraught with many dangerous or otherwise objectionable features.

We do not believe that uniform buying by the railroads would materially affect the costs of other material, at least not in our line.

From a Manufacturer of Rail Accessories

Generally speaking, our business is not seasonal, for while it is a fact that the summer months are usually quiet, the railroads pursue different policies in their rail laying programs, some laying rail in the summer, some in the winter and some in the fall and spring.

I hardly think, therefore, that a more uniform buying program on the part of the railroads would result in any reduction in the sales price of our material.

From a Manufacturer of Track Shovels

Railroads used to buy all their track shovels at one time of the year, say along in December to March; the railroads in the colder climates buying them first. This made a very short track shovel season, the orders coming in a bunch, and, needed in a hurry, did not influence the cost of production downwards. Spreading the buying throughout the year has not increased the cost of shovels to railroads and it has certainly helped them in reducing their investment and effecting a more orderly and less wasteful distribution.

From a Manufacturer of Standard Track Equipment

Our schedule of production is not affected by any of the conditions mentioned. We use as a basis for this the average monthly demand over a period of five years. A weekly inventory is taken of finished material and a semi-monthly inventory of unfinished material. These inventories must show a predetermined surplus in months, based on the average monthly requirements of the preceding five years, and our production schedule is arranged accordingly.

From a Manufacturer of Labor-Saving Equipment

Our business is seasonal. If the railroads defer the purchase of equipment until the track season commences (as has been the practice in late years) it taxes our facilities seriously at times, even to the extent of our being compelled to make deferred deliveries, resulting in the loss of valuable time to the railroads, notwithstanding the fact that we take a reasonable chance in the way of anticipating the demands and provide a reasonable stock ahead. If the railroads could and would anticipate their wants and place their orders several months in advance, it would enable us to follow a better production program and would be reflected in lower prices because it would enable quantity production.

Seasonal buying on the part of the railroads is necessary to the extent that the work to be performed with the equipment is seasonal, but the hand-to-mouth policy pursued by many railroads by holding back their purchases until the equipment is actually required on the work is necessarily reflected in higher prices, due to the fact that oftentimes express shipments of raw materials or parts entering into the construction of the equipment, and overtime work, are necessary in order to make shipment in time to avoid delays in the maintenance schedule. This also reflects to some extent in the quality of the equipment, as rush work seldom comes up to the standard of scheduled production.

We are able to use the dull periods to some extent to accumulate stocks for later orders, but at times it is necessary to curtail operation and reduce forces. We naturally try to anticipate the wants of the railroads for our equipment, and are willing to take a reasonable chance of accumulating a stock ahead of orders, but as considerable money is involved in this procedure, there is a limit to the amount that we feel justified in tieing up in a stock.

When curtailment of forces is made necessary by lack of orders, it disrupts the shop organization and naturally slows up production when business resumes again until reorganization can be effected. This is also reflected somewhat in the prices.

Uniformity of purchasing would enable the maintenance of a shop organization, the purchasing of raw materials on a more liberal basis and quantity production, all of which would be reflected materially in reduced prices of the finished product. We would not consider it practical to delay billing the railroads for all or a portion of their orders, because in our case no advantage would be gained by either party, due to the fact that no large stock of our commodity is accumulated. The railroads purchase only such equipment as is actually required to carry their maintenance schedule through economically. On the other hand, the railroads would naturally benefit by anticipating their wants and placing orders well in advance of actual requirements, insuring deliveries in time to get a full season's work out of the equipment, and at the same time with no greater outlay of money, as payments are made only on delivery, and delivery could be specified when wanted.

From a Manufacturer of a Wide Variety of Railway Supplies

That part of our business which pertains to supplying material for the maintenance of way department of railroads in this country is very seasonable, the business usually starting about February and falling off when the cold weather comes on. During the winter months our facilities in those departments are only partially utilized. This fluctuation, of course, is necessary when the railroads feel it necessary to do all of their work in the summer months, and also due to the present policy of the railroads to buy only what is necessary at the last minute.

We use the dull months for accumulation of certain stock for later orders, but inasmuch as much of our material is built to specifications for the railroads, we cannot go very far in this direction and we have to curtail operations and reduce forces during the slack months. Naturally such curtailment increases production costs when the business again picks up, as it is then necessary to break in new men when we get working to capacity. It would be hard to say what reduction we could make in our cost if a more uniform method of purchasing was followed by the railroads but it would be considerable if it would be possible for the railroads to buy material the year round.

From a Manufacturer of Culvert Material

Our business is seasonal. From the close of construction in the late fall until the opening of the season in the next spring our business is at a minimum. I do not consider that this fluctuation is necessary to the extent that it now exists. To some extent the stocking of culvert pipe would result in a more even rate of production. However, it is not practical to accumulate stocks for later orders to the extent necessary to correct this seasonal fluctuation. This is true for the fact that culvert pipe is used in a great variety of gages and diameters and the investment in a stock held would probably more than offset the benefits of uniform production.

From a Manufacturer of Track Materials

Purchases and sales of railroad products have always been "seasonal." This is especially true of railroads in the northern half of the country, where track-laying and all other outdoor activities are necessarily confined to shorter periods of time than the full calendar year, depending, of course, upon weather conditions from season to season. The labor situation, too has a distinct influence upon track work, particularly with what are called the "granger roads." Such conditions cannot help but tax our facilities seriously at times; and per contra, leave certain units of our mills under slack orders for greater or lesser periods, depending upon general business conditions.

A great deal has been stated and written regarding the "hand-to-mouth" policy of purchasing by the railroad companies, but I am not entirely in accord. Since government control I feel that the railroads have improved their methods of making purchases. They are, like any other industry dependent very largely upon what they can earn over a given period, as to whether they buy liberally or not; and while we would all like to have them constantly in the market for cars, locomotives and track materials, I can see why it would not be "good business" for them to do so.

We do not utilize so-called "dull-periods" to accumulate stocks. Our railroad business is specification business almost entirely.

Full operations on railroad material throughout any twelve-month period, provided selling values were reasonable, would certainly be reflected in lower costs of production. That is true of any department of the steel industry and would not be confined to the railroad business alone.

From a Manufacturer of Labor-Saving Equipment

Most of the railroads place their orders for material which can be charged to asset accounts at one time, covering their entire requirements for the year, at which time our facilities are taxed to their limits. During the other periods of the year the factory is engaged in fabricating material for the assembly of our products at the time when further orders are received.

Uniformity of purchasing by the railroads would reduce the cost of our production, which would no doubt reflect itself to a certain degree in the cost of our equipment to the railroads. While we would consider it practical to delay billing the roads for all or a portion of their orders placed during the dull season for delivery as required, we do not believe that the railroad supply houses should be called upon to make this concession. The railroads are strong institutions financially and the savings they would make by placing their orders in such a way as to enable the manufacturers to produce their products more cheaply would more than offset the cost of financing such a proposition.

From a Manufacturer of Heavy Work Equipment

On the whole, our business is not seasonal. The only seasonal phase of railroad buying in general is that the larger orders are more liable to come in after the first of the year when the new budgets are made up. Our observation has been that any fluctuation observed is due to a "hand-to-mouth" policy of purchasing.

We lay out our building programs several months ahead and stick to them with modifications only as required by urgent orders based on quick deliveries. We only curtail force and output when several weeks' or months' experience indicate a general decline in business, during which time it would not be wise to build up too heavy an inventory. This policy has made our peaks and valleys less sharp than in many other industries and it is not so hard to pick up when business revives.

If all railroads would adopt the policy of a few of the large ones and establish a definite replacement policy as affecting their old equipment, it would have a very beneficial effect upon our industry. Many of the smaller roads now wait until their equipment suddenly breaks down or is found to be incapable of handling some important job, and then they order hurriedly and press for very prompt deliveries which are sometimes difficult to make owing to local specialty. Anything which stabilizes production is bound to result in lower costs.

Appendix C

(4) METHODS OF MAINTAINING MOTOR CARS

F. M. Thomson, Chairman, Sub-Committee; J. D. Keiley, A. N. Reece, B. A. Wood, J. W. Kern Jr., R. W. Ross.

The railroads have adopted the motor car as an economical means of transporting labor and material. The adoption by the railroads has been so rapid and general that they now have a large investment in motor car equipment; and yet investigation shows, with a few exceptions, a lack of organized maintenance methods to insure a maximum reliability in service and minimum cost of maintenance and operation.

The early development of a means for transporting labor and material on the railroads was the pushcar. The gang was later equipped with light poles which they shoved against the ends of cross-ties to propel the car upgrade or retard speed downgrade. The next step was to equip a pushcar with a gear and crank, at which two men would sit facing each other, turning the crank until they became exhausted and then be relieved by others of the crew. This was really the first development of the handcar. In order to secure increased speed for inspection and light duty purposes there was built a car having a large roller mounted above the platform with a crank at each end and with a belt connecting the roller to the axle of the car. At this period a walking beam arrangement was used to operate pumps by small-town fire departments and by railroads at wayside water stations. This principle was applied to the pushcar and developed into our modern handcar. Since this arrangement permitted the entire gang to work on the levers at one time, it was a decided step toward economical transportation of labor and material.

The advent of the first motor car came in the early 90's, probably through the combined efforts of an active roadmaster and a manufacturer of small gasoline engines for farm purposes. This small gasoline engine was mounted on a pushcar for the roadmaster, who would in return exhibit the engine to any interested farmer along the track. This method of propelling the car became so popular that foremen and laborers would purchase small gasoline engines at their own expense and mount them on their pushcars or handcars. The railroads quickly recognized the merits and economy of this improved means of transporting labor and material. As the demand grew, manufacturers developed specially designed engines and motor cars to meet the varied needs of the railroads. At the present the tendency of the railroads is to purchase the motor car complete with frame and engine as produced by the different manufacturers. A canvass of the railroads made by the Committee did not find a railroad not using motor cars and only two where their use was curtailed on account of not being considered economical for general use.

Since about 1910 there has been a big increase in the use of motor cars on railroads by the various classes of maintenance of way and other employees in handling their work. This has been accomplished in rapid strides by improved types of motor cars to best meet the many requirements of the railroads and at the same time decrease the expense. The motor car has now become so well established that its use is almost universally recognized as a necessity for quick and efficient transportation of labor and material in the conduct of maintenance work. The recognition and adoption of the motor car has been so quick and so general that the railroads now have millions of dollars invested and yet many have not fully developed an efficiently organized method or system of maintenance. A study of the systems of motor car maintenance on the railroads by this Committee shows many varied types of organizations with a lack of accurate data in the majority of instances being kept as to actual cost of maintenance and operation of the various makes and types of motor cars; also their records often fail to show the percentage of cars which are out of service in the shops and the percentage of cars on assignments out of service awaiting repairs in the field.

In order to get the maximum results from the investment it is apparent that motor cars should be maintained in serviceable condition on a regular assignment. Cars out of service while assigned not only result in loss of interest on the investment, but also in additional expense through the slowing up of the handling of men and material. Since the general adoption and use of motor cars, new methods of handling work on a more efficient and expedient basis have been developed. As a consequence, when a motor car fails, the job is interfered with more seriously than had the work been planned for the use of the less expedient handcar.

The Committee selected thirty of the principal railroads of the United States and Canada and investigated with them as to their methods of motor car maintenance. The methods in use by them were found to be varied from meager organizations for motor car maintenance to highly organized systems of keeping motor cars in first-class service condition at all times.

TYPICAL ORGANIZATIONS

We have chosen as typical and have briefed some of the motor car maintenance organizations now in effect on several important railroads, as reported to the Committee by them:

Railroad "A"

This railroad maintains about 2200 motor cars with 21 maintainers, an average of about 100 cars per man. Each maintainer is furnished with a light motor car and carries a certain amount of material for repairs. He inspects and makes all necessary adjustments and repairs to each car as he covers his territory. He makes a report for each job in triplicate on regular form, which shows distribution of time and material used. Copy of this form is furnished Superintendent, Master Mechanic and Supervisor of Tools and Motor Cars. A motor car shop is maintained on each General Manager's District. Cars are only sent to shop when in need of general repairs or overhauling. All light repairs are made by maintainer in the field. He sends in such cars as he is unable to repair on the line, and then only after personal inspection. General repairs and maintenance of cars are handled directly under Mechanical Department. In order to keep complete and individual record of cars they are given an individual serial number. At the close of each month Superintendent furnishes Supervisor of Tools and Motor Cars with a statement showing charges for labor and material to each individual car repaired by maintainers. Each shop furnishes similar statement of expense. These are consolidated in the office of Supervisor of Tools and Equipment, where system report is made showing performance of all cars by classes and other data assembled on cost per mile basis. This railroad reports the plan has worked very satisfactorily.

Railroad "B"

This company maintains approximately 2000 motor cars of various types and makes. The Motor Car Department, looking after these cars, consists of a supervisor of motor cars and two motor car inspectors. The major part of the time of one of these inspectors is spent in looking after seven gas electric cars, and also acting as trouble shooter in the electrified zone. All water service pump repairers are also requested to render such assistance as they have time for in looking after motor cars. They have one motor car repair shop under the jurisdiction of the Store Department where motor cars needing general overhauling are sent, together with such cars as are ready for dismantling to salvage the parts. There is only one storeroom for motor car repair parts, and it carries only a small stock of parts for types in general use. This railroad plans to confine its purchases of new motor cars to such types as can be maintained by operators, whom it holds responsible. Operators of the car order such parts as may be needed for replacement and apply them when received, sending old parts to local storekeeper, who in turn sends them to the shops. If repairable, these parts are used in making repairs to cars and engines sent to shop for overhauling. This road reports their operators have had years of experience operating and maintaining types of cars assigned to them and find they are fairly successful in keeping up their cars if furnished repair parts they need. This road gets monthly reports covering each car from the operator, and advises that as a rule they have 95 per cent or better of the cars in service at all times. It feels that when the responsibility is put directly upon the operator, a more conscientious effort is made to post themselves on the proper operation and maintenance. They know that if they do not do this they may be compelled to operate handcars, which they dislike to do. Such operators as do not understand the proper operation and maintenance of their cars are educated along this line by the motor car inspectors. Obsolete type cars and engines which cannot be kept going by repairs in the field are shipped to the shops and new cars are sent out to take their places. It is felt by this railroad, that, if furnished only such equipment as is very simple to understand and operate, the operator who can intelligently operate it can also maintain and keep his motor car in continuous service better than if he was not permitted to make the necessary repairs and had to wait until the maintainer could get to him.

Railroad "C"

The method of supervising motor car operation and handling work on these lines is as follows:

They have on each division of approximately 600 miles a traveling motor car mechanic, who is required to spend practically all of his time on the line checking up conditions of motor cars, making minor repairs and adjustments, and instructing foremen in the proper way of handling the cars. When a car gets in such condition that extensive repairs or overhauling are required, the maintainer makes out a repair report which is forwarded to the shop. Maintainers are required to make weekly reports showing exactly the territory covered each day and the detail of the work performed. These reports are relayed to Chief Engineer's office through Superintendent's office. The Signal Engineer exercises general direction and supervision over the three regional repair shops which are operated in conjunction with signal interlocking repair shops under the Signal Supervisor having jurisdiction at the Division headquarters where they are located. At each shop is kept a fairly large stock of motor car parts for the various kinds of cars in service. These stocks are replenished from the System General Store. A list has been made of a standard stock of repair parts to be kept on hand at the General Store, and as material is ordered out this stock is replenished. At various times consideration has been given to the formation of a separate motor car department under the direction of a supervisor reporting directly to the Chief Engineer. However, it has been felt that this would add new overhead expense and the results would be but little, if any, better. With their present system, the Superintendent is responsible for the proper care and operation of motor cars on his division, and through reports from his traveling motor car mechanic is kept fully posted on conditions.

Railroad "D"

This railroad is almost 7000 miles long and is equipped with motor cars, but has no distinct motor car department. Repairs are handled on each division through requisition for repair parts, which are sent direct to the foremen to make their own repairs. Cars requiring general overhauling are sent to one of the central mechanical shop points, where work is done by regular mechanical forces. This railroad reports for this reason they have no special data as to work done, cost, etc. They do not report whether their method is entirely satisfactory to them or not.

Railroad "E"

This railroad, with about 1000 motor cars distributed over 5000 miles, has the following organization which looks after motor cars, tie tampers, gasoline cranes, gasoline bonding drills, etc. A Motor Car Supervisor, reporting to a General Maintenance Officer, and eleven motor car maintainers reporting to Motor Car Supervisor and to local Division Roadmasters. The duties of Motor Car Supervisor are to give general supervision to the shop and operation of the cars on the road and to consult with the Division Maintainers as to their work.

The one shop working under the Supervisor carries all repair parts for the system, rebuilds wrecked cars whenever it is considered economical, handles general overhauling, and repairs power plants for exchange. Inspection report on each car visited is made by Maintainer to Motor Car Supervisor. Monthly performance report is made by operator to Division Officer. Division Officer compiles these reports and furnishes reports to the General Office. Data relative to each car is entered on a card so that the performance of each car is shown continuously over a period of years, thus enabling anyone to determine quickly the service of any car. All this information is compiled after the end of each year into a general statement to show mileage made by different types of cars, cost of operating the cars, etc.

There is not usually more than 1 or 1.5 per cent of the cars out of service at any time. The cars overhauled in the shop are expected to be as good as they can be made without entirely replacing all parts. Effort is made to maintain the cars in a uniformly good condition. This railroad feels that their method of maintaining the motor car is the most economical they could devise, and also that the plan of having a central stock of repair parts is much more economical than permitting the maintainers to carry their own stock. They are able to reach any point with repair parts within twenty-four hours.

Railroad "F"

This is a system of about 8000 miles, equipped with motor cars. They are handling motor cars along with work equipment and all labor-saving devices or machines used by the Construction and Maintenance Departments.

The Supervisor of Work Equipment, reporting to the Chief Engineer, Assistant Chief Engineer or Engineer Maintenance of Way System, exercises general supervision over all such equipment. The District Motor Car Inspector, reporting to the District Engineers, Maintenance of Way, exercises supervision over the machines assigned on the district. The Division Motor Car Inspector, there being one to three on each Superintendent's territory, is directly in charge of the maintenance and operation of such machines on the territory assigned to him.

Each Division Motor Car Inspector has a stock of repair parts for the various motor cars, which is kept up to a standard list.

This railroad does not rebuild or overhaul cars in the shops, but applies new parts (even woodwork) purchased direct from the manufacturers. The only shop work is done by the maintainer at his bench in tool house. They report that they have been working along these lines for five years and feel they are getting good results.

Railroad "G"

This railroad, although one of the largest northern roads, does not make a practice of furnishing motor cars to section men. If a section man buys an engine the railroad furnishes a body equipped with roller bearings, four-wheel brakes and safety top, on which to mount the engine.

The company furnishes gasoline, oil and dry cells for operation and certain minor repair parts. Heavy repairs, such as complete timers, carburetors, pistons or cylinders, are not furnished at the present time, the consensus of opinion is that if the foreman is the owner of the engine, better care will be taken of it, both with regard to operation and maintenance.

Motor cars are furnished to Engineers, Roadmasters, B. & B. Supervisors and Signal Maintainers. Light repairs are made to these cars by the men operating them. If heavy repairs are needed, these are attended to in B. & B. Division shops.

No special reports are kept with regard to the cost of operation and repair of company cars at the present time.

DISCUSSION

The Committee feels that on the various railroads the conditions are such that no definite or fixed organization can be recommended to fit every railroad, particularly the smaller railroads or those having a limited number of motor cars to maintain. However, we feel that certain definite recommendations can be made towards the establishment of an organized system of Motor Car Maintenance which will obtain reliable service from motor cars at an economical cost. The fundamental principles of this organization, if not all details, may also be applied with advantage by the railroads having a limited number of cars to maintain.

Fundamentals of Good Maintenance of Motor Cars

Any system organization for efficient and economical motor car maintenance should recognize the importance of the following:

1. Sufficient instruction to Operators, with rigid enforcement.

2. Regular inspection and cleanliness as a preventative of failures.
3. Rapid and careful distribution of material and supplies.
4. Value of doing as much field repair work as possible to reduce delays to work.
5. A centrally located repair shop exclusively for motor cars, well equipped with modern machinery.
6. Supervisor of Motor Car Maintenance and Operation with authority.
7. Desirability of uniform records of costs.
8. Simplification and standardization of types and parts.

It depends somewhat on individual opinion which one of the above items is most important. Undue importance attached to one without due regard to the others would easily defeat the success and efficiency of the whole plan. For instance, it is easy to imagine how a system stressing uniform costs could work to restrict the free use of motor cars just to keep unit costs down, or how stressing minimum line delay an undue amount could allow extravagant use of repairs and labor, or how too close a policy on issuing repair parts would keep a large number of motor cars out of service, resulting in men walking to and from work or being forced to use handcars.

Instructions to Operators

If any one of the above points can be stressed without disturbing or detrimental results, it is instructions to operators. Careful coaching of operators in handling motor cars is important. Without proper handling difficulty will be experienced with the most carefully designed car. The personal equation, to a certain extent, can be reduced through the motor car manufacturer by keeping the cars simple and understandable; but, nevertheless, it cannot be entirely eliminated and, therefore, should be given careful consideration by the railroad organization. Rules relative to the care and operation of motor cars as covered by "Rules for the Guidance of Employees of the Maintenance of Way Department" in the Manual, will serve as a guide.

Inspection and Cleaning by Operators

Among the general rules and regulations regarding motor cars, one of the most important is that the cars must be kept clean and regularly inspected by the operators. It has been demonstrated times without number that motor cars which are kept clean give less trouble, longer service, and cost less for upkeep. If an operator regularly and thoroughly cleans his car at least once each week, he finds the loose bolts, nuts and other defects. Troubles are then corrected before they have time to do much damage. If the cars are regularly cleaned the operators cannot help but automatically inspect them. Some railroads have a rule that the men must thoroughly inspect their cars at frequent intervals, but have no assurance that it is done unless the cars are kept clean. Clean cars are a sure indication that the inspections are made. An important feature in this connection is that of safety; a considerable percentage of the motor car accidents is due to failure of parts which have been gradually loosening, wearing or failing in some manner over a period of several weeks, or even months.

Distribution of Supplies and Repairs

Obviously stores should be centrally located for rapid distribution to all parts of the line in order to get cars back into service with the least delay. Repair and supply requisitions should be closely and intelligently checked by someone with knowledge of the actual needs to prevent waste and yet get to the operator what he really needs. The use of relief cars is a great help in keeping gangs equipped and in preventing loss of time. The relief power unit is used to the same advantage. It is shipped by baggage in a crate to operator or maintainer. After the exchange of power units the bad order unit removed is placed in the crate, shipped back to the shop for repairs, and is then available for similar use elsewhere.

The stock of repair parts in the field should be held to a minimum. Maintainers should keep a supply of parts for light repairs only. Material for heavy field and emergency repairs should be shipped direct to the car from the stores for use of the Maintainer on that particular car.

Maximum Service Through Road Repairs and Shop Schedule

In order to get maximum service out of cars and full return on the investment it is necessary to have an organization based upon keeping motor cars assigned to service approximating 100 per cent of the time and with a minimum delay while on line in gangs where they are assigned. As much repair work as practical should be done in the field. When necessary to shop cars for overhauling, they should be moved promptly to and from the shops. Cars going to the shops should be regulated according to the current output of the shop. There is a loss of interest on investment, and often delay to work of gangs, by permitting cars to accumulate awaiting their turn at the shops.

Motor Car Repair Shops

Where there is sufficient work to justify the maintaining of a separate motor car shop, it is not considered satisfactory to have the work done in the Mechanical Department shops, even though separate mechanics may be detailed exclusively for the motor car work. Motor car repair shops, wholly under the supervision of the Maintenance of Way Department, should be maintained centrally located for overhauling or rebuilding cars. In no case should the repairs be done by or under the direct supervision of the mechanical forces, as these men are not familiar with motor cars and are primarily interested in locomotives and other work of that nature. The motor car mechanics and repairmen should have special training entirely different from other shop employees, in that motor car repairs are often more exacting as to fits and practice and require different handling of tools and machinery. A motor car shop should be equipped with sufficient modern tools and machinery to handle repairs and overhauling of cars quickly and economically. Modern equipment, especially designed to meet the requirements, should be used, and not that discarded from other shops. The number and location of shops will best be determined by local conditions and requirements. A store with a complete stock of motor car repair parts should be operated in conjunction with each shop. The Committee has prepared a list of tools and equipment for a motor car repair shop handling the repairs of approximately 1000 or more motor cars in service. This list was compiled from the equipment used in several railroad motor car shops supplemented by recommendations from the motor car manufacturers, and is shown in the addenda to this Appendix.

Organization—General

The organization should be headed by a practical railroad man with sufficient executive ability and sound mechanical knowledge to supervise the maintenance and operation of motor cars over the entire system. He should report direct to the Chief Officer of Maintenance of Way, as this department uses most of the motor cars and is most vitally interested. To be most successful the Motor Car Organization must have authority to institute certain regulations as required, and to enforce them. The success and value of motor cars depends just as much upon the methods of maintenance and operation as upon the cars themselves. The System Supervisor's duties should embrace direct control of all mechanical details of the cars, supervision of the maintainers, responsibility for correct individual and system reports, regulation of purchase of cars and supplies in conjunction with the Stores Department, and supervision through other officers of the care and operation of motor cars.

Organization—Divisional

Motor car maintainers either will report to the System Supervisor or be responsible to him through the divisional organization. The number of cars or the territory to be assigned to a maintainer will depend upon the distribution of the cars, the extent of their use and other conditions. Where consistent with the amount of work, maintainers' territories should conform to the various operating divisions of the railroad. On territory fully equipped with motor cars, each maintainer will handle the repairs of about 100 cars. They should be provided with a light motor car and equipped with a supply of parts for ordinary repairs. They will spend their time on the road instructing operators, inspecting cars, and making repairs within the limits of economy. It will be the duty and responsibility of the maintainer to determine whether a car will be repaired in the field or the shops. When a car has reached such a condition that extensive repairs and rebuilding are necessary, the maintainer will furnish a work report to the Supervisor who will notify the maintainer when the car should be shipped to conform with the working schedule of the shops.

Cost-Keeping Methods and Statistical Records

Uniform records of cost of maintenance and of operation are indispensable in determining which types and makes of motor cars are the most economical. They will indicate whether a certain organization is operating efficiently, and will furnish a basis of comparison of one division with the remainder of the system, or of one railroad with another. These records will also indicate definitely the limiting point of expense justifiable in keeping their cars in condition for service. In the Proceedings for 1923, Volume 23, pages 1007, 1008, 1009, Rules and Organization Committee, there has been suggested a set of unit cost reports. However, our investigation shows that the railroads with the better motor car maintenance organization now in effect are varying from these to get certain other valuable data. We recommend the forms referred to in Conclusion 7 of this report.

System Supervisor and office expense will be pro-rated over all cars on the system. All labor, material and Maintainer's expense is charged to the individual motor car as worked on, regardless of whether material is applied in shops or on line. Charges for emergency jumps and general trips will be pro-rated over all cars on the division.

As typical motor car cost data and information, the Committee has selected and shown as Exhibits 5, 6 and 7, statements from those submitted by the railroads for the year 1924. These reports also exemplify the manner in which the forms recommended by the Committee may be used to determine which types and makes of motor cars are the most economical and how comparisons may be obtained as to the operating and maintenance costs.

Standardization of Types and Parts

Much can be done to reduce motor car maintenance expense by the adoption of the fewest number of makes and types of cars by each railroad that will best meet its needs and requirements. The manufacturers can still produce simpler cars that can be maintained and operated with less cost and yet meet the railroads' requirements satisfactorily. Also, through co-operation between the railroads and the manufacturers, many parts of the motor car, such as the brakes, frames, bearings, etc., can be standardized and made interchangeable on all makes of motor cars. These measures will tend to reduce the investment in stock parts and lower repair costs, irrespective of the system of Motor Car Maintenance Organization in effect.

The following conclusions are submitted by your Committee, with the recommendation for adoption by the Association and publication in the Manual.

CONCLUSIONS

The varying conditions on different railroads do not permit the universal acceptance, in all details, of any specific outline of an organization for the maintenance of motor cars, especially on those railroads which use only a limited number of cars. However, certain fundamental principles can be recommended for the establishment of an organized system which will obtain reliable service at an economical cost. The following principles, while essential to roads having a large number of motor cars, also apply in some degree to all railroads, depending upon the number of motor cars in service.

1. The instructions for motor car operators should be plain and sufficient, and should be rigidly enforced. Rules relating to the care and operation of motor cars, included in the "Rules for the Guidance of Employees of Maintenance of Way Department" in the Manual will serve as a guide in formulating these instructions.

2. Motor cars must be kept clean, and must be inspected regularly by the operators. Clean cars give longer service, with less trouble, and cost less for maintenance. Clean cars indicate that inspections are being made regularly by the operator. This will aid in detecting defects before they become serious.

3. Stores should be centrally located, for rapid distribution of repair parts, in order to get cars back into service with the least delay. Requisitions should be judiciously checked. The use of relief cars and relief power units will reduce delay in the event of motor car failure.

4. The emphasizing of field repairs while on the job, and the sending of cars to shops for overhauling on a schedule regulated in accordance with the current output of the shop, and based upon the service and mileage that should be reasonably expected from the car, will insure maximum service from cars.

5. Where there is sufficient work to justify, motor car shops centrally located and wholly under the control of the maintenance of way department, should be maintained for repairing worn or damaged cars. Modern equipment, especially designed to meet the requirements of motor car repairs, should be provided..

6. The organization for the maintenance of motor cars should be headed by a practical railroad man, with sufficient executive ability and sound mechanical knowledge to supervise the maintenance and operation of motor cars over the entire system. To be most successful this System Supervisor should have authority to institute certain regulations for the care and operation of motor cars, and to enforce them. The success and value of motor cars depend just as much on the methods of maintenance and operation as upon the cars themselves. The System Supervisor's duties should embrace direct control of all mechanical details of the cars, supervision of all maintainers, responsibility for correct individual and system reports, regulation of purchase of cars and supplies in conjunction with the Stores Department, and supervision through other officers of the care and operation of motor cars.

Motor Car Maintainers, approximating one for each 100 cars, should report to the System Supervisor, or, through the divisional organization, be responsible to him. They should spend their time on the road instructing operators and making regular field inspections and repairs.

7. Uniform records of inspection, and of cost of maintenance and operation are indispensable in determining the most economical type and make of motor car. Such records will indicate whether an organization

is operating efficiently, and will furnish a basis for comparison. These records will also indicate the expense justifiable in keeping a car in condition for service. In keeping these records the forms presented in Exhibits 1, 2, 3 and 4 are recommended.

8. Motor car maintenance expense can be reduced through the adoption of the fewest number of makes and types of cars by each railroad to best meet its needs and requirements. The use of standard parts interchangeable with various makes of cars is recommended to reduce investment in stock parts and to lower maintenance costs.

Exhibit 1

.... RAILROAD

MOTOR CAR CONDITION REPORT

....................Division Date..................

Class............ No........... Manufacturer................ Service................

Location........................ Date................ Date Last Inspected..............

	Good	Fair	Bad	Remarks
Body				
Safety Rail				
Rail Sweep				
Wheels				
Axles and Bearings				
Brake				
Bolts and Fastenings				
Coupler				
Spark Coil				
Batteries				
Wiring				
Switches				
Timer				
Spark Plugs				
Magneto				
Tank and Connections				
Connecting Rod				
Piston and Rings				
Wrist Pin				
Cylinders				
Coaster Valves				
Exhaust Valves				
Intake Valves				
Carburetor				
Cam Shaft				
Main Bearings				
Transmission and Drive Gear				
Crank and Gear Case				
Lubrication				
Fuel Supply				
How Kept				
General Condition and Care				
Gage				
Any Unauthorized Appliances (yes or no)				
Proper Signal Equipment (yes or no)				
Time Card Carried (yes or no)				

This report to be made by Division Motor Car Inspector, covering all cars in his territory, regardless of position held by employee using car or department in which employed, and must be signed by employee using or in charge of car. Use (X) to indicate condition of parts; use back of sheet for further explanation.

This report shows true condition of car:

....
Division Motor Car Inspector.

....
Foreman or Employee in Chargee of Car.

Exhit

(MOT

e

Lubricant

Lubricat Oil Us Gallo

Exhibit 2

RAILROAD

MOTOR CAR OPERATOR'S AND MAINTAINER'S MONTHLY REPORT

Car No.

Month of 192 Type

Car Owner Manfr

District . .Location Sec. No.

	Amount	Price	Cost
		Leave Blank	
Days out of service account bad order			
" " " " " idle, including Sundays and Holidays			
Number of miles operated during month			
Gallons clear gasoline used during month			
" mixed " " " "			
" clear kerosene "			
" mixed "			
Quarts cylinder oil			
Pounds cup grease			
Number feet belt " "			
" batteries			
" spark plugs			
" canvas covers " " "			

General condition of Car . ... Good .. Fair Bad
(Underline the word which shows car condition)

Remarks

Motor Car Operator

Repairs Made During Month (Detailed)

Description Labor Performed and Repair Parts Used	Labor Cost		Material Cost	Total Cost Labor and Material
	Shop	Field		

192

Motor Car Maintainer

....

ROADW

Out of

f Awaiting
nd Repairs

Per cent
of Total

....192...

Exhibit 3

. . . Railroad

RECAPITULATION OF ROADWAY MOTOR CAR REPORTS

Division Class of Service Location

Car No Engine No Mfg'r Shop No Mfg'r Model

Month 192	Total Car Days	In Service Car Days	Out of Service		Total Miles Run	Fuel and Lubricants		Cost of Repairs						Total Cost Labor and Material	
			Awaiting Material and Repairs	Account Idle, Including Sundays and Holidays		Gasoline Used Gallons	Lubricating Oil Used Gallons	Shop Labor		Field Labor		Material			
Brought forward from previous report															
January															
February															
March															
April															
May															
June															
July															
August															
September															
October															
November															
December															
Total for Year															
Grand Total															

nd
s

Exhibit 4

....Railroad

ROADWAY MOTOR CAR SERVICE AND MAINTENANCE COST

Year Ended December 31, 192..

No. of Cars	Type	Total Car Days	In Service		Out of Service				Total Miles Run	Fuel, Lubricants and Other Supplies		Cost of Repairs					Cost Operation and Maintenance		
					Account of Awaiting Material and Repairs		Account Idle, Including Sundays and Holidays												
			Car Days	Per cent of Total	Car Days	Per cent of Total	Car Days	Per cent of Total		Total Cost	Cost per Mile	Shop Labor	Field Labor	Material	Total	Average per Mile	Total	Per Mile	Per Day of Service

Exhibit 5

Railroad H

COST OF MAINTAINING AND OPERATING MOTOR CARS FOR YEAR 1924—GROUPED BY TYPES

Number of Cars	Make and Type	Miles	Shop Repairs		Field Repairs		Total Shop and Field Repairs	Material and Supplies for Operation of Car	Total Expense	Average Cost Per Mile						
			Labor	Material	Labor	Material				Shop Labor	Shop Material	Field Labor	Field Material	Shop and Field Repairs	Material and Supplies for Operation of Car	Total
3	DU	89,975	$	$	$153.58	$	$153.58	$1,677.40	$1,830.98	$	$	$ .002	$	$ .002	$ .018	$ .020
284	AP	885,468	4,249.21	3,374.84	12,986.15	3,207.72	23,817.92	15,669.56	39,487.48	.005	.004	.015	.001	.028	.017	.045
32	AQ	180,298	940.60	814.41	1,925.07	823.07	4,503.24	2,903.11	7,406.35	.005	.005	.010	.005	.025	.016	.041
48	AR	271,490	1,157.68	2,622.47	2,534.58	507.48	6,822.21	3,145.50	9,967.71	.004	.010	.009	.002	.025	.012	.037
43	AS	151,818	1,627.51	1,908.22	2,464.19	1,177.51	7,177.43	2,451.13	9,628.56	.011	.013	.016	.007	.047	.016	.063
96	AT	576,172	1,744.58	1,372.03	5,635.39	3,008.96	11,760.96	5,423.91	17,184.87	.003	.002	.010	.005	.020	.009	.029
35	CO	119,372	202.77	136.96	2,087.37	610.47	3,037.57	2,777.68	5,815.25	.002	.001	.017	.005	.025	.023	.048
9	BW	29,546	53.41	26.24	354.09	143.23	576.97	305.78	882.75	.002	.001	.012	.005	.020	.010	.030
10	BX	31,659	6.49		401.91	171.97	580.37	326.35	906.72			.013	.005	.018	.010	.028
39	BY	116,960	673.47	411.17	2,074.10	775.51	3,934.25	2,010.32	5,944.57	.006	.004	.017	.007	.034	.017	.051
105	BZ	302,973	1,898.70	1,007.45	4,973.61	1,058.94	8,938.70	6,639.02	15,577.72	.006	.003	.017	.003	.029	.022	.051
Company Owned 704		2,755,731	$12,554.51	$11,673.79	$35,590.04	$11,481.86	$71,303.20	$43,329.76	$114,632.96	.005	.004	.013	.004	.026	.016	.042
Privately Owned 34		90,521	83.35	48.68	1,058.28	730,26	1,920.57	2,123.31	4,043.88	.001	.001	.011	.008	.021	.023	.044
Total, All Cars 738		2,816,252	$12,637.86	$11,722.47	$36,648.32	$12,215.12	$73,223.77	45,453.07	118,676.81	.004xc	.004c	.013c	.004c	.025c	.016c	.011c

Exhibit 6

Railroad H

COST OF MAINTAINING AND OPERATING MOTOR CARS FOR YEAR 1924—GROUPED BY TYPE AND CLASS OF SERVICE

Class of Service	Number of Cars	Make and Type	Miles	Shop Repairs		Field Repairs		Total Shop and Field Repairs
				Labor	Material	Labor	Material	
B. & B.	4	AP	24,395	$ 67.26	$ 42.35	$ 221.15	$ 149.42	$ 480.18
	3	AQ	6,908	156.84	135.39	130.03	8.01	430.77
	1	AR	1,546	8.26	44.54	97.36	.26	150.42
	32	AS	116,677	1,392.13	1,582.62	1,890.66	971.21	5,836.62
	7	AT	27,611	166.14	117.82	339.69	98.13	721.78
	1	CO	2,472	......	......	72.13	31.84	103.97
Total	48	......	179,609	1,790.63	1,923.22	2,751.02	1,258.87	7,723.74
Section	275	AP	849,815	4,045.37	3,209.62	12,552.13	3,034.42	22,841.54
	13	AQ	49,201	398.03	307.37	709.21	190.94	1,605.55
	34	CO	116,900	202.77	136.96	2,015.24	578.63	2,933.60
	38	BY	116,960	673.47	411.17	2,069.24	775.51	3,929.39
	104	BZ	300,712	1,824.91	978.43	4,933.15	1,047.51	8,784.00
	5	BX	11,716	3.29	......	178.24	55.50	237.03
Total	469	......	1,445,304	7,147.84	5,043.55	22,457.21	5,682.51	40,331.11
Roadmaster	28	AT	204,036	385.41	225.18	2,015.41	1,062.60	3,688.60
Paint Gang	1	AP	740	......	......	27.86	......	27.86
	1	AR	4,213	76.98	114.90	40.71	2.33	234.92
Total	2	......	4,953	76.98	114.90	68.57	2.33	262.78
Signal Dept.	1	AP	2,180	......	......	31.36	5.83	37.19
	5	AQ	16,911	100.17	49.39	206.45	65.60	421.61
	30	AR	181,102	681.19	1,751.55	1,534.08	352.39	4,319.51
	2	AS	5,465	......	......	102.83	34.16	136.99
	6	AT	31,378	103.09	81.43	291.01	151.73	627.26
	2	BW	12,833	......	......	84.97	41.14	126.11
	1	BX	5,825	......	......	53.18	.47	53.65
Total	47	......	255,694	884.75	1,882.37	2,303.88	651.32	5,722.32
Telegraph Dept.	1	AP	2,180	67.19	53.90	39.61	1.14	161.84
	3	AQ	13,500	89.60	81.04	136.83	10.55	318.02
	9	AR	56,174	286.98	504.30	490.31	86.37	1,367.96
	12	AT	85,786	171.89	249.08	802.87	594.35	1,818.19
	1	BW	495	......	......	18.16	12.23	30.39
	1	BY	......	......	......	4.86	......	4.86
Total	27	......	158,135	615.66	888.32	1,492.64	704.64	3,701.26
Car Dept.	5	AR	23,769	78.47	136.63	274.55	56.08	545.73
	1	AS	11,950	......	......	35.86	6.43	42.29
	10	AT	61,907	315.00	233.05	577.16	261.69	1,386.90
	1	BX	3,765	......	......	33.06	......	33.06
Total	17	......	101,391	393.47	369.68	920.63	324.20	2,007.98
Scale Dept.	6	AT	17,898	85.60	59.44	213.81	39.00	477.85
Pumpers	3	AT	25,217	73.02	36.68	164.74	105.12	379.56
	5	BW	15,912	53.41	26.24	205.60	71.47	356.72
	1	BX	7,925	3.20	......	65.91	115.52	184.63
Total	9	......	49,054	129.63	62.92	436.25	292.11	920.91
Engr. Dept.	1	AP	2,586	69.39	68.97	80.68	9.13	228.17
	1	AR	3,224	25.50	70.55	47.56	......	143.61
	1	AS	2,340	......	......	39.37	26.46	65.83
	6	AT	19,155	111.00	123.27	230.29	263.82	728.38
Total	9	......	27,305	205.89	262.79	397.90	299.41	1,165.99
Water	6	AT	30,068	87.78	90.28	253.87	125.87	557.80
	1	BX	2,428	......	......	43.66	.48	44.14
Total	7	......	32,496	87.78	90.28	297.53	126.35	601.94
Fence Gang	1	AP	3,572	......	......	33.36	7.78	41.14
	2	AS	7,874	......	......	108.37	66.42	174.79
	1	BZ	2,261	73.79	29.02	40.46	11.43	154.70
Total	4	......	13,707	73.79	29.02	182.19	85.63	370.63
Superintendent	8	AQ	93,778	196.05	240.72	742.55	547.97	1,727.29
Store Dept.	2	AT	167	3.47	13.80	39.37	10.51	67.15
	1	BX	......	......	......	27.86	......	27.86
Total	3	......	167	3.47	13.80	67.23	10.51	95.01
Extra Gang	2	AS	3,895	225.52	309.10	157.17	70.98	762.77
Yardmaster	1	AT	1,910	3.79	......	64.91	14.84	83.54
Hump	3	DU	89,975	......	......	153.58	......	153.58
	1	AS	325	......	......	27.86	......	27.86
Total	4	......	90,300	......	......	181.44	......	181.44
Steel Gang	2	AS	3,292	9.86	16.50	102.07	1.85	130.28
Agent	1	BW	306	......	......	45.36	18.39	63.75
Roundhouse	1	AR	1,462	......	......	50.01	10.05	60.06
Motor Car Maint.	9	AT	71,039	238.39	142.00	612.26	231.30	1,223.95
Total Company Owned	704	......	2,755,731	$12,554.51	$11,673.79	$35,590.04	$11,184.86	$71,303.20
Total Privately Owned	34	......	90,521	83.35	48.68	1,058.28	730.26	1,920.57
Grand Total	738	......	2,846,252	$12,637.86	$11,722.47	$36,648.32	$12,215.12	$73,223.77

Railroad H

Exhibit 6

COST OF MAINTAINING AND OPERATING MOTOR CARS FOR YEAR 1924—GROUPED BY TYPE AND CLASS OF SERVICE

Material and Supplies for Operation of Car	Total Expense	Average Cost Per Mile						
		Shop Labor	Shop Material	Field Labor	Field Material	Shop and Field Repairs	Material and Supplies for Operation of Car	Total
$ 365.39	$ 845.57	$ .003	$ .002	$ .009	$ .006	$ .020	$ .015	$ .035
149.41	580.18	.023	.019	.019	.001	.062	.022	.084
22.70	173.12	.005	.028	.063	......	.096	.015	.111
1,794.78	7,631.40	.012	.014	.016	.008	.050	.015	.065
311.09	1,032.87	.006	.004	.012	.004	.026	.011	.037
90.56	194.53	......	......	.029	.013	.042	.037	.079
2,733.93	10,457.67	.010	.011	.015	.007	.043	.015	.058
15,115.89	37,957.43	.005	.004	.015	.004	.028	.017	.045
806.54	2,412.09	.008	.006	.015	.004	.033	.016	.049
2,687.12	5,620.72	.002	.001	.017	.005	.025	.023	.048
2,010.32	5,939.71	.006	.004	.017	.007	.034	.017	.051
6,565.55	15,349.55	.006	.003	.016	.004	.029	.022	.051
137.21	374.24	......	......	.015	.005	.020	.012	.032
27,322.63	67,653.74	.005	.003	.016	.004	.028	.019	.047
1,949.66	5,638.26	.002	.001	.010	.005	.018	.010	.028
15.26	43.12	......	......	.037	......	.037	.021	.058
46.24	281.16	.018	.027	.010	.001	.056	.011	.067
61.50	324.28	.016	.023	.014	......	.053	.012	.065
53.03	90.22	......	......	.014	.003	.017	.024	.041
311.75	733.36	.006	.003	.012	.004	.025	.018	.043
2,159.71	6,479.22	.004	.009	.008	.002	.023	.012	.035
101.36	238.35	......	......	.019	.006	.025	.018	.043
283.07	910.33	.003	.003	.009	.005	.020	.009	.029
135.16	261.27	......	......	.007	.003	.010	.010	.020
58.01	111.66	......	......	.009	......	.009	.010	.019
3,102.09	8,824.41	.003	.007	.009	.003	.022	.012	.034
47.15	208.99	.031	.025	.018	.001	.075	.021	.096
271.17	589.19	.007	.006	.010	.001	.024	.020	.044
603.48	1,971.44	.005	.009	.009	.002	.025	.010	.035
769.39	2,587.58	.002	.003	.009	.007	.021	.009	.030
5.60	35.99	......	......	.037	.025	.062	.011	.073
......	4.86	......	......	......	......	......	......	......
1,696.79	5,398.05	.004	.006	.009	.004	.023	.011	.034
260.93	806.66	.003	.006	.012	.002	.023	.011	.034
209.88	252.17	......	......	.003	.001	.004	.017	.021
602.57	1,989.47	.005	.004	.009	.004	.022	.010	.032
33.22	66.28	......	......	.009	......	.009	.009	.018
1,106.60	3,114.58	.004	.004	.009	.003	.020	.011	.031
186.99	664.84	.005	.003	.014	.005	.027	.010	.037
222.83	602.39	.003	.001	.007	.004	.015	.009	.024
182.28	519.00	.003	.002	.013	.004	.022	.010	.032
68.41	253.04	......	......	.008	.015	.023	.009	.032
453.52	1,374.43	.003	.001	.009	.006	.019	.009	.028
26.88	255.05	.027	.027	.031	.004	.089	.010	.099
31.70	175.31	.008	.022	.015	......	.045	.009	.054
25.77	91.60	......	......	.017	.011	.028	.011	.039
197.81	926.19	.006	.006	.012	.014	.038	.010	.048
282.16	1,148.15	.008	.010	.014	.011	.043	.010	.053
268.81	826.61	.003	.003	.008	.004	.018	.009	.027
29.50	73.64	......	......	.018	......	.018	.012	.030
298.31	900.25	.003	.003	.009	.004	019	.009	.028
45.96	87.10	......	......	.009	.002	.011	.013	.024
145.23	320.02	......	......	.014	.008	.022	.018	.040
73.47	228.17	.033	.013	.018	.005	.069	.032	.101
264.66	635.29	.005	.002	.013	.006	.026	.020	.046
1,364.24	3,091.53	.002	.003	.008	.006	.019	.014	.033
1.08	68.23	.021	.083	.236	.063	.403	.006	.409
......	27.86	......	......	......	......	......	......	......
1.08	96.09	.021	.083	.402	.063	.569	.006	.575
117.30	880.07	.058	.079	.040	.018	.195	.030	.225
25.19	108.73	.002	......	.034	.008	.044	.013	.057
1,677.40	1,830.98	......	......	.002	......	.002	.018	.020
10.45	38.31	......	......	.086	......	.086	.032	.118
1,687.85	1,869.29	......	......	.002	......	.002	.019	.021
46.36	176.64	.003	.005	.031	.001	.040	.014	.051
2.71	66.19	......	......	.148	.060	.208	.009	.217
20.74	80.80	......	......	.034	.007	.041	.014	.055
605.42	1,829.37	.003	.002	.009	.003	.017	.009	.026
$43,329.76	$114,632.96	.005x	.004x	.013x	.004x	.026x	.016x	.042x
2,123.31	4,043.88	.001	.001	.011	.008	.021	.023	.044
$45,453 07	$118,676.84	.004	.004	.013	.004	.025	.016	.041

Exhibit 7

Railroad "E"

OPERATION OF MOTOR CARS—1924

Following is a summary of monthly reports covering 920 motor cars in all classes of service:

Make and Type	Number Cars in Service	Total Mileage	Total Gallons Gasoline	Average Miles Per Gallon	
				1924	1923
AP	188	625,145	31,570	19.7	20.0
AQ	134	423,379	27,618	15.3	15.3
AR	51	298,367	10,452	28.5	26.5
AS	221	636,797	37,355	17.0	16.8
AT	199	1,153,722	32,580	35.4	35.8
AN	1	1,440	36	40.0	40.0
EM	48	136,738	6,723	20.3	17.1
EP	28	76,717	4,240	18.0	19.0
EL	1	966	16	60.3	45.0
BW	37	184,746	4,623	40.0	42.0
BX	1	1,344	39	34.4	36.0
BK	3	13,339	377	35.3	36.0
BL	2	15,835	373	42.4	49.0
BY	5	17,296	926	18.7	23.4
CO	1	1,032	72	14.3	20.5
Total, 1924	920	3,586,683	157,000	....	....
Total, 1923	846	3,155,781	139,759	....	....

The cost of operation was as follows:

	1924	1923
Motor Car Shop, payroll and expenses (including supervision)	$ 17,905.00	$ 19,911.00
Division Maintainers, salaries and expenses	22,341.00	18,529.00
Material issued for repairs	34,618.00	39,934.00
Gasoline, 157,000 gallons, at 17.5 cents	27,475.00	27,952.00
Oil and Grease	5,500.00	5,365.00
Batteries, on basis of 5 cells per 1,000 miles, 14,065 dry batteries at 30 cents	4,220.00	3,229.00
Interest, 920 cars at $320.00, at 6 per cent	17,664.00	15,228.00
Depreciation at 8 per cent	23,552.00	20,304.00
	$153,275.00	$150,452.00
Cost per mile	4.27c	4.70c

The above cost includes rebuilding 103 cars (108 in 1923) and 95 power plants (77 in 1923).

Twenty-eight (28) sections were eliminated in 1924. Since 1919 fifty (50) sections have been eliminated, which represents an annual saving of $69,600 in Section Foremen's salaries.

ADDENDA TO APPENDIX C

Motor Car Repair Shop Equipment

Power Driven

1 Upright Drill Press with Cone Drives (No. 3 Morse Taper Spindle).
1 Lathe (bed long enough to take crankshaft 5 ft. 4 in.).
1 Power Trip Hammer, 30 lb.
1 Emery Wheel (smooth and coarse stones).
1 Buffer (with steel wire and fabric wheels).
2 Electric Drills (Maximum ⅜ in. H. S. St., shank drill).
1 Gas Driven Engine with Belt Attachment to Break in Newly Repaired Motors.
1 Power Driven Saw.

Mechanical

1 5 in. Combination Swivel Based Vise.
1 3 in. Combination Swivel Based Vise.
2 4 in. Machinist's Vises.
1 Carpenter's Vise.
1 Miter Box (using 5 in. by 30 in. saw).
1 Set No. 3 Ratchet Stock and Dies (pipe).
1 Set ½ in., ¾ in., 1 in. Dies (pipe).
1 Set Pipe Cutters.
1 5 in. Foot Adze.
1 Crosscut Saw.
1 Acetylene Welding Set.
1 One Ton Chain Hoist.
1 Wheel Puller.
1 Set Bolt Dies U. S. S. ¼ to 1 in. with Taps.
1 Blow Torch.
1 ½ in. and ¾ in. Conduit Bender.
1 Large Solder Pot and Ladle.
1 Stand for Electric Drill (size 1).
1 Set Straight Reamers, ½ in. to 1$\frac{1}{16}$ in. (No. 3 Morse taper shank).
1 Set Taper Reamers, ½ in. to 1$\frac{1}{16}$ in. (No. 3 Morse taper shank).
1 Set Drill Bits, ¼ in. to 1$\frac{23}{32}$ in. (No. 3 Morse taper shank).
1 Set Expansive Reamers, ½ in. to 1⅝ in. (hand).
1 Reamer, Crankshaft Rear Bearing, 1114 S. C.
1 Set Inside Micrometers (2 in. to 5 in.).
1 Set Outside Micrometers (2 in. to 5 in.).
1 Small Press for Bushings, etc.
1 Reamer for Standard Wheel Hubs.

Blacksmith

1 Solid Steel Anvil.
1 6 in. Blacksmith's Vise.
1 Blacksmith's Forge with Power Driver Blower.
1 Set Swedges (top) for Blacksmith's Anvil, ¼ in. to 1½ in.
1 Set Fullers (top) for Blacksmith's Anvil, ¼ in. to 1½ in.
1 Set Fullers (bottom) for Blacksmith's Anvil, ¼ in. to 1½ in.
1 1¼ in. Square Shank Regular Hardie.
1 Cast Iron Swedge Block.
1 Set Round Blacksmith Punches, ⅜ in. to ¾ in.
1 Set Blacksmith Cold Chisels, 1 in. to 2 in.
1 Set Blacksmith Hot Chisel, 1 in. to 2 in.
1 ¾ in. Bolt Clipper.
1 16 in. Straight Lip Tong.
1 22 in. Straight Lip Tong.
1 16 in. Curved Lip Fluted Jaw Tong.
1 22 in. Curved Lip Fluted Jaw Tong.
1 18 in. Rivet Tong.
1 24 in. Rivet Tong.

1 12 lb. Sledge Hammer.
1 3 in. Square Flatter.
1 1½ in. Set Hammer.
1 Blacksmith's Hammer, 42 oz.
1 Ball Pein Hammer, 1¾ lb.
1 Framing Square.
1 Pair Outside Calipers (large).
1 Pair Inside Calipers (large).
1 Air Hammer (medium size).
1 Face Plate, 5 ft. by 8 ft., for Straightening Steel Frames.

CARPENTER'S HAND TOOLS (PERSONAL).

1 No. 11 Saw.
1 No. 8 Saw.
1 Framing Square.
1 6 in. Try Square.
1 Stanley Odd Jobs Tool.
1 10 in. Carpenter's Brace.
1 Set Wood Bits, $\frac{3}{16}$ in to 1 in.
4 Ship Augers, ½ in., ¾ in., ⅞ in. and 1 in.
1 Expansive Bit, ⅞ in. to 3 in.
1 Ratchet Screw Driver.
1 Screw Driver Bit for Brace.
1 Jack Plane.
1 Smoothing Plane.
1 Drawing Knife, 16 in.
1 Combination Carborundum Stone, 1 in. by 2 in. by 8 in.
1 Carpenter's Claw Hammer.
1 Hand Axe.
1 Set Nail Sets.
1 Level.
1 Plumb Bob.
1 Straight Edge.

MOTOR CAR MECHANIC'S HAND TOOLS (PERSONAL)

1 No. 33 Double Head Open End Wrench, 15 degree angle.
1 No. 38 Double Head Open End Wrench, 15 degree angle.
1 No. 40 Double Head Open End Wrench, 15 degree angle.
1 No. 661 Set Screw Wrench.
1 6 in. Monkey Wrench.
1 12 in. Monkey Wrench.
1 Set Socket Wrenches, 1⅜ in. to $1\frac{3}{32}$ in.
1 Carpenter's Brace, 8 in.
1 Set Wood Bits, $\frac{3}{16}$ in to 1 in.
1 10 in. Stillson Wrench.
1 18 in. Stillson Wrench.
1 24 in. Stillson Wrench.
1 Hand Saw, No. 9.
1 Framing Square.
1 6 in. Try Square.
1 Jack Plane.
1 Set Hand Punches, $\frac{3}{16}$ in., ¼ in., $\frac{5}{16}$ in., ⅜ in.
1 Set Center Punches.
1 5 oz. Ball Pein Hammer.
1 1⅛ lb. Ball Pein Hammer.
1 Set Bearing Scrapers.
3 Screw Drivers, 4 in., 8 in., 10 in.
1 Combination Carborundum Stone, 1 in. by 2 in. by 8 in.
1 No. 21 Double Head Open End Wrench, 15 degree angle.
1 No. 23 Double Head Open End Wrench, 15 degree angle.
1 No. 25 Double Head Open End Wrench, 15 degree angle.
1 No. 27 Double Head Open End Wrench, 15 degree angle.
1 No. 29 Double Head Open End Wrench, 15 degree angle.
1 No. 31 Double Head Open End Wrench, 15 degree angle.

Appendix D

(5) ECONOMY IN USE OF LABOR-SAVING DEVICES

G. M. O'Rourke, Chairman, Sub-Committee; M. C. Blanchard, P. B. Jeffries, C. E. Johnston, J. B. Mabile, W. L. Rohbock.

In the study of the economy resulting from the use of labor-saving devices, it is apparent that a vast field of investigation is possible. Track forces are usually composed of local labor, which generally is not as good from a standpoint of efficiency as in former years.

In order to overcome the effect of limited force, inefficient, and, in most cases, inexperienced labor, labor-saving devices have become a necessity. Special study and experiment have resulted in the adoption of numerous devices in an attempt to reduce this labor cost and increase output per man, with the result that at this time machines are being developed to assist in the performance of almost all maintenance operations. With the use of such machines, in numerous cases, comes their acceptance as labor savers without any knowledge of the actual saving realized, and possibly in some instances of whether any man hours are actually saved.

Realizing the scope of the field of study, the Committee decided to concentrate its efforts on a limited number of devices and to make a thorough investigation of a few rather than to touch lightly on a large number and arrive at no definite conclusions. Consequently, the following seven devices have been selected for consideration in this report:

Motor Cars.
Weed Destroyers.
Rail Cutting, Drilling and Building Up Devices.
Tie Tamping Machines.
Rail Layers.
Ditchers.
Locomotive Cranes.

With the adoption of labor-saving devices comes the necessity of a special force to attend strictly to their maintenance. In order to prevent valuable equipment from lying idle because of some minor difficulty, and to prevent interruptions to the carefully planned programs, it is to the best advantage of the railroad companies to retain skilled mechanics to make needed repairs and adjustments at the time of break-downs and to have on hand essential repair parts and extra equipment.

Inspections at regular intervals by these mechanics have eliminated much of the delay due to improper working of the machines. At the end of the working season, all machines should be sent to the shops where they should be given a careful examination, thoroughly overhauled and placed in readiness for full service during the following season.

The work of this Committee has been carried on with the view of studying in detail the operation of each device and of comparing the relative values of the different types for performing the same work to each other, as well as studying the actual saving realized by each machine compared to doing the work by hand.

In some instances it is difficult to make a direct comparison of devices intended to perform similar operations due to the vastly different operating conditions, and to the scarcity of data. In the compilation of this report data have been accumulated from railroads in the United States, Canada and Mexico, and from the reports submitted it is apparent that the study of the economy resulting from operation of labor-saving devices is in its infancy.

It was at first thought advisable to restrict the source of information to data obtained from "Class 1" roads entirely, but after further consideration it was decided to draw information from as many railroads as possible, believing that in many instances smaller railroads having more limited capital, feel a more urgent need of labor-saving devices in order to provide properly maintained track.

Motor Cars

The economy resulting from the use of motor cars has been a much debated topic. The majority of railroads have accepted the motor car as the most economical means for the transportation of section gangs, bridge gangs and extra gangs, and their use is being extended rather than curtailed.

With the advent of a dependable motor car, many of the railroads reporting lengthened the section mileage maintained by a given gang, as the time saved in making moves on the section has been substantially reduced, and the saving of non-productive energy consumed in pumping handcars has been conserved for productive work on the track. Roads which did not lengthen sections, however, reported savings accruing from the same sources at least equal to those which did lengthen sections.

There is a definite hazard to life and property created with the use of motor cars, and their careful operation cannot be too highly stressed. Under certain conditions, on some multiple track lines of heaviest traffic, in yards and on terminal railroads particularly, the use of motor cars cannot always be recommended, but, taken as a whole, they have proven themselves economical. The International Railway Congress recently arrived at the following conclusion: "Motor cars (providing due regard is paid to regulations relating to the safety of running on the line) constitute an economic means of transporting men and material."

All railroads responding to the questionnaire, with the exception of terminal railroads, have already adopted the motor car, and in most instances its use is being extended. In some few instances roads report being already fully equipped.

There are numerous kinds and sizes in general use, varying in initial cost from $125.00 to $725.00, the average cost of all reported being approximately $337.00 per car. The annual maintenance expense is also subject to a wide variation, due, probably, to the different methods of performing the work.

The operating speed on the majority of roads is 20 miles per hour, and at this rate of speed it is estimated that an average of approximately 50 per cent of the actual running time may be considered as saving over hand-car operation.

Weed Destroyers

The removal of vegetation has been recognized as an annoying problem by Maintenance of Way officers, and has been a subject for study to arrive at some means by which the old method of weeding by hand may be superseded.

Weeds overgrowing the running rail cause the locomotive drivers to slip, while the moisture retained by the weeds tends to accelerate decay of the ties. In addition, they collect dirt, causing foul ballast, interfere with drainage, create a fire hazard and present an unsightly appearance. The problem grows in importance, because the time when the weeds require cutting occurs at the time when maintenance forces are busiest performing necessary track work and when they should on no account be delayed. The time required for hand weeding, therefore, constitutes a serious set-back in the maintenance program. In view of the importance of removing weeds, several means and methods have been adopted and put into general practice to supplant weeding by hand.

Mechanical means of cutting weeds along the shoulder of the roadbed are being used rather extensively and the work is being accomplished at a reasonable cost. This method does not destroy the vegetation, but it does temporarily remove the objectionable growth. Mowers mounted upon or pulled by motor cars cut the grass on both sides of the track and operate at a speed from two to four miles per hour. The mowing machine cuts more evenly than does hand cutting, and releases section forces for the performance of track work at the particular time when cutting is necessary.

This method of weeding is being accomplished at an average cost of $1.667 per mile of track. Its objectionable features are that it does not destroy vegetation, and that at least two, and as an average, three cuts per year must be made to satisfactorily keep down vegetation.

The weed burner has proven itself of value in weed killing and is being utilized by a number of roads. Besides burning the weeds, the burner kills the roots of less hardy vegetation, and consequently retards regrowth. While the chemical weed destroyer is more extensively used, roads reporting using the weed burner method of destroying weeds utilized it over more miles of track than any other one method.

Burning is accomplished by the application of heat directly on the vegetation from either an oil flame, or from superheated steam. This method is being accomplished at an average cost of $12.28 per mile. While burning has a tendency to sterilize the roadbed to prevent regrowth, two to three applications per year are in almost all cases required.

The chemical weed destroyer is the most generally used of any of these devices, being used by the greater number of railroads and over a greater number of miles. There is a wide variation in the ratio of water to chemical used and to the number of gallons of chemical applied per mile of track. In general, one application per year has been found sufficient to satisfactorily destroy vegetation. One application does not in all instances prove sufficient to rid the roadbed of growth, as some species of vegetation are not as easily destroyed as others, and in spots where hardy vegetation abounds, as many as three applications per year may be necessary.

The ratio of water to chemical varies from as high as 20 to 1 to 3 to 1, with an average of 10 to 1. The cost per mile at prevailing prices varies between $22.00 and $85.00, with an average of $40.43 per mile per annum.

The saving by use of the chemical spray compared to hand weeding is on an average, $38.00 per mile, or approximately 50 per cent of the estimated cost of hand weeding.

Rail Cutting, Drilling and Building Up Devices

Heavy rolling stock subjects the rail ends to severe punishment and wear with the result that the end of the rail is the first part to show wear and necessitate renewal of the rail. End battered rail has always presented a difficult problem for maintenance engineers, and until some means is developed by which uniform wear is obtained, the battered ends must be removed, or repaired to secure full life of the rail.

To meet this condition, two distinct methods are being used at the present time. The first, and probably the oldest, is to cut off the battered ends of the rail for a sufficient distance to obtain the original section. The other method which has come into rather general use is that of building up the damaged ends by means of welding.

As a reclamation measure, motor driven machines are installed at centrally located points to handle the sawing and redrilling of large tonnages of rail, or a saw and its power unit are mounted on a car and moved from place to place where the rail to be reclaimed has been concentrated with a view of minimizing its transportation and handling.

Centrally located sawing units require the outlay of from $30,000.00 to $40,000.00 and to justify this expenditure the equipment and method of operation must be carefully studied in order to realize a return on the investment. With such equipment, rail is being sawed and redrilled at a minimum cost of $0.71 per ton, and an average for the plants of this nature reported is $1.18 per ton. To carry on the various operations, a force of approximately 22 men is required, which, with the cost of fuel, etc., make an operating expense of about $80.00 per day.

Portable saws may be equipped at less expense than stationary saws, but under operating conditions cannot obtain the efficiency of the more elaborate outfit, and consequently the cost of reclaiming rail with the portable saw is slightly higher than that with the permanent saw. The reclamation cost with the portable saw is approximately $1.20 per ton. The annual maintenance cost is approximately the same as that of the stationary saw, being about $150.00 in both instances.

The permanent saw has an advantage in that it is capable of handling rail with the greatest efficiency and turning out the finished product at a lower cost than the portable saw. On the other hand, the portable saw is brought to a point where rail has been concentrated and eliminates the necessity of the long haul to and from the centrally located plant, and consequently returns the rail to the track in a shorter period of time.

In the case of railroads having a small amount of rail to be reclaimed each year, it has been found practical to have the work done by an outside concern at a contract price. This method eliminates the heavy expense of assembling and maintaining a sawing unit, and saves the depreciation and interest on the investment. To most economically employ this method, it is desirable to have the work done by a concern so located as to necessitate minimum haulage of the rail.

The other method of reclaiming rail is, as previously mentioned, by building up the worn ends by means of welding. By this method, a gang of from 2 to 4 men repair the joints with the rail in the track, under traffic, at an average cost of $1.33 per joint.

There is a conflict in opinion among the railroads that are building up joints, regarding the effect of welding joints on maintenance of track surface. Some roads contend that no saving is realized in this respect, while others estimate as high as a 50 per cent saving.

It is generally agreed that building up joints lengthens the life of the rail at least two to four years depending upon traffic, thereby effecting a saving which more than justifies the expenditure.

Tie Tampers

In the maintenance of high speed track, surfacing out-of-face occupies a prominent place in the annual expenditures. The cost of surfacing is due to the great amount of labor consumed, and any device which reduces the amount of labor and facilitates more rapid accomplishment of the work can be utilized to great advantage.

Although tamping is a comparatively simple operation it requires a considerable amount of experience and dexterity on the part of the laborer and constant supervision on the part of the foreman to produce the desired result at a reasonable cost.

As in the case of other maintenance operations, the original method was to do the work by hand. It has been found that it is difficult to find the same quality of tamping done by any number of men, some men readily adapting themselves to the work and others seeming never to acquire the proper method. The result of work done by such a gang is rough track in a short while after the work has been completed. Pick tamping costs on an average of $0.1018 per foot of track for work which is not as uniform as that done by mechanical means.

To supplant tamping by hand, mechanical tamping machines operated by either compressed air or electricity have been placed on the market and are being used by the majority of leading railroads. Of the two mechanical tampers, the air machine is the more widely used.

The pneumatic tamping outfit consists of an internal combustion engine compressing air to operate tamping bars which are hose-connected to the compressor. The outfits are of different capacities to operate four, eight and twelve tampers. The action of the pneumatic tamper is similar to that of the ordinary air hammer, the force of the blow being absorbed in forcing ballast under the ties.

Tamping is accomplished by this means at an average cost of $.0635 per foot of track. The most economical practice of maintaining these machines has been found to send the outfit to the shops of the individual railroad company at the close of the season and subject the machine to a thorough overhauling by men familiar with such work, and at a time when there are no section forces awaiting its return to the track. By this method it has been found that the machines so overhauled operate through the following season with little or no attention.

The electric tamper consists of an internal combustion engine operating an induction type generator, the force generated being delivered through wires to the tamping tools. Tamping is being done at an average cost of $0.0642 per foot of track.

The size of gangs operating these machines varies between seven and twenty men. In most instances, the four-tool outfit is used, and with this equipment, the variation in size of gang is due, no doubt, to the different conditions under which the work is performed, governed most directly by the number of ties to be renewed at the time of surfacing. In order to alternate the men using the tampers, six to seven men, exclusive of motor operator, are the absolute minimum to perform a strictly tamping operation. When the track is raised and the ties renewed, additional men are required to perform these operations and to finish the track behind the tampers.

The annual maintenance cost of these machines as reported varies from $105.00 to over $500.00 for the pneumatic tamper, with an average of $246.00 and from $36.00 to $117.00, with an average of $76.00 for the electric.

Rail Layers

Brief observation of the work of a gang in laying or relaying rail will convince one of the desirability, if not of the necessity, of substituting some form of machine for the laborious task of handling rail manually with tongs. This substitution becomes increasingly important as the size of the section and the length of the rail increase, as both are doing so rapidly of late. To meet this demand several designs of cranes have been developed, both manually and power operated, while locomotive cranes are also employed for this purpose. Some of these cranes are of sufficiently light construction to permit them to be set off the track to enable trains to pass while others, like the locomotive cranes must be run to the nearest siding. With the latter type of equipment particularly it is important that the forces be given the uninterrupted use of the track for as long a time as possible. With any of these types of equipment, best results can be secured only when they are employed with gangs large enough to complete the preliminary operations ahead of the machines and to leave the new rail safe for traffic, at the same rate as the machine will place the rail in the track. This force varies from 50 men with the small manually operated crane to 200 with a locomotive crane. The amount of rail that can be laid with the various types of equipment varies in the same manner.

All of these machines release all but 3 or 7 of the 16 to 24 men otherwise employed in lifting the rail. They also handle it more rapidly and with less danger of accidents.

The statistics we have indicate that the small hand operated crane is the most widely used. Through the use of rail laying machines of various types about 18 lineal feet of rail per man hour are being layed, or about 6.5 track feet more rail per man hour.

Ditchers

In order to have properly maintained track, one of the requisite details is to provide proper side ditch drainage; another is to provide sufficiently wide shoulders to prevent sliding of the ballast with the consequent irregularity of line and surface. The actual saving in track maintenance due to proper cutting and maintaining of ditches and providing adequate shoulders will usually compensate for the expenditure necessary in the purchase of equipment to gain this end.

To meet this need, the railroad ditcher has been adopted; this consists of a crane of rugged construction equipped with a steam shovel and additional especially designed features which adapt it to the work of maintenance of way ditching, and for other purposes such as laying rail, grading and general handling of materials.

Another generally used method of providing side ditches to properly care for drainage is through use of the spreader car. With the ditching attachment in place on the spreader, the device will trim the ballast, shape the subgrade, and at the same time dig a uniform ditch of standard cross-sectional area, the flow line of the finished ditch being on the same grade as the track and as true as the surface of the top of rail.

The approximate operating cost of the ditcher is $116.00 per day, of the spreader, $91.00 per day; and the annual maintenance expense is approximately $896.00 for the ditcher and $415.00 for the spreader.

An average cost of moving dirt with the ditcher outfit is $0.21 per cu. yd., which, compared with $0.50 to $0.75 per yard for moving dirt by teams, and $1.00 to $1.25 for moving by hand, shows a substantial saving in favor of the ditcher. The average cost of moving material by means of the spreader is $0.11 per cu. yd. In addition to its usefulness as a ditching device, the spreader car, through the proper attachments, is used in the making, widening, and shaping of embankments; moving and leveling sand, rock etc.; plowing snow and ballast.

Locomotive Cranes

The attitude of the laborer toward arduous service has changed in the past few years, until now it is a difficult task to have them perform such work with any degree of efficiency. This is particularly true in handling heavy materials or where long continued physical effort is required. To overcome this difficulty, maintenance department officers have turned to the portable crane as a quick, safe and otherwise economical means of performing various kinds of work. The uses of the locomotive crane in maintenance work are too numerous to detail, but its most common applications are loading and unloading heavy material; erecting structures; handling scrap by means of a bucket or electric magnet attachment; driving piles, when equipped with the necessary attachments; laying rail; spotting cars in yards and terminals; excavating with a clam shell or drag line attachment; and handling ballast in connection with its renovation. Being automotive, it is valuable in handling material in yards and terminals, eliminating the necessity of handling material on push cars. The adaptability of the crane is one of its most valuable features, in that it may be converted for any one of a number of different operations without loss of its efficiency.

There are a number of different makes of cranes of various capacities in use. The cost varies between approximately $7,000.00 for the smaller cranes, and $19,000.00 for those of greater lifting capacity. Those with a 50 ft. boom and a maximum lifting capacity of approximately 25 tons appear to be the most generally used.

Savings through the use of such type machine can be developed by study of statistics in the addenda.

Conclusions

1. The economy derived through the use of the labor saving devices subject of investigation during the year 1925, viz., motor cars, weed killers,

MOTOR CARS

Railroad	Cost of Machine	Maintenance Cost	Operating Expense	Life of Car	Saving
13	$240.00	....	....	10 years	....
	725.00	....	....	....	....
17	247.80	....	....	5 years	12½%
	400.00	....	....	5 years	12½%
	260.00	....	....	5 years	12½%
	300.00	....	....	5 years	12½%
27	290.00 Av.	....	....	10 years	....
7	390.00 Av.	....	....	....	....
9	250.00	$ 45.60	$ 33.72 per year	12 years	....
31	250.00	30.00	50.00 per year	15 years	....
10	280.00	25.00	....	10 years	....
30	125.00	10.00	38.00 per year	8 years	....
12	....	....	....	....	10%
23	275.00	....	....	9 years	....
19	450.00	....	....	12 years	....
3	450.00	....	....	7 years	....
16	240.00	....	....	10 years	....
20	288.00	75.64	....	....	....
4	....	....	....	4 to 10 years	....
35	230.00	69.90	57.60 per year	15 years	....
21	240.00	....	....	10 years	....
2	....	....	....	10 years	....
11	389.00	$100.00 per year	....	....	10%
	461.25	100.00 per year	....	....	10%
	725.00	100.00 per year	....	....	10%
34	425.00	74.14	30.00 per year	10 years	....
	200.00	40.26	23.07 per year	10 years	....
5	125.00	45.00	120.00 per year	10 years	....
	310.00	40.00	90.00 per year	10 years	....
33	450.00	120.00	66.00 per year	8 years	12½%
	435.00	120.00	66.00 per year	8 years	12½%
	158.00	120.00	66.00 per year	8 years	12½%
14	425.00	40.00	70.00 per year	10 years	12½%
26	....	....	....	....	....
25	500.00	....	80.00 per year	8 years	....
24	319.00	$85.00 per year	75.00 per year	10 years	....
32	450.00	54 00 per year	90.00 per year	12 to 15 years	....
22	160.00	24.00 per year	46.00 per year	10 years	12%
6	240.00	....	....	12 years	10%
8	200.00	....	60.00 per year	6 years	12½%

rail cutting and building up devices, tie tampers, rail layers, ditchers and locomotive cranes has been demonstrated and their use recommended.

2. In order to arrive at the actual savings realized, additional study is necessary because the subject is of such magnitude that it is practically impossible to cover more than a small portion of it in one report. It is the recommendation of the Committee that investigations along these lines be continued, a small number of labor-saving devices being selected for detailed study each year.

3. A large amount of the data from which this report was compiled was incomplete and showed a marked need of an accurate method by which cost data on labor items should be recorded. As assistance in future work along these lines, this Committee recommends that the Committee on Records and Accounts be requested to prepare a set of standard forms on which data relative to labor-saving devices may be kept. The adoption of forms of this nature will keep the desired information readily accessible, it will be in such form that it may be more accurately compiled and studied, and the information will be in the same units.

Tabulated data are shown in addenda to this Appendix.

MOTOR CARS

Length of Section	Were Sections Lengthened	Speed M.P.H.	Recommendations
5.6 miles	Only two	25	Extend use—For all main line sections and extra gangs
6 to 8 miles	No	15	Extend use—For all gangs
7 to 10 miles	Yes, 2 to 4 miles	20	Extend use—For all branch lines
10 miles	Yes, doubled	20	Extend use—For all gangs
7 miles	No	15	Extend use—For all gangs
5 to 17 miles	No	20	Extend use—For all gangs
6 miles	No	20	Extend use—For all gangs
8 miles	No	15	Extend use—For all gangs
3½ miles to 5½ miles	No	20	All gangs now furnished with cars
10 miles	Yes, 4 miles	20	Extend use—For all gangs
7 miles	Yes	20	Extend use—For all gangs
5 miles	Yes	20	Little extension of use at present
9 miles	Yes, 3 miles	15	Use being curtailed—Only for very long sections
8 miles	Yes, 30 to 50%	12	All gangs fully equipped
8 miles	No	15	Use being curtailed—Hand car preferred
6 miles	No	20	Extend use—For all gangs
7 miles	Yes, 2 miles	20	Best for section gangs. No extension of use at present
6 miles	....	15	Extend use—For all gangs
M. L. to 3 miles	Yes	20	All gangs to be equipped
Br. L. to 8 miles	....	....	....
6 to 8 miles	Yes, 1 to 3 miles	20	Extend use—For all gangs
8 miles	....	....	Generally extended—Curtailed on heavy traffic lines
8 miles	....	20	Extend use—For all gangs
6 track miles	No	20	Extend use—All except yard and terminal gangs
5 to 8 miles	Yes, ½ mile	....	Extend use—All except yard and terminal gangs
7 and 8 miles	Yes, 30%	20	Extend use—To all gangs
6 miles	No	20	Recommended only for bridge and extra gangs Hand cars used for section gangs
9 miles	Yes	15	Extend use—For all gangs
7 miles	No	20	Extend—For all gangs
7 miles	No	15	Extend—For all gangs
....	Yes	20	Extend—For all section gangs

WEED KILLERS

Railroad	Type	Applications Per Year	Chemicals Amount Per Mile	Number Miles Treated	Cost Per Mile	Width of Effectiveness	Ratio of Water to Chemicals	Saving
17	Chemical..	1	46.4	2580	$28.19	18 feet	3:1	$36.56 per mile
	Burner.....	2	....	3464	7.53	....	....	67.47 per mile
	Mower....	2	....	1038	3.17	10 feet	....	4.83 per mile
	Mower....	2	....	367	1.79	....	....	7.21 per mile
18	Chemical..	1	50	60	22.50	10 feet	15:1	....
27	Chemical..	1	62	400	30.00	16 feet	10:1	50.00 per mile
13	Chemical..	1	75	65	52.23	14 feet	20:1	50.00 per mile
7	Chemical..	1	60	498.8	41.90	16 feet	7:1	....
9	Chemical..	1 to 3	40	812	54.83	14 feet	6:1	....
	Burner.....	2 to 3	....	1688	13.44	14 feet	....	26.00 per mile
	Mower....	2	....	4812	1.25	7 feet	....	3.50 per mile
2	Chemical..	1 or 2	....	458.8	85.85	20 feet	8:1 to 16:1	15.00 per mile
	Burner....	....	....	861	13.10	....	....	....
	Mower....	....	....	1669	1.91	....	....	....
33	Burner....	2	....	1170	11.50	....	....	85.00 per mile
31	Burner....	3	....	3484	12.35	18 feet	....	90.00 per mile
14	Spray Cans	1	13	250	25.00	12 feet	20:1	50% of hand weeding.
25	Burner.....	2	....	800	9.19	....	....	(Applied from sprinkling can only where needed.)
35	Chemical..	1	96	4074	48.31	10 feet	15:1 to 20:1	....
22	Burner....	3	....	1000	12.00	10 feet	....	....
6	Mower....	3	....	50	3.00	....	....	....
8	Burner....	2 to 4	....	4564	16.00	10 feet	....	....

RAIL CUTTING, DRILLING AND BUILDING UP

Railroad	Device	Cost of Equipment	Operating Cost	Time of Operation	Gang Required	Cost per Joint	Maintenance Cost Per Year	Saving
17	Stationary Saw	$29,000.00	$ 75.00	20 seconds	24 men	$0.71 per ton	$150.00	$0.40 to $1.00 per ton.
	Portable Saw	15,000.00	45.00	20 seconds	24 men	1.39 per ton	150.00	
	Welding	Leased		0.8 M. H. per joint	7 men	1.35 per joint		
18	Welding	Leased			2 men	1.25 per joint		
27	Welding	Leased		1 M. H. por joint	2 men	1.80		
7	Welding	Leased		1.73 M. H. per joint	6 men	1.73		
9	Portable Saw	5,000.00	143.66	15 minutes per cut	22 men	0.998		Approximately 15 minutes per cut.
10	Welding	31.15		0.5 M. H. per joint	3 men	1.25		
5	Welding	300.00		0.75 M. H. per joint	4 men	2.00		
3	Welding	75.00		0.75 M. H. per joint	4 men	1.25	67.00	
	Stationary Saw			400 rails per day				
4	Stationary Saw		80.00	25 seconds	22 men	1.50 per ton		
35	Welding	110.00		0.5 M. H. per joint	5 men	1.81 per joint		
2	Welding					1.23		
33	Stationary Saw	45,000.00		30 seconds				
	Welding				3 or 6 men	1.25		
31	Welding	500.00	8.00		2 men	0.45 to $0.60		20 per cent of maintenance of rail and fastenings.
14	Welding				2 men			
26	Stationary Saw	31,284.00			22 men			
32	Stationary Saw	15,000.00						
	Welding	75.00	$22.50 per day	30 minutes per joint	2 men	1.56		3 years' additional use.
	Welding		12.00 per day	30 minutes per joint	2 men	1.56		3 years' additional use.
22	Welding	174.00		40 minutes per joint	6 mon	2.00	35.00	
6	Welding	Leased		35 minutes per joint		1.74		

TIE TAMPERS

Railroad	Tamper	Cost of Machine	Fuel per Hour	Performance	Cost of Tamping	Size of Gang	Maintenance Cost	Saving
29	Electric	$2,260.00	$0.064	9.4 track ft. per M. H.	$0.049 per ft.	10 to 20 men		$125.00 per mile.
	Picks				0.071 per ft.			
17	Comp. Air	2,500.00	0.40	6.38 track ft. per M. H.	0.077 per ft.	13 to 19 men		206.00 per mile.
	Electric	2,000.00	0.125	6.49 track ft. per M. H.	0.0915 per ft.			150.00 per mile.
	Picks							
27	Comp. Air	2,900.00	0.50	3.16 track ft. per M. H.		12 men	$117.87	No saving of labor, but track holds up twice as long.
13	Comp. Air	2,600.00						Little saving of labor but better work done.
7	Comp Air	2,800.00	0.439	7.10 track ft. per. M. H.		20 men	105.90	Does better work than electric.
	Electric	2,560.00	0.155	9.10 track ft. per M. H.		20 men	36.25	
9	Comp. Air	2,600.00	0.36	5.6 track ft. per M H.			533.00	
	Electric	1,995.00	0.10				117.00	
19	Comp. Air	1,775.00						
3	Comp. Air	1,800.00	0.52	9.7 track ft. per M. H.		7 men		$264.00 per mile.
	Picks			6.09 track ft. per M. H.				
2	Electric				0.052 per ft.			$348.00 per mile.
	Comp. Air				0.050 per ft.			$359.00 per mile.
	Picks				0.118 per ft.			
11	Comp. Air	2,405.00	0.45		0.0688 per ft.	18 to 24 men	200.00	$114.00 per mile.
	Picks				0.1487 per ft.			
15	Comp. Air	1,913.00	0.35		0.0856 per ft.	6 to 7 men		$135.00 per mile.
	Picks				0.0940 per ft.			
1	Comp. Air	2,867.00	0.37		0.0361 per ft.			$216.00 per mile (sand and gravel ballast).
	Picks				0.0771 per ft.			
31	Comp. Air	2,000.00						
33	Comp. Air	2,874.00	0.17			12 to 16 men		
14	Comp. Air	2,200.00	0.595			16 to 20 men	275.00	Approximately 40 per cent of labor.
26	Comp. Air	2,444.00	0.625			9 men		
32	Comp. Air	2,200.00	0.19	3 track ft. per M. H.		10 men	91.80	Approximately 42 per cent of labor.
	Electric	2,000.00	0.11	3 track ft. per M. H.		8 men	91.80	

RAIL LAYERS

Railroad	Device	Cost of Machine	Size of Gang	Time Studies		Saving
				Machine	Tongs	
13	Hand Crane	$ 400.00				11 men, full time.
29	Hand Crane		45 men, small job	13.48 lin. ft. per M. H	7.24 lin. ft. per M. H.	3.12 track ft. per M. H.
17	Hand Crane	400.00	35 men	24.6 lin. ft. per M. H		13.2 track ft. per M. H.
	Mechanical Crane	5,375.00	62 men	42.6 lin. ft. per M. H		8.85 track ft. per M. H.
7	Hand Crane	432.70	60 men	11.8 lin. ft. per M. H		
9	Hand Crane	425.00	80 men			13 men, full time.
	Gas Electric	4,000.00	80 men			13 men, full time.
31	Hand Crane					
30	Hand Crane	425.00	65 men	14 lin. ft. per M. H		3.1 track ft. per M. H.
12	Hand Crane	410.00	45 men			8 men, full time.
3	Hand Crane	500.00	52 men	13.85 lin. ft. per M. H	11.2 lin. ft. per M. H	5.9 track ft. per M. H
4	Hand Crane	500.00		15 lin. ft. per M. H		
2	Mechanical					
	Mechanical Crane	4,500.00				
31	Hand Crane	350.00	50 men			
5	Hand Crane	425.00	60 men	20.3 lin. ft. per M. H	16 lin. ft. per M. H	1.85 track ft. per M. H.
33	Hand Crane	500.00	60 to 75 men			11 to 15 men, full time.
14	Hand Crane	400.00	70 men	30 lin. ft. per M. H		2 track ft. per M. H.
25	Hand Crane	439.00	30 to 50 men			
32	Hand Crane	425.00	40 men			
22	Hand Crane	425.00				
6	Hand Crane	360.00				

DITCHERS

Railroad	Machine	Cost of Machine	Operating Cost per Day	Maintenance Cost per Year	Cost per Yard			Cost per Lin. Foot	Saving
					Machine	Teams	Hand		
17	1	$ 8,660.00	$105.41	....	$0.20	$0.50	$1.00	....	30c to 80c per yard.
27	1	11,300.00	....	$1,634.11	.39	....	1.23	....	84c per yard.
7	3	1,850.00	161.13	1,055.00	.473	....	....	....	....
	1	10,000.00	163.21	1,055.00	.487	....	....	....	....
9	1	12,750.00	130.32	....	.275	....	....	....	....
	4	8,000.00	141.44	....	.275	....	....	....	....
	2	13,500.00	130.32	....	.16	$1.17 to $1.57	$0.80 to $1.60	....	....
31	1	6,000.00	85.00	....	.25	....	....	....	....
	2	12,000.00	85.00	....	.08	....	....	....	....
10	1	....	76.52	....	....	....	....	....	....
	3	....	87.74	....	....	....	....	....	....
30	1	....	119.00	300.00	.303	....	....	....	....
16	1	....	....	....	....	....	....	....	....
	2	....	....	....	....	....	....	....	....
20	1	....	....	....	....	....	....	....	....
4	5	....	....	....	....	....	....	....	....
	6	....	....	....	....	....	....	....	....
	1	....	....	....	....	....	....	....	....
35	1	....	123.60	739.00	.356	....	....	....	....
	5	....	123.60	819.21	....	....	....	....	....
21	7	000.00	120.00	....	....	....	....	....	....
	8	10,000.00	120.00	....	....	....	....	....	....
	2	14,000.00	120.00	....	....	....	....	....	....
2	2	17,000.00	....	....	....	....	....	....	....
11	1	6,285.00	160.00	....	....	....	....	....	....
34	1	4,500.00	81.68	1,188.31	.26	....	....	....	....
	2	17,000.00	57.20	250.00	....	....	....	....	....
5	2	10,000.00	45.04	....	.05 to .20	....	....	....	35c to 80c per yard
33	1	8,150.00	72.00	300.00	.04	....	....	....	31c to 46c per yard.
14	2	17,000.00	75.00	175.00	....			1c to 1.5c	4c to 15c per yard.
26	1	13,395.00	....	....	....	....	....	4c to 8c	....
	2	15,500.00	....	....	.60	....	....	....	....
25	2	....	85.00	....	....	....	....	5c	....
24	8	....	106.00	....	....	....	....	....	....
	1	....	106.00	....	....	....	....	....	....
32	1	11,000.00	100.00	700.00	.40	....	....	....	....
22	1	8,985.00	173.00	....	.40	.50	2.00	....	....
	2	15,500.00	85.00	....	....	....	....	....	....
6	1	6,198.00	....	200.00	.60	.40	9.00	....	....
8	3	2,300.00	....	50.00	.60	.40	9.00	9c	....
	2	....	....	....	....	....	....	....	....

PORTABLE CRANES

Railroad	Manufacturer	Cost of Machine	Maintenance Cost Per Year	Length of Boom	Lifting Capacity	Crew Required	Cost of Loading	Saving and Other Uses
13	2	$12,745 00		40 ft.	30 T at 12 ft. to 9 T at 40 ft.	8 men		22 men—Pile Driver and Excavator
	2	9,541.00		46 ft.	18 T at 16 ft. to 5 T at 45 ft.	8 men		22 men—Pile Driver and Excavator.
	1	15,510.00		50 ft.	30 T at 12 ft. to 7 T at 40 ft.	8 men		22 men—Pile Driver and Excavator.
18	3			30 ft.	5 T at 24 ft.	2 men		Erecting small buildings.
27	3	8,700.00			3 T at 50 ft.	3 men	$0.157 per T	
	1	11,000.00			30 T at 29 ft.	3 men		70 per cent.
	4	15,000.00						
7	2	12,000.00		50 ft.				Excavating and Pile Driving.
	4	20,000.00		50 ft.				
	5	17,231.00		50 ft.				
9	3	9,000.00		30 ft.		4 men		4.5 cents per ton.
	5							
	4							
10	3	16,000.00		50 ft.		3 men		
12	1	18,000.00		50 ft.	15 T at 15 ft. to 4 T at 50 ft.			
5	3	15,000.00	$ 200.00	50 ft.	16 T at 17 ft. to 4 T at 50 ft.	4 men	0.15 per T	2600 M. H. per month.
3	6	11,600.00	600.00	50 ft.	25 T at 12 ft. to 4 T at 50 ft.	7 men		
	7	12,750.00	600.00	50 ft.	13 T at 12 ft. to 3 T at 50 ft.	7 men		370 M. H. per day in cleaning ballast
	5	17,000.00	600.00	50 ft.	26 T at 12 ft. to 4 T at 50 ft.	7 men	0.10 per T	
35	4	7,260.00		50 ft.	15 T at 25 ft. to 6 T at 50 ft.			
21	1	19,000 00		40 ft.	40 T at 26 ft.	2 men		Bridge construction, rail laying.
	3	5,000.00		25 ft.	2 T at 15 ft.	6 men		
34	1	15,000.00	1,576.48	45 ft.	4 T at 40 ft. to 25 T at 12 ft.	4 men	0.04 per T	$0.38 per ton.
33	5	13,000.00	500.00	35 ft. to 70 ft.	3 T at 70 ft. to 35 T at 12 ft.	4 men	0.16 per T	100 M. H. per day.
	3							
	8							
	2							
	1							
	3							
31	1	14,000.00		45 ft.				
26	7	6,500.00		35 ft. to 40 ft.	1.5 T at 10 ft. to 2.5 T at 40 ft.	1 man		
	9	8,000.00						
	3							
32	4	19,000.00	200.00	40 ft. to 50 ft.	20 T at 12 ft. to 3.2 T at 50 ft.	4 men	0.065 to 0.45	100 M. H. per day.
	1	19,000.00	200.00		20 T at 12 ft. to 3.2 T at 50 ft.			
6	7	5,965.00	100.00	48 ft.		2 men	$0.05	
	5	22,890.00	100.00	50 ft.		2 men	0.05	
	1	15,036.00	100.00	50 ft.		2 men	0.05	

Appendix E

(6) EDUCATING AND TRAINING MAINTENANCE OF WAY EMPLOYEES

C. E. Johnston, Chairman, Sub-Committee; E. B. Hillegass, R. L. Schmid, C. E. Weaver.

A Sub-Committee of the Committee on Economics of Railway Labor in 1922 submitted a report upon methods for training and educating employees in engineering and maintenance work. This report was divided into two parts, viz.: (A) Training and Educating Engineers or Employees in the Engineering Department in Maintenance Work, and (B) Training and Educating Employees (other than Engineers) in Maintenance of Way Department Looking to Greater Economy and Efficiency as Well as Promotion. Ten conclusions were drawn from this report, six from Subject (A) and four from Subject (B). These conclusions are to be found on pages 678 and 679 of Volume 23, Proceedings for the year 1922.

It has been thought advisable by your Committee to review the conclusions aforementioned with the idea of discussion from the standpoint of various activities that have since been developed.

DISCUSSION OF CONCLUSIONS FROM SUBJECT (A)

1. Engineers trained in maintenance work are essential to an efficient organization.

This conclusion is merely a premise. It has in recent years had broader application than formerly and there can be little doubt that much of the improvement in maintenance methods and economies is due to its general acceptance. It would be clearly impossible to evaluate its direct influence.

2. The systematic training of young engineers for maintenance work should be carefully undertaken and if in due course they do not display necessary qualifications to combine practical and technical training with ability to organize, direct and supervise work, they should not be retained in this branch of service.

Your Committee is not informed to what extent the systematic training of young engineers along this line has been attempted. There have been some sporadic movements of this kind for a number of years, but the consensus of opinion seems to be that the results at best have been doubtful. Indeed, there are practical difficulties which make the successful working of this plan somewhat idealistic. Your Committee is of the opinion that if these practical difficulties can be overcome and the plan consistently carried out, the result would justify the effort.

3. Training of young engineers in maintenance work may best be accomplished by rotation in service.

Within practical limits, many roads are demonstrating the success of this system. It has the distinct advantage of broadening the vision of the younger men and teaching them the relationship that different kinds of work or parts of work bear to each other. It also has the advantage of deferring specialization until a substantial foundation has been acquired.

4. It is essential to the training of young engineers that they familiarize themselves with the rules and practices of the Operating and Accounting Departments.

One successful method of familiarizing young engineers with the rules of the Operating and Accounting Departments is through the medium of meetings where questions of this kind are discussed. This will be treated in more detail under Subject (B). However, your Committee recognizes the importance of familiarizing young engineers with these points and takes occasion to stress the importance of this conclusion.

5. In the interest of an efficient organization it is desirable to maintain a fixed minimum engineering force throughout the year.

It is the belief of your Committee that the practice of maintaining a fixed engineering force throughout the year is general. This practice has the advantage of holding men in the service and qualifying them for promotion. By this plan, men become familiar with the various methods of doing work, available records and innumerable details that require a long term of service for new men to master.

6. It is desirable that there be practical cooperation between railway managements and schools and colleges offering technical courses for the better preparation of young engineers entering railway service.

Your Committee has no available information as to how much cooperation now exists between railway managements and schools and colleges with this end in view. Your Committee feels that while it is doubtless a worth-while undertaking, much along this line has already been accomplished through the medium of this Association and the already large and growing representation of educators in its membership. Undoubtedly, the close contact which exists between this Association and the many teachers which belong to it has accomplished much in the way of harmonizing college curricula with the needs of railway work. Your Committee recognizes the importance of this contact which should produce greater and more satisfactory results than individual cooperation between managements and colleges.

DISCUSSION OF CONCLUSIONS FROM SUBJECT (B)

1. A thorough and systematic method of training employees is essential for efficiency and for promotion to advanced positions.

Your Committee believes that important development has taken place on many railroads in accordance with this recommendation. In the last few years, there have been formed several associations of maintenance workers organized along lines that have assured thorough and systematic training. It naturally follows that this training produces efficiency and prepares men for promotion. So important has the development of these associations become and so excellent have been the results forthcoming that your Committee deems it timely to trace the work of these associations and give an outline of the organization.

Since your Committee is fully informed as to organization and procedure of certain associations, they will be described as typical. Such information as is available to your Committee indicates that the achievements of all associations organized along proper lines and consistently conducted are uniformly good.

One important point is that there are no elective offices. The offices of such associations should be attached to certain positions. The Secretary should be free to devote as much time to association activities as they require. In this way, politics of all kinds are eliminated from the organization, which is important when the fact is remembered that many similar movements have been wrecked through this agency. Monthly meetings are desirable, which may be held in rotation on the divisions. Approximately half the section foremen, bridge, signal and other maintenance foremen of the division on which the meeting is held should be invited to attend. All of the supervisors of that division should be present and in addition a fair representation of office employees from the Division Engineer's and supervisors' offices. In addition to these men who belong on the division where the meeting is held, as many of the Division Engineers of other divisions as can conveniently do so should attend, and also a few of the other supervisors and foremen from other divisions. The General Office should be represented by one or more Assistant Engineers, and when feasible by one or more draftsmen or office men. In this way, an attendance of some size that represents all departments of maintenance of way activity is assured.

A point for meetings should be selected where trains from both directions have convenient arrival and departure hours. All arrangements for meals should be made by the Secretary and paid for by voucher, which obviates handling these items through expense accounts. The meetings should be begun about 10 o'clock in the morning and end usually about 5 or 5:30 o'clock in the evening, with an hour recess for lunch. At the evening meal, after-dinner speeches may be called for from visiting officials or other guests who should talk on subjects of their own choosing.

The programs for the meetings should be made up by the Secretary, acting with the Executive Committee. It is a point thought worthy of mention that in one such association no one has ever refused to prepare a paper when invited. This is unmistakable evidence of the regard in which the association and its work is held by the men. The papers should deal with all phases of maintenance work, including time-keeping, accounting for materials, and occasionally broader subjects such as organization, morale, etc. The experience of several associations is that the papers produce lively discussions. Men of other departments should be invited to speak on subjects which they have in common with the maintenance force and give their perspective on such activities. This brings about a common understanding which is conducive to closer cooperation.

Representatives of the Safety Department should attend all meetings. These representatives should be qualified to call attention to any Safety features which enter the general subjects discussed. Having Safety considerations injected in this manner serves to make strong impression on the men. The Safety Department should also avail itself of the meetings to give the record of accidents, one period compared with another, in order to call attention to improvement or retrogression in the handling of work from the standpoint of safety.

It is generally agreed that it is extremely unwise to use these meetings for "calling down" or in any way embarrassing those in attendance. At first, the foremen are likely to be somewhat reticent, and their attitude may disclose a lurking suspicion that they are assembled in order to more effectively "rawhide" them. As soon as this suspicion is dispelled, they will become enthusiastic, look forward to the meetings and vie with each other for an opportunity to attend.

Perhaps an actual incident will show the influence of one of these associations on the morale of the men. Some time ago there was a strong attempt to get the maintenance force on one railroad to abandon its system of employee representation and affiliate with the National organization. The organizers, recognizing that a maintenance meeting would afford them an unusual opportunity, were in evidence at one of the meetings. They were treated civilly by the officers and no obstacles were put in their way. At that time there was a widespread discussion of wages and working conditions, by no means limited to that particular railroad. However, on the train leaving the meeting point that night one of the officials happened to walk up to the smoker. He found some fifteen or twenty men carrying on a lively argument about one of the papers which had been presented that afternoon, and all alone, several seats removed from the discussion, one of the principal organizers. From the evident interest of the men in their argument, it was apparent that wages and working conditions, the question of the hour in most branches of service in that section of the country, was at that particular moment receiving no part of their thought. This cannot help but stand out in strong contrast to the ordinary group of employees and is a powerful argument for keeping men interested in their work.

It should be stated at this point that it is generally conceded that neither wages nor working conditions should ever be referred to at meetings. Both the men and officers should tacitly recognize such subjects as taboo. Negotiations on those subjects may be at their height, but never a word should be spoken of them on the floor of the meetings, nor so far as practicable, during the intermissions. The same applies to discipline of all kinds. If these points are carefully observed, the meetings are put on a wholly different plane from the everyday affairs and all who attend will stand on the common ground of study, investigation and the exchange of ideas for the furtherance of their work. The conventional relationship of superior to subordinate is for the time being suspended.

Perhaps the most important benefit derived from the organization of maintenance associations is the attitude of the men toward their work and their superiors, because this is a fundamental without which other benefits would be transient. However, the effectiveness of these associations as a medium of education, if properly conducted, can hardly be overrated. From this perspective all the good features that education produces accrue to the associations. The things that should come before the associations are practical things and they should receive practical discussion. If this is done, the men cannot help learning that there are several ways of doing the most ordinary tasks as well as the most refined operations, and that a selection is worth while and must be backed by good reasons. Broadly speaking, it teaches them to think, and equally as important, it fixes for them the primary precepts on which to base their thought. They instinctively acquire the relationship of time versus cost.

With education also comes the need for economy and the knowledge of how to achieve economies in both labor and material. The men also get an insight into the broader plans and aims of their superiors and come to realize that they are integral parts of the whole. They find themselves entities and not merely pawns which are moved by chance or favor. Foremen should be taught that it is to their credit to develop good foremen and supervisors should likewise be taught that it is to their credit to produce good supervisors. Appreciable difference in these particulars will unquestionably result from the influence of a properly designed and conducted maintenance association. Where associations have been in effect for some length of time, it is commonplace to hear a section foreman take the floor at a meeting and without embarrassment or hesitation give a talk that shows thought and sound judgment on some point that is a distinct contribution to the subject under discussion.

Your Committee feels that one not familiar with the papers read before these associations would be agreeably surprised at the form and presentation of the subjects. It is by no means uncommon to see papers of these associations reprinted in *Railway Engineering and Maintenance,* the *Railway Review* and various employee magazines. At least one such association gets out a printed bulletin as soon after the meetings as practicable. This bulletin contains the papers read, together with a transcript of the discussion. The bulletin serves to keep the entire Maintenance of Way Department in full knowledge of what takes place at the meetings, and it is eagerly read by both those who attended the meetings and those not so fortunate. In addition to the papers and discussions this bulletin also contains editorials, personal notes and occasionally an instructive or timely article on some subject not discussed at a meeting. This bulletin carries no advertising matter of any kind.

2. In promotion, merit and fitness should govern. Employees having necessary qualifications should be given every legitimate opportunity and encouragement to obtain necessary training and experience.

Your Committee believes that conditions have long since made merit and fitness the only considerations for promotion. With the ever-increasing need and demand for greater efficiency and economy, it seems hardly probable that any recession from these criteria is to be feared. However, your Committee is firm in emphasizing the recommendation that employees having the necessary qualifications be given every legitimate opportunity and encouragement to obtain the requisite training and experience. It is the opinion of your Committee that this is being done to a larger extent and in a broader way at the present time than ever before. The two reasons actuating this development are first, a more liberal attitude on the part of officials, and second, the decreasing supply of desirable men to fill subordinate positions. Your Committee cannot but point out the fact that here again a maintenance association provides a medium which may be made to serve this end with peculiar aptness. Reflection will disclose that an association may even develop latent qualifications and also provide both the encouragement and the education necessary for promotion.

Your Committee thinks it well to say a word in regard to physical fitness for promotion. It is a fact confirmed by observation and supported by both pathology and psychology that physical fitness is important, not only for work of good quality and normal quantity, but also for the capacity for learning and clear thinking. These facts accentuate the desirability of seeing that only men who are physically sound be employed. It is of course necessary to examine men for sense perception in sight and hearing, since defects in these attributes disqualify a man immediately. It is becoming recognized, however, that these elementary tests do not fulfill all that should be required in men considered for promotion, and where possible, an examination similar to that required for admission to the Army is recommended. The health requirement should be a condition for original employment, but since this is not always possible because of location or of the demand for men, it should be more generally adopted for those otherwise eligible for promotion.

Notwithstanding the educational benefits to be derived from academic sources, your Committee feels that the personal education that the immediate superior can give those showing latent ability is one of the most important influences in the development of men. To this end, your Committee believes that the entire supervisory force from the foreman up should be constantly impressed with the obligation of giving all the practical education possible to those under them. There are numberless cases where almost the entire education of men depends upon what they can learn from their supervisors. Because of that fact, this avenue of learning should be taken advantage of to the fullest possible extent. Again, that knowledge derived from a book or a discussion can best be "driven home" through practical example with the consequence that even when education may be acquired through other means the education that may be gained from the superior retains a significant importance.

Your Committee appreciates the fact that experience holds equal place with fitness and education. It is only from experience that the self-confidence necessary to meet the unusual situation springs. It is therefore important that men be given the experience that begets a complete knowledge of their responsibilities and obligations as quickly as they are thought to be timber for promotion. This has been successfully done by having them fill higher positions temporarily under the observation of their superior. A foreman can advantageously turn his gang over for a day to a laborer who shows promise. A supervisor, during periods of enforced absence, can be relieved by a foreman. These are only suggestions by which your Committee hopes to bring out the point that no opportunity should be slighted which would give those in line for promotion the experience which will make them proficient.

Your Committee is mindful of the fact that in many sections of the country foreign labor or negro labor is all that is available and that where this condition obtains a more difficult situation has to be met. However, the peculiarities which this condition produces differ for each kind of labor employed. What would apply to Italians might not apply to Mexicans, and perhaps the expedients for dealing with negro labor would differ from both. These complications forbid dealing with each condition. It is the belief of your Committee that with necessary modifications to fit the special case, the general principles touched upon will be of benefit wherever employed.

Those roads lying in latitudes where long and severe winters make their work seasonal have yet another problem due to their inability to offer continuous employment. This is a great impediment to education and all other systematized effort to prepare men for promotion. Here again your Committee feels that the general principles discussed may be advantageous if modified to suit the particular case.

Judging from the general aspect in many sections of the country, the problem of obtaining competent foremen will become increasingly difficult and is a point deserving careful thought and study.

3. To accomplish best results, methods should be installed to promote individual effort and interest. Personal contact and personal interest shown on the part of the supervisory forces will go far to bring this about.

Your Committee is of the belief that the last few years have brought about a wholesome improvement in these directions. Many methods have been introduced which give impetus to individual effort and interest. These embrace prizes and awards, the creation of friendly competition, and the circulation and discussion of good records in the performance of work. A more important development intended to further individual effort, interest and personal contact between the men and their superiors has been the creation of personnel departments. Personnel work has been undertaken in an organized way on many railroads and it is the opinion of your Committee that the results have been satisfactory. Personnel work, generally, embraces both welfare movements more or less paternalistic in character, and social activities designed to create an *esprit de corps* and build up morale. Illustrative of the type of welfare work, group insurance deserves mention. Group insurance policies have been placed by a number of large roads. It is the information of your Committee that generally speaking the management participates to some extent in the payment of premiums. On many roads the insurance carries accident and health benefits. When these features are included, three of the major hazards of life, which are frequent causes of sub-conscious disquietude, and which are translated into unrest and dissatisfaction, are protected. The three hazards which group insurance provides for are sickness, accident and premature death. Since practically all railroads have pension systems, a fourth hazard is guarded. The rates on group insurance put this protection within the reach of all classes and allow many the benefits of insurance who could not obtain individual insurance protection on account of physical impairment or dangerous occupation. Many of these policies have been in effect long enough for the employees to appreciate their worth through sad example and it is clearly evident from the number of these policies now in effect and the frequency with which new policies are being placed that group insurance is of recognized benefit.

Your Committee heartily commends the distinct and widespread improvement in housing conditions that has taken place in the past few years. The influence on one's outlook on life created by living conditions is great. A nicely kept yard, a neatly painted house and sanitary arrangements produce a psychic satisfaction that automatically sublimates itself into greater purpose and sustained effort. Conversely, a dilapidated house, ill-kept yard and unsanitary conditions are frequently responsible for a sub-conscious carelessness, the effect of which can be traced in personal habits and workmanship. Nor should the interior of the living quarters be neglected. Some roads allow a reasonable amount of time with pay for attention to section house grounds and this practice is thought a good investment. Keeping extra gang camp cars attractive and sanitary is more difficult than section houses and bunk houses owing to the high labor turnover and the class of men who normally occupy them. Notwithstanding these obstacles reasonable attention to camp cars is amply warranted. To give point to this statement by illustration, probably the most contented and efficient group of workers, considered as a class, are those in telegraph and signal outfits, where considerable attention is given living conditions.

The social activities sponsored by personnel departments range all the way from baseball, basketball, bowling and minor sports to picnics, theatricals and dances. Your Committee feels that all of these media properly conducted contribute to good-will and the building up of personal contact and confidence between the men, their superiors and the management. Employee magazines contribute to these same ends by providing pleasing publicity for these endeavors and further a wholesome rivalry in planning the execution of such pastimes.

Your Committee feels it should call attention to the specific benefit of a maintenance association in regard to the creation of individual effort and interest and the further and equally important feature of personal contact. Wherever maintenance associations have been organized it has been found that they have developed the interest of men in their work and that they have sustained the interest, a really more difficult thing than merely creating it. Furthermore, personal contact is made possible under conditions more propitious than can be produced at a social gathering, because the background is that of work and accomplishment.

4. Employees should be encouraged to seek further education from outside sources on general principles of railway operation, such as through correspondence, night schools and periodicals on railway maintenance.

Your Committee believes this recommendation is being quite generally followed out. A number of roads encourage men to affiliate with correspondence schools and allow tuition to be arranged through payroll deduction. However, it is believed that many men who would be glad to avail themselves of such opportunities are not aware that correspondence courses on subjects pertaining to their work are obtainable, and it is recommended that superior officers, Division Engineers and supervisors be admonished to put in possession of those who might be interested information as to where correspondence courses can be obtained, the cost and the general treatment of the subject. Many roads distribute railway magazines both of a general nature and those dealing particularly with maintenance work through their organizations. In some cases, definite systems of circulating these magazines are in effect. It seems to your Committee that the small per capita cost of individual subscriptions together with the distinct advantages afforded by that method, particularly in allowing men to refer back to articles at desirable times, should justify many more individual subscriptions than are now believed in force. Your Committee calls attention to the fact that in order for the men to get the full benefit of these magazines and the articles they contain, supervisors should keep themselves informed as to the interesting items which appear and discuss them with their men. This serves the double purpose of making sure that the men are reading the magazines and of impressing them on their minds through discussion.

Summary

It is the belief of your Committee that much progress has been made in the last few years in all the features embraced by the ten conclusions based on the 1922 Report of this Committee and that at the present time no modification of these conclusions is advisable. Your Committee realizes that while many roads have shown a wholesomely progressive attitude in the activities herein discussed, there is much yet to be done by even the leaders in these movements, while there are many roads who have yet to undertake organized and concerted work of this variety. However, in the light of what has been accomplished in interest, the stabilization of working forces and economy by those who have engaged in these endeavors, your Committee believes that increasing importance will attach to all movements tending to raise morale and cement good-will between management and employee.

REPORT OF COMMITTEE VI—BUILDINGS

W. T. Dorrance, *Chairman;*	J. W. Orrock, *Vice-Chairman;*
G. A. Belden,	F. R. Judd,
Eli Christiansen,	L. L. Kelly,
*Arthur Crable,	A. MacGlashan,
H. G. Dalton,	D. F. McLaughlin,
F. M. Davison,	Milburn Moore,
C. G. Delo,	L. G. Morphy,
Hugo Filippi,	F. L. Riley,
A. M. Griffin,	G. A. Rodman,
E. A. Harrison,	A. L. Sparks,
A. C. Irwin,	O. G. Wilbur,
	A. H. Williamson,

Committee.

To the American Railway Engineering Association:

Your Committee respectfully presents herewith report covering the following subjects:

(1) Revision of the Manual

The Committee have studied Revision of the Manual for several years, and report this year in "Appendix A," their recommendations.

(2) Freight House Design

No work has been done during the past year on this subject. The Committee feel that the reports previously presented by this Committee and also by the Committee on Yards and Terminals have brought the subject up to date so far as information now available is concerned.

(3) Specifications for Buildings for Railway Purposes

The Committee has prepared additional roofing specifications as indicated in "Appendix B," covering Asphalt Impregnated Asbestos Felt and Asphalt Cement.

The Committee recommends for approval by the convention, for printing in the Manual, the Specifications on Roofing, presented to the Convention in March, 1925, and the additional roofing specifications presented in "Appendix B," and the Specifications for Concrete as printed in Appendix "A."

(4) Ventilation of Railway Buildings, Except Enginehouses

No new data has been available since the Committee's report of last year, and it is felt that this subject is in sufficient detail with the data at hand. The matter has been presented as information and there will be no recommendation for insertion in the Manual.

(5) Ornamental Roof Covering for Passenger Stations

The Committee considers this subject is covered in the Specifications for Buildings for Railway Purposes.

Bulletin 285, March, 1926.

*Died, January 11, 1926.

(6) Study and Report on the Design and Construction of Water Station Buildings, collaborating with Committee on Water Service.

This Committee has conferred with the Committee on Water Service and believes that details of building construction should not be included in the report at this time. They are in accord with the general requirements as set forth, with the omission of the building details.

(7) Outline of Work for Ensuing Year

The Committee offers the following list of subjects which it might be of interest to have studied. The Committee is ready to undertake such of these subjects as may be deemed advisable and is ready to take up any other subject which the Board of Direction may assign.

1. Study of steel sash versus wood sash for Railway Buildings.
2. Artificial lighting for Railway Buildings.
3. Detail study of plastic and composition floors for Railway Buildings.
4. Study of maximum grade permissible for ramps for Railway Buildings.
5. Study of possibilities in converting old passenger stations into modern structures.
6. Study of methods for improvement of office arrangements (lighting, ventilation, conveniences, etc.).

Action Recommended

1. The adoption of recommendations contained in Appendix "A."
2. No action desired.
3. That specifications for Railway Buildings covering the following subjects be approved for publication in the Manual: Concrete—Roofing.
4. No action desired.
5. No action desired.
6. No action desired.

Respectfully submitted,

The Committee on Building,
W. T. Dorrance, *Chairman.*

Appendix A

(1) REVISION OF MANUAL

G. A. Belden, Chairman, Sub-Committee.

DEFINITIONS

No change recommended.

ASH PITS

The present subject-matter in the Manual under this heading is to be eliminated, and the revised subject-matter contained in Bulletin 257, Vol. 25, pages 87 to 89, is to be substituted. Adopted at Annual Convention 1923. Proceedings Vol. 24, page 1117.

ENGINE HOUSE DESIGN

The present subject-matter in the Manual under this heading is to be eliminated and the revised subject-matter contained in Bulletin No. 250, Vol. 24, pp. 79-82 is to be substituted.

Adopted at the Annual Convention 1922. Proceedings Vol. 23, page 1094.

FREIGHT HOUSES

Recommended Practice Governing the Design of Inbound and Outbound Freight Houses

General

Separate houses for inbound and outbound freight should be provided where the volume of freight handled will justify the investment.

The outbound house should be not more than 30 feet wide and the inbound house should be from 40 to 60 feet wide.

Where but a single house is needed a width of from 30 to 40 feet is good practice.

In large cities consideration should be given to providing, above the inbound house, one or more floors which may be advantageously leased to shippers for storage purposes.

Materials

In general this type of freight house should be built of fire-proof materials throughout. Where economy in the initial investment makes necessary the use of frame buildings, these should have filled floors between masonry foundation walls, and should be divided into sections by fire walls spaced not more than 200 feet apart. The superstructure should be designed to conform as nearly as possible with slow burning construction.

Fire Walls

Where fire walls are necessary they should conform with the Underwriters' requirements for thickness and height and should have tees at the ends and fireproof aprons where the house has combustible side platforms. Openings in fire walls should be as limited in number as possible. No opening should have an opening greater than 80 square feet and each opening should be equipped on each side with standard automatic fire doors.

Fire Protection

(a) General.—Where water pressure is available, standpipes and hose racks not more than 150 feet apart should be provided for fighting fire. By putting them on the fire and end walls they are thought to be more accessible and less liable to be blocked by freight than if located at other points, but by putting them about 44 feet from the end of each section, fewer hose connections are necessary to cover the entire station. The valve controlling the water supply should be located below the frost line and controlled by a stem extending above the floor. The valve should be located in a pit, so as to be readily accessible for repair or renewal. It should be drained into the pit, and this in turn be connected to the sewer. A 2½ inch standpipe of wrought iron should be run up to approximately 8 feet above the floor, and to this should be attached a hose rack, equipped with 50 feet of 2-inch linen hose. The Underwriters now recommend 1½-inch hose wherever it is to be handled by inexperienced men, but provision should be made on the water line for a 2½-inch outlet for city house; care being taken that the threads on the outlet are the same as the city equipment.

(b) Chemical Extinguishers.—Chemical extinguishers should be provided in addition to the hose and standpipes. As they are put out of service by freezing, some provision should be made for replacing them or keeping them warm. Tanks containing a solution of calcium chloride are used successfully.

(c) Red Light.—In houses where electricity is available there should be over each hose rack a small red light to designate the location of the fire-fighting apparatus, this light to be kept burning at all times.

(d) Watchman's Clock.—Where a watchman is employed, a watchman's clock system, with stations located at various points throughout the building, should be employed.

Floors

(a) The type of floor used should conform with the requirements given elsewhere in this Manual under the recommended practice for "Floors for Freight Houses."

(b) Floors should be sloped across the house in the direction of trucking at the rate of 1 inch in 8 feet. Outside platforms should slope away from the building at the same rate.

(c) On the street side of the inbound house, the floor should be from 3 to 4 feet above the street grade, depending on the type of trucks generally in use. On the street side of the outbound house, the height of the floor above the street grade should not exceed 3 feet.

Fenders

On the driveway side of all freight houses, suitable longitudinal wooden fenders should be provided to protect the walls from damage by trucks and wagon wheels.

The fenders should be designed so that they can be readily renewed and should preferably be kept about 2 inches from the walls of the building by separators.

Platforms

(a) Platforms along the track side of the house eliminate the necessity of spotting cars at doors and of keeping open a trucking aisle inside the house on the track side. Such platforms should be not less than 8 feet wide where hand trucks are used, and not less than 12 feet wide where electric trucks are used.

In locations where the winters are long and severe, the elimination of outside platforms with the consequent spotting of cars at doors, is sometimes desirable.

Where outside platforms are omitted, the widths of houses should be increased to provide space for trucking aisles.

(b) For loading and unloading machinery and other large bulky packages, platforms should be built, usually as extensions to the inbound and outbound houses, with ramps on the ends of the platforms.

The extension platforms should be at least 8 feet wide, and if possible 16 feet wide, especially if covered. A stub-end track butting against a platform with a ramp is valuable.

(c) Where both outbound and inbound houses are arranged in the same layout a transfer platform is usually included. One of the best designs for covering these platforms is a butterfly shed, with the posts located in the center of the platform. Where this design is used the platform should not be less than 12 feet wide, to provide room for trucks between the posts and the cars.

Roofs

(a) Where State laws permit, protection over the cars is often used. This should be at least 17 feet above the top of rail, and should preferably extend to within 18 inches of the middle of the car. This will allow walking on the top of cars.

(b) The platforms should be protected by an overhanging roof, not greater than the width of the platform and at least 10 feet above the platform level.

(c) There should also be an overhanging roof, or other protection on the team side to protect goods while being unloaded, the overhang to be at least 4 feet and preferably more, 12 feet at least being needed to give protection from a driving rain.

On account of merchandise being piled high on trucks, it is desirable to have at least 14 feet above the level of the driveway.

Posts

It is desirable to have the floors of freight houses entirely free from posts, but in houses approaching 50 feet in width, the saving made by using posts becomes considerable and great enough to offset the advantages due to their omission.

Cranes

Where no gantry crane is provided in the freight yard, a stiff leg or pillar crane should be provided on the end of the extension platform.

Checkers' Stalls

Stalls for checkers should be located at least one in each section. These should be approximately 4 feet 6 inches by 4 feet 6 inches, with a shelf along the back and drawers beneath. Sometimes they are left entirely open in front, and sometimes are closed up and heated, depending on local conditions. Some roads make their checkers' stalls portable, so as to allow them to be moved in case of a special congestion of freight at certain points.

Doors

Several kinds of doors are satisfactory:—counterbalance (either folding or not), rolling shutters and horizontal sliding.

It is advantageous to have as much door opening on the team side as possible. With all types of doors except the last, all of the house can be opened except for the space occupied by posts.

With horizontal sliding doors not more than half of the space can be opened up at one time.

With no outside platform continuous doors should be used, so that an opening can be obtained at any point opposite a car door.

As all freight trucked into the house and cars must pass through the car door, the height of the freight-house door need be little greater than the car door. All door openings should be at least 8 feet high. On the team side a greater height might at times be convenient.

Door jambs in masonry walls should be protected by metal guards to a height of at least 4 feet.

Downspouts

Downspouts should not be located inside the building and in placing them outside they should be properly protected.

Lighting

(a) Artificial Lights.—Artificial light is needed for operation at night and during the late afternoon in the winter, and wherever possible electricity should be used, with wires run according to the specifications of the National Board of Underwriters. One or more lines of lights should be run the full length inside the house, and one line over outside platforms.

Another circuit should be run along the face of the platform wall parallel to the track, with outlet boxes not over 44 feet on centers, with socket arrangement for push plug for use in attaching an extension cord to hang inside the car to provide for loading on dark days and at night.

The type of lights will depend somewhat on the height of the ceiling. All lights should be stationary and operated in circuits from conveniently located panel-boards.

The circuits should be carefully planned, so as to allow maximum economy in use of lights.

(b) Natural Light—Natural light should preferably be provided in the side walls above the doors. Skylights in the roof are expensive to maintain and ineffective, as is also glass in canopies, or on any plane approaching the horizontal.

Offices

In large houses a separate office should be provided for the foreman. If this can be an elevated structure it will save floor space.

In large houses the general office for the clerks and the private office for the agent should be provided by a second story over the inbound house, and in the second story should also be a space for file, records and stationery cases, toilets and locker facilities for clerks. This all should, as far as possible, be in view from the desks of the agent or chief clerk. The cashier and his desk should ordinarily be located on the first floor.

Where possible it is preferable to have the clerks' and agent's offices, the toilet rooms, etc., for the freight handlers and draymen, the room for "over, short and damaged freight," and the cooperage room for repairing broken packages, etc., all in one section.

In the larger terminals provision may be wanted to care for perishable freight, and when it is provided it should also be located in this section.

Repair Room

(a) General—The weighing of package freight at freight houses is very important from a revenue standpoint, and the railroads are installing a greater number of scales, and giving serious consideration to the weighing of all package freight, except possibly standard packages of known weight.

There are some points where practically all the freight handled is of standard package freight, and at such houses very few scales are needed.

(b) Combination Inbound and Outbound Houses—In layouts where one house handles both inbound and outbound freight, and where the business is heavy and diversified, the scales should be located preferably at every third door opening, or a maximum of 75-ft. centers.

Where this number of scales are used they should be ample to take care of outbound weighing. Scales should be located on the driveway side of the house.

(c) Combination Freight and Baggage Rooms—At small outlying stations, where there is a combination baggage and freight room, fixed scale with platform level with the freight room floor, located preferably at one side of the door nearest the driveway side, is recommended, as at this point it will be less liable to damage from trunks or large packages.

(d) SEPARATE OUTBOUND AND INBOUND HOUSES IN SAME LAYOUT—In outbound houses it is desirable to have a scale at every second door opening, or a maximum of 75-ft. centers. These to be located approximately 6 to 8 feet from the receiving side of the house.

In inbound houses it is desirable to have scales placed 100-ft. centers, as the maximum, and located on the receiving side.

(e) CAPACITY—Scales for houses handling freight only should have a minimum capacity of four (4) tons. Higher capacity scales cost very little more and are economical from an operating standpoint, as they will stand up better under the abuse they are usually subjected to.

At combination freight and baggage rooms fixed scale level with the freight house floor, with a minimum capacity of two (2) tons is recommended.

(f) LOCATION—The ideal location for scales is to so place them that freight can be weighed as received and trucked to cars without rehandling.

(g) PLATFORMS—In large houses scale platforms should be as small as practicable to accommodate the trucks used, and usually not over 6 feet by 8 feet, except at certain localities, where one or two large scales are necessary to handle freight that is especially bulky.

(h) TYPE OF SCALE—Where large volume of freight is handled during short periods, dial attachments to scales are recommended, as the additional cost and maintenance is justified by the increased amount of freight that can be handled.

Tracks

DISTANCE TO CENTER LINE OF TRACK—The distance from the center of the nearest track to the face of the platform or freight house should be not less than 5 feet 9 inches, where tracks are on tangents.

DISTANCE PLATFORM TO TOP OF RAIL—The top of rail should be not more than 4 feet below the floor or platform level at the track edge, where refrigerator cars are not to be handled in any quantity. With occasional refrigerator cars the doors can be opened before the cars are set.

Where refrigerator cars are to be handled regularly, the height should not be more than 3 feet 8 inches, this conforming to the recommendation of the M.C.B. Association. (See M.C.B. Proceedings for 1911, Vol. 45, page 728). Many roads are building cars that are lower than the maximum figures given above, and each road, in deciding the height of platform above the top of rail, should take into consideration the sizes of cars that predominate on its line.

LOCOMOTIVE COALING STATIONS

The present subject matter in the Manual is obsolete and should be disregarded.

The Committee on Shops and Locomotive Terminals is now studying this subject and if the report of that Committee is adopted at the next convention, it will replace the section now in the Manual.

OIL HOUSES

(a) Oil houses at terminals should be separated from other buildings.

(b) Oil houses should be fireproof and the storage in large houses preferably be either underground or in the basement.

(c) Oils that are stored in sufficient quantities should be delivered to the tanks in the house direct from tank cars. For oils that are stored only in small quantities, provision should be made for delivery to storage tanks from barrels by pipes through the floor.

(d) The delivery system from the storage tanks to the faucets should be such that the oil can be delivered quickly and measured automatically. The delivery should also be such that there will be a minimum of dripping at the faucet and that the dripping may drain back to the storage tanks.

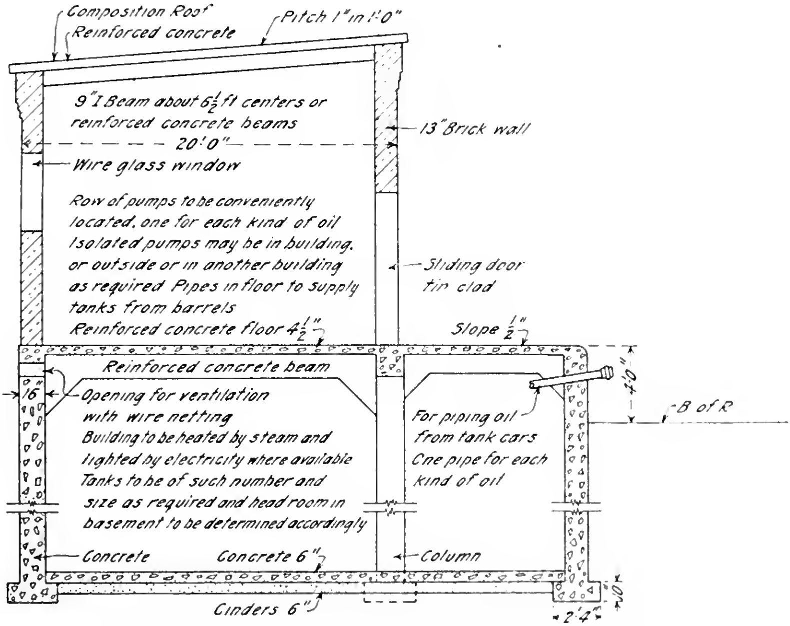


FIG. 2. CROSS-SECTION OF TYPICAL OIL HOUSE, 20 BY 40 FEET.

(e) Openings for ventilation should be provided above the level of the top of the tanks.

(f) Lighting, when required, should be by electricity and heating by steam.

(g) For fire protection purposes a live-steam line should be run to the oil storage space, controlled by a valve outside the house.

(h) It is necessary to provide sufficient heat in oil houses so that in cold weather the heavy oils can be maintained at a temperature at which they can be pumped.

A

(i) Where paints and paint oils are carried in oil houses they should be stored in evaporation proof tanks, equipped with agitators.

(j) Lighting fixtures should be of a vapor proof type.

REST HOUSES

Purpose

Rest houses are built to furnish accommodations for trainmen held at terminals away from home. The need of these houses is increasing with the construction of large terminals away from the centers of the towns. With them the men can be given clean and satisfactory accommodations, are kept out of temptation, are in better condition for their work, and are close at hand when wanted. The success of the house is dependent very largely upon the manager. With a man having the requisite ability and enthusiasm, the house and its associations can be made attractive and to have a valuable influence.

Location

The rest house should be so located as to be readily accessible, but sufficiently removed from other terminal facilities so as to permit of attractive surroundings.

Requirements

Rest houses should provide the following facilities and accommodations:

(a) Sleeping rooms
(b) Locker and lavatory rooms
(c) Lounge and reading rooms
(d) Toilet rooms
(e) Dining or lunch rooms
(f) Kitchen, pantries and store rooms
(g) Boiler room and fuel storage.

Sleeping Rooms

Provision should be made for dormitories, or individual sleeping rooms as local conditions may require.

Sleeping rooms should be located as far from lounge rooms, dining rooms and kitchen as possible, but close to lavatory and toilet rooms. They should be well ventilated with outside exposure if possible and designed so that they can be easily and readily cleaned. They should be equipped with comfortable beds, chairs and clothes lockers and convenient to them space for storing bedding and linen should be provided. Shades should be provided for windows.

Locker and Lavatory Rooms

Locker and lavatory rooms should be located convenient to sleeping rooms, and should also be readily accessible for those who wish to use them but who do not desire sleeping accommodations.

Where the extent of the investment will permit, separate lavatory rooms are recommended for the dormitories and for general use.

Lavatory rooms should be equipped with shower baths, wash basins, mirrors for shaving, and the usual accessories that are provided in a modern bath room.

Locker rooms, which should be adjacent to lavatory rooms, or part of the lavatory rooms, should be furnished with metal lockers, brenches or chairs, and mirrors.

Both locker and lavatory rooms should have impervious surfaces, properly water proofed, and preferably plastered walls.

Floor drains should be provided in floors and shower bath compartments should be of slate, marble or metal.

Fixtures should be supplied with hot and cold water.

Lounge or Reading Rooms

Adjacent to the lobby should be a lounge or reading room equipped with sufficient furniture and decorations to provide a comfortable, homelike atmosphere, where employees may read, write or rest.

Lobby

There should be but one public entrance. The entrance lobby should be a room large enough to serve as a center for the activities of the building, with an office for the manager, safe for checking valuables, bulletin board, phone booth, etc.

Toilet Rooms

Ample toilet room facilities should be provided, preferably separate facilities for dormitories and for general use convenient to the lobby. These should be designed to conform with the best practice in sanitation, both as to construction and fixtures, and should be well ventilated and have outside exposures, if possible.

Dining or Lunch Room

Where these facilities are provided they should preferably be located adjacent to the lobby. A lunch counter should be provided, supplemented by tables, if the extent of the project justifies it. The equipment should be durable, sanitary and preferably designed and installed by a manufacturer of such equipment.

Kitchen, Pantries, etc.

A properly designed kitchen with necessary pantries, storerooms, provision rooms, etc., should be provided adjacent to the dining room, furnished with modern, sanitary equipment.

For refrigeration a mechanical refrigeration system is recommended.

Meeting Room

Where the investment will permit, a room should be provided where meetings, lectures, etc., may be held.

Heating

Heating should preferably be by steam furnished from a central or individual heating plant. Where a separate heating plant is necessary, provision should be made for coal storage, and economical removal of ashes.

Lighting

Adequate artificial lighting should be provided, preferably by electricity.

General Construction

In general the building should be of fireproof construction throughout. Fire protection, fire escapes, fire gongs and all the best appliances for fire protection should be provided.

Outside porches are desirable.

In all cases the size of the building and extent of the facilities should be proportioned and designed to meet the particular requirements and local conditions, using the foregoing recommendations as guides rather than rules.

PASSENGER STATIONS

Passenger Stations with One General Waiting Room

The use of one general waiting room for a passenger station (without reference to separate waiting rooms for colored people) is recommended as good practice for the following reasons:

(1) It permits the general waiting room to be properly proportioned.

(2) It permits proper development of a retiring room for women, with private entrance to the lavatory.

(3) It readily admits of the other rooms being properly proportioned.

(4) It permits ease of access from the agent's office to the trains ,to the baggage room and to the waiting room.

(5) It permits the ticket office to be of proper size and location for general office purposes.

(6) It admits of the station being contracted in size without detriment to facilities.

(7) It offers economy in heating.

Heating

Method of, for Medium-Sized Stations

Stations with one or two waiting rooms, and an office, can be heated satisfactorily and economically by the use of stoves, especially where it is not necessary to maintain an even temperature throughout the entire day. The danger of fire from the use of stoves should be guarded against as much as possible.

Where two or more waiting rooms separated by an office are to be heated, a single central heating plant, preferably in the basement, is recommended as being the most economical and satisfactory. For such a heating plant a hot water, steam or hot air furnace may be used. The hot air furnace constitutes a greater fire risk than either the steam or hot water heater. An even temperature is more easily maintained by hot water than by steam, but a station is more quickly heated with a steam system than with a hot water system. The pipes and radiators of a hot water system must be kept above a freezing temperature.

Lighting, Electric

Electricity is the safest, most satisfactory and desirable method of lighting, and should be installed in all stations where reliable current is available at reasonable cost.

It is recommended that lighting be provided according to the two schedules following. The table gives general figures showing the approximate amount of light required at various locations in and around passenger stations:

FIG. 1. DIVISION OF FLOOR AREA RECOMMENDED FOR PASSENGER STATIONS WITH ONE GENERAL WAITING ROOM.

FIRST CLASS

Important City and Suburban Stations

Waiting Room	Direct	3 to 3.5	foot candles
Ticket Office	Direct	3.5 to 4.5	" "
Ticket Windows	Direct, 1 drop	4 to 4.5	" "
Baggage Room	General Illumination	1 to 2	" "

With Local Drop Over Desk and Window

News Stand	Direct Illumination	5	foot candles
Toilet Rooms	Direct General Illumination	1.5 to 2	" "

With One Drop Over Each Two Stalls

Cover Sheds and Main Platforms	Direct	1.5	foot candles
Outlying Platforms	Direct	1	" "
Station Approaches	Direct	1 to 1.5	" "

Second Class

Unimportant Country Stations

Waiting Room	Direct General Illumination	3 foot candles
Ticket Office	Direct General Illumination	3.5 " "
Ticket Window	One 25 Watt Lamp	3.5 " "
Baggage Room	Direct Illumination (1 or more drop)	
Toilet Room	Direct (generally 1 drop is sufficient)	
Platform adjacent to Station	Direct	1 to 1.5 foot candles
Outlying Platforms	Direct	2.5 to 5 " "

The center of distribution of the lights for the station and surroundings should be located conveniently to the office of the official responsible for the economical use of same.

Platforms (High Platforms at Passenger Stations)

It is recommended that high platforms be provided only in connection with tracks devoted exclusively to passenger traffic.

Sanitary Provisions for Stations

In all stations different planes should be connected by curves; all heads and angles that may collect dirt and protect disease germs should be avoided; and sufficient artificial light should be provided, as dark places are the ones that collect dirt and filth.

Shelter Sheds

In that part of the country where heavy snow occurs the Umbrella type of shed is preferable though somewhat more expensive in first cost.

In that part of the country where heavy snows are not a factor, the Butterfly type of shed is preferable.

Stairways

General.—These recommendations include the main requirements of building codes of a number of representative large cities, but should be used with due regard to local city and state regulations. Provisions as to strength of construction and fireproof features are not included.

Avoid steps and stairways where inclines and ramps can be satisfactorily used instead. Avoid any combination of sloping surfaces and steps.

Consider both the general design and details of stairway construction with a view of handling crowds of people with the individuals moving in parallel lines with ease and with safety, against slipping and falling, keeping such movement free from interference by other lines of travel.

In connection with the construction of new passenger stations and the maintenance and alteration of old stations, special study and consideration should be given to provisions for the safety of pedestrians in an effort to remove, as far as possible, all risks of personal injury, particularly from slipping, stumbling and falling. The actual risks and their relative economic importance are revealed by experience of railroads handling rush crowds, the statistics of insurance and compensation bureaus, and are also reflected by state and city building codes, relative to construction of factories, schools, auditoriums, etc.

Personal injury from slipping, stumbling and falling should be guarded against by choice of finish and wearing surfaces for floors and platforms, by avoidance of many details in common use which induce stumbling and slipping, by proper construction of ramps and stairways, including the use of safety treads on all main stairways, and by proper standards of maintenance, both as to condition of use and time of renewal or repair.

The construction of stairways in passenger stations should conform as to safety features to the recommendations given below.

No plans for extensive alteration of existing passenger depots, or general layouts for new stations, should be approved without a critical examination or study being made of the traffic movement in rush hours, and no details of construction should be used affecting stairways and surfaces on which passengers walk without careful consideration be given with a view to avoid or reduce as much as may be possible the risk of personal injury to passengers in and about stations.

Drainage.—Obtain necessary drainage at the ends of the tread, and not by sloping the surface in line of travel.

Location, General.—Place important stairways conspicuously in the main line of travel, keeping such travel in straight lines where possible. Arrange so that crowds at the head and foot of stairways can naturally assemble and disperse, with a minimum amount of confusion and cross-currents of walking. To this end, provide at the top and bottom of stairways, where possible, corridors or vestibules, using the same width as for the stairway. Such corridors should open directly into the room served without any funnel-shaped entrances, and with plenty of room for quick distribution.

Locate minor stairways away from regular lines of travel, and avoid combinations of service or minor stairways, with main stairway.

Consider possible lighting arrangements, particularly from natural light, avoiding locations where stairways will be poorly lighted in cloudy weather or where they will appear dark to a person entering them from bright sunlight.

Lighting.—In making lighting arrangements, consider that many people with poor eyes cannot, at best, see very clearly in descending stairways, particularly when the appearance of treads is uniform throughout. Provide ample natural and artificial light, avoiding direct light and shadows, and making certain that lights from adjacent rooms do not shine directly into the eyes of people using stairways.

Maintenance.—In the choice of materials and arrangements, consider the maintenance conditions that will exist in daily use, particulraly those in wet and stormy weather just before stairways are cleaned, and also give consideration to that poorest condition of safety treads and other parts which will exist just before renewal is required and made.

Pitch and Landings.—The pitch of stairways, i. e., the inclination as determined by the dimensions of treads and risers, and the frequency and proportion of landings, should be such that stairways may be ascended with ease, and as nearly as may be with a free natural walking step. The continuous upward lifting of the body, for anyone not accustomed to such exercise, and particularly for fleshy people, those with weak hearts, or anyone in poor health, is a great exertion. Landings break the continuity of this exertion, and offer a needed resting place for the weak. To fix pitch and landings properly, the following should be approximately observed:

Provide treads not over 13 in. nor less than 11 in. in width, and risers not over 7 in. nor less than 6 in. in height; and make the sum of two risers and one tread be between 25 in. and 26 in. The width of treads should be taken as the horizontal distance face to face of risers.

Where stairways require more than 16 risers, provide intermediate landings, keeping the length of single flights as near to 10 to 12 risers as may be possible. Use no steps with less than three risers.

Where feasible, provide the same height of risers and width of treads for all stairways used by the traveling public in any one building. Always make risers and stringers of closed construction.

Make the width of landings in the direction of travel not less than four feet.

Avoid, if possible, all minor entrances on landings or at the top or bottom of main stairways. If this cannot be done, provide suitable length of landings, so that doors can be opened and used freely by any minor class of traffic without, in anywise, causing interference with travel at the main stairway.

Railings.—Provide hand rails on both sides of all stairways and center rails on stairways eight feet wide, and additional rails to keep the distance between adjacent hand rails not less than 3 ft. 0 in. nor more than 6 ft. 0 in. Where intermediate hand rails are used, a double hand rail is recommended. Place center line of hand rails at least 5 in. from face of sidewalls, or 8 in. center to center for intermediate hand rails. Make section of hand rail rigid to give uninterrupted travel for a secure grip. Provide a hand rail without sharp drops or raises, and extend it beyond the last riser, and turn it downward, so that it offers no entanglement for clothes or baggage. Curve hand rails at all bends on landing. Provide such balustrades and hand rails as will prevent small children from falling or getting through them. In this connection, consider the use of curb to divide stairs under the center hand rails. Place top of hand rail 34 in. above tread, measured on line of face of riser. On the open side of stairway, provide barriers at least 42 in. high, to guard against accidental falls of persons over balustrade. At intermediate hand rails, provide newels not less than 6 ft. high, and secure the rails to them without encroaching on hand clearance. Provide newels which will not present sharp edges and corners.

Signs.—Place no signs, mirrors, or other objects of interest where they will attract the attention of persons using stairways, except such signs as are necessary to direct travel.

Stairways, Outside.—Where feasible, enclose, or roof over, all outside stairways not only to keep off sleet and snow, but also to prevent a slippery condition, due to rain and mud. Do not provide open risers. In choice of safety treads for outside stairways, consider means which will have to be used during winter weather to maintain surface of steps in good condition.

Treads.—Where used, nosing on treads should be limited to a projection of one inch.

Provide approved safety treads on all main stairways, using a renewable type securely fastened. Make length of safety tread 4 to 6 in. shorter than that of the stair tread, and use a width of safety tread of from 5 in. to 8 in. Place the surface of the safety tread flush with surface of the balance of the stair tread. Consider means, such as color schemes, which used in connection with safety treads, will clearly indicate the location of the steps, particularly the outer edge or nosing.

The use of wide safety treads, particularly those covering the entire width of the step, are of questionable necessity and value, as they present a uniform appearance for the entire flight of steps, and make it difficult for people to clearly see where they are stepping.

Type.—For main stairways, use a straight run of steps and landings wherever architecturally possible. Where turns cannot be avoided, provide landings and, if possible, restrict the turn to ninety degrees.

Width.—Proportion the width according to the character of traffic handled, the extent to which hand baggage will be carried, and the maximum stairway capacity desired during rush hours. Be guided by experience with local requirements rather than by thumb rules, bearing in mind that main stairways should be maintained wide enough so as not to check the movement of crowds, and that the width of minor stairways should often be determined by the rate at which people may continue to move away from them. (See text of report for certain data obtained in connection with construction of Hudson Terminal Building, New York).

Bevel, or round, landings to maintain a constant width, and keep people moving in concentric, or parallel, lines.

Where two stairways unite at a landing and form a single stairway, make the width of the latter equal to the combined widths of the other two.

For minor and service stairways, use no width less than 3 ft. 0 in. between hand rails.

SECTION TOOL HOUSES

Class A

House, 14 by 20 feet, with long dimension parallel to track; house to have sliding door 8 feet in clear at extreme end on track side to permit the storing of handcar.

Class B

House, 12 by 18 feet, with long dimensions parallel to the track; house to have sliding door 8 feet in clear at extreme end of track side to permit the storing of handcar.

Class C

House, 10 by 14 feet, with the short dimension parallel to the track, with double swinging doors, swinging out on the end nearest the track.

Building to be on wooden posts, unless the location can be permanent, in which case brick or concrete piers may be substituted.

ROOFINGS

General

The following factors should be considered in selecting a roofing for a railway building:

1. Probable life, including chance of damage by the elements and ordinary wear.
2. Possibility of leaks due to character of construction.
3. Initial cost.
4. Cost of maintenance.
5. Fire resisting value.
6. Appearance, and architectural value.

The type of roofing to be used is in general controlled by the structural design of the building, its location and use, and conversely the design of the building should be adapted to the use of an efficient roofing.

An efficient roofing may be defined as a roofing which will insure the building against damage by rain or snow at the least annual cost consistent with the architectural effect desired. In special instances the value of the roofing as an insulator must be considered, and in all cases the fire resisting value should be given due weight.

Basic Materials

The basic roofing materials may be classified as follows:

(a) Slate, tile and asbestos
(b) Metals
(c) Bitumens used with felts and fabrics
(d) Wood.

Slate.—When properly selected and applied, slate gives an ornamental roof of long life at a low cost for maintenance.

Slate should not be used on roofs having a pitch of less than 6 inches per foot, and should be laid with not less than a 3-inch headlap over the second course below. It is recommended that slaters' felt be provided under all slate roofing. In localities subject to heavy snow fall, snow guards should be provided on slate roofs.

Clay Tile.—Clay tile are made in a variety of shapes and sizes and may be obtained either glazed or unglazed. This type of roofing should be laid only on reasonably steep roofs and over a layer of waterproof felt.

A clay tile roof is heavy and requires special roof framing. Skilled workmanship is needed to provide a watertight roof. The value of a clay tile roof lies chiefly in the architectural effect produced.

Roofs of clay tile laid on open strips are not recommended.

Cement Tile.—Tile made of Portland cement mortar produce ornamental and permanent roofs when properly manufactured and laid. Careless methods of manufacture may produce an unreliable product. The process of manufacture should be covered by a definite specification and subject to inspection.

Cement tile are manufactured in two forms, viz., shingle tile and structural tile.

(a) Shingle tile should be applied in the same manner as slate and under the same conditions.

(b) Large cement tile, reinforced with metal and laid without sheathing directly on purlins make a permanent and economical roof for large buildings.

Glass can be introduced into the tile, taking the place of skylights.

Asbestos Shingles.—Shingles made of Portland cement and asbestos fibre make an ornamental and durable roof covering. They should be applied in the same manner and under the same conditions as slate. These shingles are made in a variety of colors and patterns, but the diagonal, or "French," method of laying these shingles is not recommended.

Corrugated Asbestos.—Corrugated asbestos sheets made of Portland cement and asbestos fibre make a good roofing material for some classes of buildings with steep roofs. The sheets are laid directly on purlins, or strips, without sheathing, and produce a practically permanent roof.

Metal Roofing.—Sheet copper and lead are recognized as practically permanent roof coverings, but are not specially adapted for use on the average railway building on account of their high initial cost. Rolled sheets of pure zinc make a good roof covering at a lesser cost than copper or lead.

Iron sheets coated with tin make a good roofing material, but require periodic painting to give long life.

Galvanized iron or steel sheets have some merit for minor buildings, but should be considered only where first cost is a controlling factor.

Steel sheets coated with asphalt and asbestos fibre have considerable merit.

Small metallic shingles of copper, zinc, tin or galvanized iron or steel are not recommended for general use.

Bituminous Roofings.—Roofs built up of layers of felt cemented together with pitch or asphalt and with or without a mineral surface are especially valuable on flat surfaces. They may, by using special kinds of asphalts, be used on roof surfaces having a slope as steep as 6 or 8 inches per foot.

Bitumens.—The common bituminous materials used are:

Coal tar pitch
Asphalts (petroleum and natural)
Vegetable gums

Their value lies in the fact that they are practically insoluble in water and that they are elastic, adhesive and comparatively stable.

Coal tar pitch is obtained from the destructive distillation of bituminous coal. It is easily affected by heat and cold, is not acted upon at all by water, is easily worked and if properly protected is very stable. It should ordinarily be used as it comes from the still, "straight run," of a consistency suitable to the climate and to proper application.

Roofing asphalts may be either natural lake asphalts fluxed with oils, or petroleum asphalts obtained from the distillation of crude oil.

The lake asphalts are unsuitable for roofing in their natural state.

A single asphalt fluxed with a single oil is for most purposes a crude and unsatisfactory material. To secure the best results for any desired purpose, several oil and asphaltic substances must ordinarily be compounded. This requires skill and experience. Those properly made are for certain conditions invaluable, particularly for ready roofing, for which tar products are not suited.

The asphalt and petroleum products are not so readily affected by heat and cold as is coal-tar pitch, and lesser amounts of them are necessary to get good results. They are more expensive, require more skill in handling, and when protected, some at least are to some extent liable to lose their life by drying out of the oil fluxes. Unprotected, they do much better than does coal-tar.

The petroleums found in this country vary considerably, and grade roughly in quality, according to location from East to West. The California oils, with their asphaltic base, furnish materials especially valuable for roofing.

Water gas-tar pitch, a by-product in the manufacture of water gas, which is enriched by gas from petroleum oils, resembles coal-tar. It is inferior to coal-tar for roofing purposes, and materials made from it should only be accepted in the low-priced products. It has more value as a saturant of felts than as a coating.

Of the vegetable gums, cotton seed gum makes a good material for built-up roofings. It is stable in water, oxidizes very slowly and is easily worked.

Felts.—The bituminous substances are used with felts whose qualities considerably affect the roofing. The ordinary felt is made of rags, mainly cotton. "Wool felt" is a misnomer. Asbestos felts, as compared with the rag felt act less as a carrying medium for the bitumen, but rather as a protection to the layers of bitumen. They are not suited for use with coal-tar pitch, but are not injured by hot asphalts. They are more expensive than rag felts, but have some peculiar and valuable qualities.

Burlap made from jute decays easily when not protected. It is used in a few ready roofings with rag felts to increase their tensile strength, the need of which is not generally agreed to.

Built-Up Roofs.—The built-up roof is especially valuable for flat surfaces. It can be made as heavy as desired, and if properly laid and of good materials gives a roofing which by long experience has been shown to be economical and efficient.

For the flat roof built under average conditions, coal-tar pitch is recommended in preference to asphalt products. It is more easily handled, requires less skill, and, while more material is necessary, it is still cheaper, and in our opinion more certain results can usually be expected from its use when laid by the average contractor. The large amount of material, while heavy, has insulating value. Good results, however, can be expected from built-up roofs using good asphalt compounds, where laid by skilled workmen.

When the slope of the roof is over three inches to the foot, the application of a built-up roof becomes more difficult for both coal-tar and asphalt, it being harder to get even mopping, and there is more chance of accident for the men.

The desirable straight-run coal-tar pitch cannot be used, it being necessary to add some stiffening material which is supposed to somewhat affect the life of the pitch. This must not be done except under supervision skilled in such work, and especial care must also be taken in the selection and application of the stone or slag coating.

Built-up roofs with a ready roofing for the coating sheet are proposed by various manufacturers. They should have their best value for steep slopes.

The advantages of a coal-tar pitch built-up roofing are such that it is recommended that where a permanent roof is desired, and where the character of the structure allows, the building be so designed as to allow its use. A flat roof makes an economical structure and has small fire hazard. A pitch of from one-half to one inch to the foot is better than anything steeper.

Prepared, or Ready Roofing.—Prepared roofings in general consist of one or more layers of felts, cemented together at the factory and shipped in rolls. They may have a smooth surface, or be coated on the weather side with crushed mineral.

The ready roofing has better value for the steeper roofs than for those of small pitch. It averages much cheaper than the built-up types. Most kinds, to get a fair life, require occasional recoating. For flat slopes they are hard to lay absolutely tight, and they are not economical for a permanent structure, but on slopes of from three inches to the foot up, their use is more justifiable.

Ready, or prepared, roofings are recommended for use on small, temporary and other buildings, where the cost, considering maintenance of more expensive roofings, is not justified. They are also of value for steep slopes, where a built-up coal-tar cannot be used, and for locations where the skilled labor necessary for a built-up roof is not available. The steeper the slope the greater their relative value and the wider their economical field.

The heavier varieties are, in general, the more desirable because of their chance for longer life and their greater fire-resisting value. In making selections the reliability of the manufacturers, service tests and the cost should be governing factors.

Asphalt Shingles.—Shingles, similar in composition to prepared roofing, with either plain or mineral coated surfaces, and laid shingle fashion on steep surfaces, are suitable for minor buildings of a more or less temporary character. Their use is not recommended on permanent buildings.

Wood Shingles.—The use of wood shingles is not recommended for railway buildings on account of the fire hazard.

Workmanship

The success and life of any roof will depend as much on good workmanship as upon careful selection of materials. Thorough inspection of workmanship is recommended.

Flashings

The installation of adequate flashings should be given careful consideration in connection with all roof work. Most of the trouble in alleged defective roof work can generally be traced to insufficient or incorrect flashings. Flashings should be selected so as to have approximately the same life as the roofing materials.

Protection

Where a built-up roof is subject to wear, and where the character of the construction warrants the expense, flat tiles or brick should be used as a protective coating instead of gravel or slag.

Guarantee

The practice of depending entirely upon the guarantee in selecting roofings cannot be trusted to secure proper results, although the length of guarantee offered with a built-up roof is an indication of its probable life.

ICE HOUSES AND ICING STATIONS

Icing stations may be built to handle (1) natural ice, (2) artificial ice, and (3) a combination of both natural and artificial ice. Provision must be made at many plants for the handling of a certain amount of crushed ice.

They may be divided into two classes, according to the method used to handle the ice, namely, gravity stations and mechanical stations.

The method of operation indicates the general design to be used in construction. Gravity plants are much cheaper to build than are mechanical plants, but are slower in operation.

The design selected, either gravity or mechanical, should be one in which the ice is always under control, so there will be no collision of the cakes in transit, thus avoiding delays and loss of ice by breakage. Back travel and duplicate handling of the ice should be avoided.

The location of the house, number and arrangement of rooms and location of platforms and machinery require careful study so as to assure economical and rapid operation both in filling the house and icing cars.

Where natural ice is harvested houses are filled by means of portable slides, made up in sections and laid on the ground from the source of supply to the foot of a motor-driven elevator at the house. If the local ice supply is not sufficient or if the station is entirely dependent upon ice shipped in, a platform, at car floor height, must be provided along the track side of the house. This platform may be used in loading ice for shipment as well as for handling ice to storage.

Where large capacity is required it is desirable to build the house higher rather than to spread it out. Heights from 18 ft. to 36 ft. are generally used.

To prevent rise of temperature, due to heat passing through the ground, some of the storage space should be below the grade line, extending about a foot below frost line, if drainage is obtainable.

Ice houses are generally of frame construction with a gable roof. The side walls of the storage house should be so constructed as to afford maximum insulation. If a concrete foundation is not provided, the walls should be tied together at the bottom with rods to prevent spreading. These rods should be below the floor line to avoid obstruction. In the storage portion of the house the use of interior supporting members should be avoided, as they interfere with the handling of the ice. The floor may be wood plank on sleepers set in a cinder bed, concrete on cinders or a combination of concrete and cork, as conditions warrant. Floors should pitch slightly toward the center so that when the house is filled the ice will not throw any stress on the outside walls. A drain tile should be laid through the center of the house for drainage.

Platforms for icing cars may be single or double-deck. Where single platforms are used the height is generally 13 ft. to 16 ft. 6 in. above top of rail. Where two-deck platforms are used general practice is to have heights of 13 ft. to 14 ft. for the lower one and 20 ft. to 23 ft. for the upper one. Double-deck platforms need not be wider than 12 ft., as cake ice is handled on the lower one and crushed ice, in two-wheeled carts, on the upper one. Single platforms should be somewhat wider, as both kinds of ice are handled on the same platform. A suitable distance from center line of icing track to the platform is 6 ft. Provision should be made on platforms for a supply of salt. Ample arrangements should be made for lighting so that night operation can be carried on.

At important stations it is desirable to provide two tracks, one on each side of the platform, so two trains can be iced at the same time

Where operating conditions require it, mechanically operated endless chain platform conveyors and inclines should be installed.

FLOORS FOR RAILWAY BUILDINGS

Transfer Platforms.

Wood plank platforms should preferably be laid with the planks parallel to the line of trucking traffic. Metal plates may be used for a runway to produce easier trucking and to reduce wear on the plank. Concrete floors are used in some cases and for extremely heavy traffic, a concrete base with creosoted wood or asphalt block or asphalt mastic wearing surface is used.

Freight Storage Houses.

For freight storage houses, which are usually of fireproof construction, concrete floors are generally approved.

Freight Piers.

Floors on freight piers must, of necessity, largely conform to the style of construction used in the pier. They should be fire-resisting and in many cases must have flexibility enough to take up the vibration caused by boats being moved along the pier.

Blacksmith Shops.

Floors of cinders, earth or clay are to be preferred in all cases.

Machine Shops.

In small buildings a wood plank floor, of thickness suited to the severity of service, is common practice. For buildings of a higher grade, wood blocks (preferably treated), asphalt blocks or mastic give excellent results. Concrete floors may be used where local conditions justify this construction as economical, although their lack of resiliency may result in discomfort to employees and their hard surface may damage tools dropped upon it.

Paint Shops.

In passenger car paint shops a concrete floor meets all requirements and it is doubtful if a more expensive type of floor is justified. In freight car shops, where paint is sprayed on, a floor of cinders is suitable.

Freight Car Repair Shops.

Wood floors can be used if something better than cinders is desired and if provision has to be made for trucking material between tracks. Concrete is very satisfactory for a floor of higher grade.

Store Houses.

Concrete floors are satisfactory and are in common use, but for locations where very heavy material is handled, wood blocks, asphalt block or mastic are to be preferred. In small storehouses, at outlying points, the ordinary wood plank floor is commonly used.

Oil Houses.

Because of the necessity for fireproof construction, concrete is recommended for oil houses.

Carpenter Shops.

In carpenter shops where considerable bench work is done, wood plank floors are desirable because of the comfort to workmen they afford. Concrete floors are more easily kept clean and are sometimes used.

Office Buildings.

Office buildings of the better class should have oak, maple or dense pine floors as indicated by the use for which the various rooms are intended. Hallways and toilets should have floors of concrete, marble, tile (either natural or composition), terrazzo or some kind of a sanitary composition, provided the importance of the building warrants the expenditure. For office buildings of lesser importance, floors of composition, concrete or pine are satisfactory. If concrete is used it is desirable to provide some kind of a resilient covering for added comfort to employees.

Passenger Stations.

In large city stations and in suburban stations of importance terrazzo, tile or some other high grade type of composition floor is generally accepted as best meeting the requirements. In such locations the architectural suitability of a floor is of as much importance as its wearing qualities. For ramps, a non-slip wearing surface is essential. For small stations concrete or wood floors are commonly used. In stations where concrete or terrazzo floors are used, a wood or other type of resilient floor covering should be provided in the ticket office.

Signal Towers.

Floors in signal towers may be of concrete, composition or wood, depending upon the type of construction of the building. When concrete is used in connection with electrical machinery, precaution should be taken to secure a non-dusting surface.

Freight Houses.

In small houses, which are usually of frame construction, a plank floor laid on wooden joists is satisfactory and economical. In larger and more important houses, where much trucking is done, a floor of greater first cost is justified and appreciable economies in operation can be obtained by the selection of a suitable trucking surface. Concrete floors are fairly permanent, sanitary and easy to keep clean, but have as disadvantages a possible failure of the wearing surface, especially at expansion joints, and an unyielding surface which occasionally produces complaints from truckers. Expansion joints should be located outside of the heavily used surface wherever practical. If a concrete surface is not considered suitable, some different type of wearing surface such as square edge maple, wood or asphalt blocks or asphalt mastic may be laid on the concrete. A creosoted wood plank floor on a concrete base with a wearing surface of untreated maple flooring has been known to give very satisfactory service. If the cost of a concrete base is not justified an excellent floor can be made by laying creosoted plank on a fill of cinders or gravel, the top layer of which is treated with tar or some asphaltic compound, and covering the creosoted plank with a maple wearing surface. Asphaltic concrete may be applied over a wood base with good results.

Engine Houses.

In minor houses, where not many running repairs are made, a floor of clean engine cinders, well compacted, is frequently used, but whenever possible a better type floor should be provided. For houses of more importance concrete floors or floors of brick or creosoted wood blocks on concrete base should be used. Asphalt floors, either mastic or block, if used in engine houses, should be of such composition as to resist the action of steam and oil.

PAINTS FOR RAILWAY BUILDINGS

Paints are applied to Railway Buildings for:

(1) To protect the materials of which the building is constructed, thus prolonging its life.
(2) To improve the appearance of the building.
(3) To improve the lighting of the interior, resulting in increased efficiency of employees and a reduction in expenses for artificial lighting.
(4) To improve the sanitary conditions.

Properly selected paints will preserve wood, metal and other building materials and the repainting the surfaces of such materials is desirable and necessary at certain intervals due to the perishable nature of paint, and the loss of its protective properties and deterioration in appearance.

For office and shop buildings, paints which diffuse the maximum amount of light will preserve the health and eyesight of workers, reduce accidents and increase the output per employee, and in addition produce a substantial saving in artificial lighting bills.

The use of correct paints for toilet rooms, offices and rooms for storage of food products improves their sanitary condition. Paints should be selected which can be cleaned without injury to the paint, and which will produce the most impervious surfaces.

Questions which arise in connection with painting buildings are:

(1) When does the structure need painting?
(2) What paints shall be used?
(3) How shall these paints be applied?

Answers to these questions follow:

(1) A structure requires painting when first erected, and at such times thereafter when the paint shall have ceased to have a protective, lighting or sanitary value, or when it shall have lost the standard of appearance which is generally maintained.

(2) In general, most railways have adopted certain standards of distinctive colors for painting buildings, each company having its own com-

bination of colors, which has been selected for various reasons, such as longevity, cost, personal taste of departmental heads, etc. Aside from prolonging the life of its structures, the railway which makes it a practice to keep its buildings painted with attractive, pleasing colors, gains an unconscious good-will from its present and prospective patrons, which, while difficult to express in terms of money, nevertheless has a decided value in advertising. An efficient paint should be considered, one which will have the maximum protective value, permanence of color, durability, covering capacity and hiding power.

The factors which produce an efficient paint are a selection of proper ingredients, and careful grinding and mixing of these ingredients. The final product of the process of painting is the paint coating on the structure, which should have the maximum strength, impermeability and durability, and paints which are scientifically prepared to fulfill these conditions are made from formulas developed to produce a paint mixture which, will have the minimum voids, and at the same time meet the requirements as to color.

The protective value of a paint is largely dependent on the ability of the paint film to prevent air and moisture from reaching the surface of the structural materials, and also to some extent on the preservative nature of the ingredients of the paint. Paints having the greatest protective value will be found to be those composed of a combination of pigments whose particles have varying characteristic sizes, bound together by a vehicle which has a high power of absorbing oxygen. Of such paint vehicles the most satisfactory is linseed oil, which when spread in the form of a thin film will take up oxygen and form a hard, elastic, nonsticky product called linoxyn. This organic linoxyn is perishable and its purity, strength and protection from attack makes for the longevity of the paint. The inorganic or powdered mineral solids of the pigments will crumble unless held together by the linoxyn, but the pigments must be so ground and blended that they will protect the binder and present the greatest mineral surface to atmospheric attack. It follows from this that the strength and durability of a paint coating is dependent on the strength and durability of the pigment particles, which should consist in part at least of chemically inert pigments, and the requisite thickness of a paint film, together with the utmost strength and durability can best be obtained by a properly proportioned blend of pigments of determinate sizes. The application of these principles permits the design of paint formulas to produce paint coatings neither too thick, and therefore uneconomical and subject to internal strain, nor too thin and thus weak and inefficient for protection.

The permanence of color of a paint will be dependent on the unfading qualities of the color producing pigments, while the hiding power will depend on the density of the pigments when ground in oil and the thickness of the film.

In general there are two methods for specifying and ordering paints:

(a) To order proper grade product of a reputable manufacturer There are manufacturers who produce and sell efficient paints. They have studied the subject exhaustively and are constantly trying, by improving methods, to increase the efficiency of their product.

Satisfactory results can be obtained by placing the requirements that the various classes of paint are to meet before reputable manufacturers and depending on their judgment and ability in producing the most efficient paints for the service expected. By keeping proper service records of paints there will be sufficient data to select the proper standard product of a number of manufacturers for the purpose required.

(b) To order in accordance with specifications or formulas prepared by the Railway Company.

In ordering paints under specifications or formulas, the paint formulas must be prepared and developed by experts in paint technology. The formulas should be revised from time to time so as to include improved manufacturing methods and newly discovered materials.

In preparing specifications for the purchase of paints, better results will generally be obtained by specifying rigid physical tests as a method of judging quality, rather than by giving definite formulas based on chemical composition.

Chemical analyses of paints will to a certain extent detect substitutions of improper materials, but may not show up imperfect methods of manufacture.

In the purchase of paint many substitutions may be made which will still come within the letter of the specifications and many processes of mixing and grinding can be used which, even with the best ingredients, will produce a poor paint.

(3) The service life of a paint is as much dependent upon its correct application as upon the composition of the paint itself.*

The most important factor in painting work is to see that the surface on which the paint is to be applied is properly prepared. Such surfaces should be clean and dry and free from conditions which might have a tendency to cause the paint to scale, blister or discolor.

Paints should be furnished preferably in cans, mixed to the proper consistency for direct application for recoat work. Under certain conditions paints will require some thinning, which should be done only with pure spirits of turpentine or linseed oil.

When applied, paints should be brushed out to smooth coatings of uniform thickness so as to get the maximum spreading capacity of the paint consistent with a film of the thickness to wear well and give the desired protection.

Where repainting is done in two-coat work, the first coat should be allowed to dry hard before any succeeding coat of paint is applied.

The failure of paint coatings before their expected life has been reached is a loss to the Railway Company, both from the partial loss in materials and labor used and from the deterioration of the structural materials in the building due to the lack of protection furnished.

---

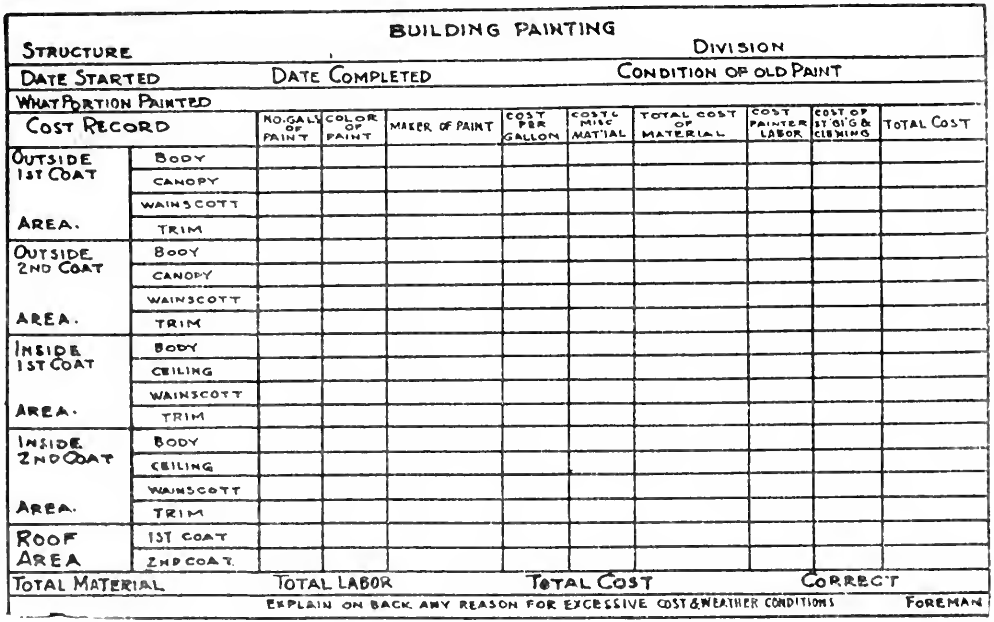
*See Specifications for Railway Buildings—Painting and Glazing.

A record of all painting work done on buildings should be kept on suitable forms, and the date painted or stenciled on buildings.

The following form shows the information that should be given and is recommended for use.

Recommended Form for Painting Records

Size of card, 5"x8".



BUILDING PAINTING

STRUCTURE DIVISION

DATE STARTED DATE COMPLETED CONDITION OF OLD PAINT

WHAT PORTION PAINTED

COST RECORD		NO. GAL'S OF PAINT	COLOR OF PAINT	MAKER OF PAINT	COST PER GALLON	COST & MISC MAT'IAL	TOTAL COST OF MATERIAL	COST PAINTER LABOR	COST OF 1ST OI'G & CLE'NING	TOTAL COST
OUTSIDE 1ST COAT	BODY									
	CANOPY									
	WAINSCOTT									
AREA.	TRIM									
OUTSIDE 2ND COAT	BODY									
	CANOPY									
	WAINSCOTT									
AREA.	TRIM									
INSIDE 1ST COAT	BODY									
	CEILING									
	WAINSCOTT									
AREA.	TRIM									
INSIDE 2ND COAT	BODY									
	CEILING									
	WAINSCOTT									
AREA.	TRIM									
ROOF	1ST COAT									
AREA	2ND COAT									

TOTAL MATERIAL TOTAL LABOR TOTAL COST CORRECT

EXPLAIN ON BACK ANY REASON FOR EXCESSIVE COST & WEATHER CONDITIONS FOREMAN

LOCATION AND DESIGN OF SIGNS FOR PASSENGER STATIONS

At flag stations or small stations without canopies it is recommended that one sign facing the track be installed, this being considered sufficient.

At larger stations without or with a short canopy it is recommended that signs be installed as follows:

(a) On each end of the building and at right angles to the track, bearing in mind visibility from the air.

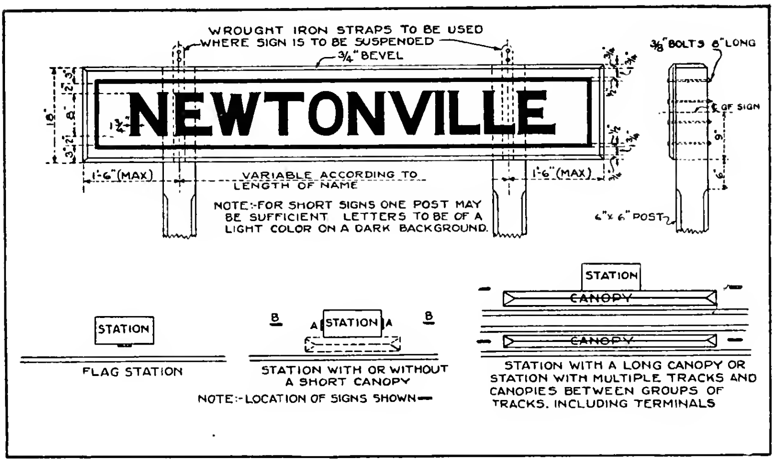
(b) Signs erected on posts at some distance from each end of the building and parallel to the track.

(c) At junctions, or for some special reasons, it may be desirable to erect signs as recommended under both (a) and (b).

At stations with a long canopy, or stations with multiple tracks and canopies between groups of tracks, including terminals, it is recommended that sufficient signs be erected on posts beyond the ends of the canopies and parallel to the tracks. At such stations the character of the main buildings is usually such that an ornamental architectural name on the building should be sufficient.

The use of built-up signs with letters of a light color on a dark background is recommended, and care should be exercised to use a background of a dull or non-reflecting surface. Blue or black smalts give very good results in this respect. The showing of distance from main terminals or other information on station signs is not recommended.

The diagram illustrates the recommended uses of signs and a type of built-up sign.



American Railway Engineering Association

SPECIFICATIONS FOR RAILWAY BUILDINGS

TABLE OF CONTENTS

SPECIFICATIONS FOR RAILWAY BUILDINGS

SECTION 1

General Conditions

1. General

These general conditions are intended to be used in connection with the American Railway Engineering Association Construction Contract form as published in the Manual, and shall apply to all sections of these specifications with equal force.

2. Company, Engineer and Contractor Defined

As used in these specifications the term Company shall be understood to mean the Railroad or Railway Company, the term Engineer shall be understood to mean the Chief Engineer of the Company or his duly authorized representative, and the term Contractor shall be understood to mean the person, firm or corporation agreeing to perform the work covered by these specifications.

3. Drawings Furnished by the Company

The drawings furnished by the Company shall be considered as part of and illustrating these specifications. These specifications are intended to supplement the drawings, the two being considered co-operative. Drawings and specifications will be part of the contract and are equally binding. They are the property of the Company and shall be returned when work is completed.

The drawings show the general character of detail work, but the Company reserves the right to furnish proper scale details of such portions as may, in the judgment of the Engineer, require them. In preparing such details slight modifications may be made if necessary without in any way invalidating the contract. The Contractor shall not execute any work requiring such details until these have been furnished, and all work shall conform with these details when executed.

Figures on drawings shall take precedence over measurements by scale, detail drawings over small scale drawings, and full size details over all other drawings. The decision of the Engineer shall be final as to the interpretation of drawings and specifications.

4. Errors or Discrepancies

If the Contractor in course of the work finds any discrepancy between the plans and the physical conditions of the locality, or any errors in the plans, or in the points given for the construction of the work, it shall be his duty to immediately inform the Engineer in writing, and the Company will promptly verify and, if necessary, correct such errors. Any work performed before these discrepancies or errors have been corrected will be done at the Contractor's risk.

5. Working Drawings

The Contractor shall submit triplicate copies of all working drawings and erection diagrams required. All such drawings must be approved by the Engineer before the work involved is started. The approval of these working drawings by the Engineer will not imply any change in the specifications or relieve the Contractor from the responsibility of any errors thereon. The Contractor shall supply additional copies of erection diagrams or working drawings on request.

6. Laying Out Work

Necessary lines, corners and elevations will be established on the site of the building by the Engineer. The Contractor shall erect permanent batter boards and protect the points so established until the work is completed and accepted. Using the points established by the Engineer, the Contractor shall lay out his own work and be responsible for its accuracy.

7. Prosecution of the Work

When the work of a Sub-Contractor engages with the work of any other Sub-Contractor, he must co-operate with the other Sub-Contractor and exercise extraordinary care to prevent injury to any work or material. Each Sub-Contractor shall do all necessary cutting, fitting and patching of his work where it engages the work of another Contractor or the Company.

8. Materials

All materials shall be new and of the grades specified, and shall be the best of their respective kinds for the uses intended.

Priced Materials. Where the quality or kind of material cannot be definitely specified, the amount of money the Contractor is to pay for same is given in these specifications. The sum so given is intended to cover the purchase price of the materials and freight charges, but this sum shall not include any cost of hauling, cartage, supervision, preparatory work, profit, or the cost of erection; it being intended that the Contractor shall include such foregoing items in his contract price. The Engineer will select such materials and notify the Contractor of his selection and the price agreed upon, but the Contractor shall contract for the material and supervise its delivery and erection as fully as other parts of the work.

If the required payment for such priced material should be more than the sum herein specified, the difference is to be paid by the Company, and if it should be less, the difference is to be deducted from the sum to be paid the Contractor under the contract.

"Approved" Materials. The term "approved" in this specification signifies that the Engineer must be consulted as to the source from which the material is to be purchased as well as its general quality and construction, but such approval does not mean the acceptance of the material actually furnished if it should be defective.

Special Materials. Special brands of materials or devices mentioned in these specifications or shown on the drawings are named for the purpose of establishing a standard or criterion of quality and character desired. Other materials of equal quality and adaptability to the purpose for which they are intended may be substituted, but only with the written approval of the Engineer. If the Contractor desires to substitute some other brand of material for that called for, he must submit a statement with his proposal, clearly and fully describing such substitutions as he desires to make. Where a specific make or kind of apparatus is called for and furnished by the Contractor, the furnishing of such apparatus does not relieve the Contractor of liability until he shall make such apparatus or appliance operative so that it will successfully perform the function for which it is intended. The Contractor shall protect the Company against claims on account of patented devices or parts proposed by him.

9. Equipment

The Contractor shall provide all equipment required for the execution and completion of the work, including all staging, scaffolding, apparatus, tools, etc., which are necessary. All equipment must meet with the approval of the Company and the Engineer may require the removal of any portion of equipment which is defective or unsuitable for the proper prosecution of the work and the Contractor will be required to substitute therefor satisfactory equipment without delay.

10. Permits, Laws and Ordinances

All work shall conform with the state or municipal laws, ordinances or regulations governing such work. The Contractor shall give all requisite notices in connection with his work to the proper authorities, and shall procure at his own expense all permits, licenses, etc., of every description, necessary for the construction and completion of the work, and shall deliver to the Company all certificates of inspection for plumbing, electric wiring or any other branch of the work for which such certificates may be required in connection with this contract.

11. Temporary Toilet Facilities

The Contractor shall establish and maintain, in a location approved by the Engineer, temporary toilet facilities for the accommodation of his employes.

12. Temporary Office

The Contractor shall provide in a suitable location on the site, for the exclusive use of the Engineer, a temporary office, which shall be weatherproof and have a door and window.

13. Temporary Heat

Where temporary heat or heat during the construction of the building is required for drying plaster or paint, for the prevention of damage to materials by freezing, or for any other reason, such heat shall be provided by the Contractor at his own expense unless otherwise specified hereinafter.

14. Force Account Work

Whenever any work is done or material furnished on a force account basis, that is, for a price based upon the actual cost of labor and materials plus an added percentage to cover overhead expenses, superintendence, profit, use of tools and equipment, and Contractor's risk and liability, the actual cost shall not exceed the fair market value of the labor and material furnished. Where work is done on this basis the time of all employes shall be entered by the Contractor on forms supplied him for that purpose, and checked and signed in duplicate daily by the Contractor and the Engineer, and no labor not so entered and checked will be allowed.

15. Accounting Requirements

At the completion of the work, the Contractor shall furnish a complete list of all quantities in accordance with the Company's classification for all work underground for each item or structure, and shall furnish in lump sum form, the cost of the superstructure for each item or building, this cost to include the proportionate part of the Contractor's overhead and profit.

Where the work is of such nature that existing facilities are removed or remodeled by the Contractor he shall furnish the Company with a statement showing in detail the cost of such work, the materials removed and the disposition of the materials. The above information shall be furnished in order to comply with Interstate Commerce Commission accounting requirements.

SPECIFICATIONS FOR RAILWAY BUILDINGS

SECTION 2

Excavation, Filling and Backfilling

1. General

The Contractor shall furnish all labor, material, tools and equipment except as otherwise noted, necessary to entirely complete all excavation for foundation walls, piers, footings, pits, ducts, tunnels, basements and any other excavation which may be implied or shown on the drawings to receive the subsequent work.

Any excavation paid for or deducted on a unit price basis shall be for the actual measured yardage.

No allowance shall be made on account of slope to the sides of excavation, but measurements for quantities of excavation shall be taken to outside of sheeting.

The unit price paid or deducted shall include the whole value of the sheeting, bracing or any other material actually used in connection with the work, either as a form for concrete foundations as a protection against caving during the process of excavating, or as a cofferdam, and shall also include any pumping or bailing which may be necessary.

2. Classification

All material excavated shall be classified as rock excavation, wet excavation and common excavation.

3. Rock Excavation

Rock excavation shall comprise rock in solid beds or masses in its original position, which in the judgment of the Engineer may best be removed by blasting, and detached rock or boulders measuring one cubic yard or more.

4. Wet Excavation

Wet excavation shall comprise that material, not included under rock excavation, which requires pumping or sheet piling to overcome seepage and overflow.

5. Common Excavation

Common excavation shall include all materials that do not come under the classification of rock or wet excavation.

6. Soil Test

Before any foundation work is placed the Contractor shall satisfy himself that the soil encountered is of such a nature that it will support the structure as designed; in case of doubt he must notify the Engineer and no foundations shall be laid until a proper investigation is made.

7. Beds for Footings

The beds for footings shall be leveled and free of all loose material before any foundations are put in place. No footings shall rest on filled ground except where absolutely necessary, and all filling under such footings shall be sand or other approved filling, puddled and tamped in place. No such footings shall be put in place by the Contractor without first obtaining permission from the Engineer.

8. Quicksand Pockets

If any quicksand pockets or other soft spots are encountered beneath foundation walls, piers or footings, the same shall be excavated and filled with concrete, the extra work being paid for on the basis of unit prices provided in contract.

9. Pumping and Bailing

The Contractor shall perform all pumping and bailing necessary to keep all excavation entirely free from water during the progress of the work under all circumstances and contingencies which may arise, using such means as may be best adapted to conditions. The cost of pumping and bailing shall be included in the Contractor's bid for excavation.

10. Blasting

The Contractor shall do all blasting necessary in connection with the excavation as shown on the drawings. All drilling, placing of charges and shooting together with the covering of blasts, shall be done in an approved manner. All work in connection with blasting shall be done in strict accordance with any laws or ordinance in effect where the work is located.

11. Disposal of Excavated Material

Excavated material shall be used for backfilling around all underground work. After forms of such work have been removed and the work has been inspected by the Engineer, the Contractor shall fill up to the finished grade as shown on the drawings.

Only material suitable for backfilling shall be so used. Large frozen lumps, boulders, etc., shall not be used. Backfilling must be placed in layers not to exceed six inches, each layer being thoroughly tamped and puddled.

The Contractor, when so required, shall haul and place surplus excavated material within a distance not to exceed 300 ft. from the building as directed by the Engineer.

Any surplus excavated material which cannot be disposed of within 300 ft. of the building shall be disposed of by the Contractor, unless otherwise released by the Company.

12. Filling

Sand or cinder filling where called for on the drawings, shall be thoroughly tamped, rolled and compacted in place by the Contractor. Where floors are on fill, the fill shall be placed in layers and thoroughly puddled, tamped and rolled or flooded. Wherever such fill occurs it shall be included in the lump sum price for the structure in which it occurs. Sand fill shall be clean sand free from sticks or other foreign matter. When cinder fill is used, cinders will be furnished by the Company, in cars as near as practicable to the site of the work, but must be unloaded and placed by the Contractor.

No filling or backfilling shall be done at a time when there is danger of frost entering the material, except at the discretion of the Engineer.

13. Grading and Final Cleaning

All grading that may be necessary around the buildings as shown by the drawings shall be done by the Contractor. Cinders, sand or clean dirt shall be used for the work as called for by the drawings.

At the completion of the work the Contractor shall thoroughly clean up and remove any rubbish, dirt or excavated material from site as called for under disposal of excavated material, and leave the site clean and graded to finished grades as shown by the drawings.

14. Pile Foundations

Where timber foundation piles are required or shown on the drawings these shall be furnished and driven by the Contractor, unless otherwise provided for in the Contract. Contractors shall quote in their bids a unit price per linear foot penetration below cut-off, for furnishing, driving and cutting of piles.

Timber piles shall be furnished in accordance with the American Railway Engineering Association specifications covering piles for trestles, except that where piles are to be untreated they shall not be peeled. Piles that will be cut off below permanent moisture will not be treated. Piles which will extend above the line of permanent moisture shall be treated with creosote oil, full cell process, in accordance with the A.R.E.A. specification for treated timber piles. Piles shall be driven by a steam or drop hammer to refusal, or until the penetration per blow under the last blows of a 2,000-pound hammer, falling 20 feet, does not exceed one (1) inch. They shall be driven in location shown on the drawings without variation of more than one (1) foot in any direction. The Contractor shall excavate around and cut off the piles at the elevations shown and properly prepare the piles to receive the masonry or other parts of the structure. Piles shall be cut off in a horizontal plane unless otherwise shown on the drawings. Where the contract provides that the piles shall be furnished and driven by the Railway Company, the Contractor shall provide in his bid for excavating around and cutting off the piles as described above.

The lengths of piles necessary shall be fixed by the Engineer after test piles have been driven. The cost of driving test piles will be paid for by the Railway Company.

15. Underground and Overhead Structures

All gas, water and drainage pipes, sewers or conduits, shall be supported in place by the Contractor and all expense attending their renewal shall be borne by him. All telegraph, electric light or telephone wires, signals, etc., which in the judgment of the Engineer interfere with the progress of the work shall be removed without expense to the Contractor. During construction the Contractor shall maintain in safety, permanent poles, wires, sewers, pipes or conduits affecting his work or with which it may interfere. If damaged through his negligence, all expenses attending repairs thereto shall be borne by him.

16. 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.

The General Conditions as given in Section 1 of these specifications shall be considered to apply with equal force to this section of the specifications.

SPECIFICATIONS FOR RAILWAY BUILDINGS

SECTION 3

Sewers and Drainage

1. General

The Contractor shall furnish all materials and labor required to make the excavation and construct the sewers, manholes, catchbasins, sewer connections to existing manholes, etc., as called for on the drawings.

2. Excavation

All excavation shall be done in accordance with the section of these specifications covering excavation. In general the excavation shall be to line and grade as furnished by the Engineer, and shall be made by open cut from the surface and the clear width at the bottom of trench shall be at least one foot greater than the diameter of the pipe. The sides shall be cut vertically or with only slight inclination. When the material encountered permits, the bottom of the trench shall be rounded and a hole dug under each joint to give the pipe an even bearing and permit the making of the joint. Where the trench is excavated below grade, except at joints, it shall be refilled to grade with easily compacted material and thoroughly tamped. Bids shall be based on common excavation. If rock or wet excavation is encountered the Contractor shall receive compensation for the excavation according to his unit price per cubic yard submitted for rock or wet excavation less the amount of his price per cubic yard submitted for common excavation.

3. Pumping and Bailing

The Contractor shall pump, bail or otherwise remove all water that may be found or that may collect, in the trenches while the sewer is being laid. No manholes, catchbasins or sewers shall be constructed or laid in water, nor shall water be allowed to run through the sewer until the mortar has satisfactorily hardened. All necessary precautions shall be taken to prevent the entrance of sand, mud or other obstructing material into the sewer. Any such material remaining in the sewer when completed, shall be removed by the Contractor.

4. Sheeting

The Contractor shall furnish, place and maintain such sheeting and bracing as may be required to support the sides of the excavation and insure the protection of the work. The sheeting and bracing shall be removed as the work progresses, in such manner as to prevent the caving in of the sides of the excavation or the injury of the sewer.

5. Grade, Joints, Etc.

Each pipe shall be laid on a firm bed and in perfect conformity with line and grades as given by the Engineer.

The end of each pipe shall be pressed firmly into the bell of the other in such manner that there shall be no shoulder or want of uniformity of surface on the interior of the sewer. The joints are to be as uniform as possible in thickness and thoroughly filled with cement mortar. Each joint is to be wiped clean on the inside as the work progresses. After the joint is made the pipe shall be firmly fixed in place by means of earth carefully placed around same before the following pipe is laid.

6. Backfilling

No portion of a trench or excavation shall be backfilled until the sewer contained in it has been examined and approved.

No rock or frozen earth shall be put in the trench until the refilling has reached at least two (2) feet above the top of the pipe. Fine earth shall be carefully thrown into the trench and around the pipe in layers not more than six (6) inches thick, each layer being thoroughly tamped. The remainder of the filling may be flooded or otherwise thoroughly compacted so that there will be no settlement. Any surplus dirt shall be disposed of as directed by the Engineer. Whenever the Engineer deems the excavated material unsuitable he may require the Contractor to furnish suitable material to be paid for at the price bid for per cubic yard for extra fill. Rock in pieces weighing over fifty (50) pounds shall not be put in the trench. Any rock used as back filling shall be placed with alternate layers of earth so that all spaces between the pieces of rock shall be filled with earth.

7. Vitrified Sewer Pipe

The pipes and specials shall be of standard length and of the best quality of salt glazed vitrified double strength sewer pipe of the "Hub and Spigot Pattern." The pipe shall be smooth, dense and sound, thoroughly burned, impervious to moisture, free from laminations, cracks, flaws, blisters or other imperfections. The interior surface shall be smooth and well glazed and straight pipe shall be true cylinder and the interior diameter shall be the full specified dimension, the inner and outer surfaces shall be concentric. No pipe less than six (6) inches shall be used except for downspout connections, or unless otherwise shown on the plans.

The pipe shall be subject to inspection and approval or rejection by the Engineer.

8. Mortar

Mortar for cementing the pipe joints shall be neat Portland cement or a mixture of equal parts of Portland cement and sand, as directed by the Engineer, with only enough water added to give it the proper consistency. Mortar shall be mixed only as needed for use. The retempering of mortar that has become partly set will not be permitted.

Mortar for brickwork shall consist of Portland cement thoroughly mixed with sand, in the proportion by volume of one (1) part loose cement and three (3) parts sand.

9. Cement, Sand, Stone

Cement, sand and stone shall be of the quality as specified in the specifications for Concrete work, Section 4.

10. Brick

The brick used shall be of the best quality, sound and hard burned, uniform and free from lime and cracks and shall not absorb more than fifteen per cent. in weight after being thoroughly dried, when immersed in water for twenty-four (24) hours, and samples must be approved by the Engineer.

11. Manholes and Catchbasins

Manholes and catchbasins shall be built at the places shown on the plans or as otherwise directed by the Engineer and shall be of the form and dimensions shown on the detailed drawings.

12. Cast Iron Covers

All covers shall be of tough gray iron, free from defects which would tend to weaken them, such as cold shuts, or blow holes, and shall be absolutely clean and have a workmanlike finish. They shall conform to the standards as shown on the plans.

13. Cast Iron and Reinforced Concrete Pipe

Cast iron pipes and special castings shall be used where shown on the plans or as directed by the Engineer. They shall be the bell and spigot type manufactured in accordance with the "Standard Specifications for Cast Iron Pipe and Special Castings" of the American Water Works Association for Class "A" pipe. The joints between cast iron pipe and special castings shall be made in the usual manner. Reinforced concrete pipe of a design acceptable to the Engineer, shall be used if called for by the plans. Joints shall be made as specified for Vitrified Pipe.

14. Foundation Drains

When the ground is wet or of a swampy nature drain or farm tile not less than four (4) inches in diameter shall be placed along all foundations on a very slight grade at approximately the level of the footings. These drains shall be placed in a layer of clean coarse gravel or broken stone not less than one foot thick, and shall be connected with the main drainage system.

15. Special Fittings

In case vitrified sewer is to be paid for on a unit price basis all "Specials" including Y's, tees, bends, etc., will be figured as two lengths of straight pipe.

16. 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 Section 1 of this specification shall be considered to apply with equal force to this section of the specification.

SPECIFICATIONS FOR RAILWAY BUILDINGS

SECTION 4

Concrete

1. General

The Contractor shall furnish all labor, material, tools and equipment necessary to entirely complete the work as herein specified and shown on the drawings.

A

Any work paid for or reducted on a unit price basis shall be for the actual measured yardage and shall include the entire value of the sheeting, bracing and forms used in connection with the work.

2. Cement

The cement shall meet the requirements of the American Railway Engineering Association's "Specifications for Portland Cement." It shall be stored in a weather-tight structure with the floor raised not less than one foot from the ground in such a manner as to permit easy access for proper inspection and identification of each shipment. Cement that has hardened or partially set shall not be used.

3. Fine Aggregate

The fine aggregate shall consist of sand, crushed stone or gravel screenings, graded from fine to coarse, and passing when dry, a screen having holes one-quarter (¼) inch in diameter. Not more than twenty-five (25) per cent. by weight shall pass a No. 50 sieve, and not more than six (6) per cent. a No. 100 sieve when screened dry, nor more than ten (10) per cent. dry weight shall pass a No. 100 sieve when washed on the sieve with a stream of water. It shall be clean and free from soft particles, mica, lumps of clay, loam or organic matter.

The fine aggregate shall be of such quality that mortar briquettes made of one (1) part Portland cement and three (3) parts of the fine aggregate by weight shall show a tensile strength, after an age of seven (7) days, not less than the strength of briquettes of the same age, made of mortar of the same consistency in the proportion of one (1) part of the same cement to three (3) parts of Standard Ottawa sand.

4. Coarse Aggregate

The coarse aggregate shall consist of gravel or crushed stone, which unless otherwise specified or called for on the plans, shall, for plain mass concrete, pass a screen having holes two and one-quarter (2¼) inches in diameter, and for reinforced concrete a screen having holes one and one-quarter (1¼) inches in diameter; and be retained on a screen having holes one-fourth (¼) inch in diameter, and shall be graded in size from the smallest to the largest particles. It shall be clean, hard, durable and free from all deleterious matter; coarse aggregate containing dust, soft or elongated particles shall not be used.

5. Water

Water shall be clean, reasonably clear and free from oil, acid and injurious amounts of vegetable matter, alkalies or other salts. The Contractor shall arrange for his own water supply and shall pay for same.

6. Reinforcing

Generally the material used shall be a type of deformed bar and of high carbon steel manufactured by the open-hearth process.

It shall in all respects conform to the American Railway Engineering Association's "Specifications for Billet Steel Concrete Reinforcing Bars."

Whenever it is necessary to splice the reinforcement otherwise than shown on plans, the character of the splice shall be decided by the Engineer on the basis of the safe bond stress and the stress in reinforcement at the point of splice. Splices shall not be made at points of maximum stress.

Proper racks shall be provided by the Contractor for the storage of reinforcing bars from the time they are delivered till they are used, and these racks shall prevent the stored bars from coming in contact with the ground.

Material used in reinforcing concrete shall be free from grease, rust, scales or coating of any character which will tend to reduce or destroy the bond between the steel and the concrete. All reinforcing steel shall be placed in strict accordance with drawings and same shall be held securely in place until the concrete has set.

All structural steel shapes used for reinforcing shall conform to the requirements of the American Railway Engineering Association's "Specifications for Steel Railway Bridges."

7. Proportioning

The unit of measure shall be the cubic foot. Ninety-four pounds, one sack of cement or one-fourth barrel or cement shall be assumed as one cubic foot. All concrete footings, piers, walls, etc., except those to be waterproofed, or reinforced, shall be in the proportion of one (1) part Portland cement, two and one-half (2½) parts fine aggregate and five (5) parts coarse aggregate unless otherwise shown on plans.

All concrete which is to be waterproof and all reinforced concrete shall be in the proportion of one (1) part Portland cement, two (2) parts fine aggregate and four (4) parts coarse aggregate unless otherwise shown on plans.

8. Mixing Concrete

All concrete shall be mixed by machine (except when under special conditions the Engineer permits otherwise), in a batch mixer of an approved type, equipped with suitable charging hopper, water storage and a water measuring device which can be locked.

The ingredients of the concrete shall be mixed to the required consistency and the mixing continued not less than one and one-half (1½) minutes after all the materials are in the mixer, and before any part of the batch is discharged. The mixer shall be completely emptied before receiving materials for the succeeding batch. The volume of the mixed material used per batch shall not exceed the manufacturers' rated capacity of the drum.

When it is permitted to mix by hand, the mixing shall be done on a watertight platform of sufficient size to accommodate men and materials for the progressive and rapid mixing of at least two batches of concrete at the same time. The batches shall not exceed one-half (½) cubic yard each. The materials shall be mixed dry until the mixture is of a uniform color, the required amount of water added, and the mixing continued until the batch is of a uniform consistency and character throughout. Hand mixing will not be permitted for concrete deposited under water.

9. Consistency

The quantity of water used in mixing shall be the least amount that will produce a plastic or workable mixture which can be worked into the forms and around the reinforcement. Under no circumstances shall the consistency of the concrete be such as to permit a separation of the coarse aggregate from the mortar in handling. An excess of water will not be permitted, as it seriously affects the strength of the concrete, and any batch containing such an excess will be rejected.

10. Premixed Aggregate

Provided the contract specifically permits, premixed aggregate may be used instead of separate fine and coarse aggregates. Frequent tests shall be made to determine the relative proportions of fine and coarse aggregates, and if these proportions are unsatisfactory to the Engineer, or so irregular as to make it impracticable to secure a properly proportioned concrete, he may reject the material, or require that it be screened and used as separate fine and coarse aggregates.

The proportion of the cement to the fine aggregate shall at no time be less than that specified for the classes of concrete where separate aggregates are used.

11. Retempering

The retempering of mortar or concrete which has partially hardened; that is, remixing with or without additional materials or water will not be permitted.

12. Forms for Concrete

Foundation concrete may be placed without forms if in the opinion of the Engineer the sides of the excavation are sufficiently firm so that the concrete may be thoroughly rammed without the adjacent earth yielding, otherwise the concrete must be placed in substantial forms.

Forms shall be of wood or metal and shall conform to the shape, lines and dimensions of the concrete as called for on the plans. Form lumber used against the concrete shall be dressed on one side and both edges to a uniform thickness and width, and shall be sound and free of loose knots.

For all exposed edges, corners or other projections of the concrete, suitable moldings or bevels shall be placed in the angles of the forms to round or bevel the edges or corners of the concrete.

The forms shall be well built, substantial and unyielding and made sufficiently tight to prevent leakage of mortar, thereby causing voids in the concrete. They shall be properly braced or tied together by rods, bolts or wires. Metal braces or ties shall be so arranged that when the forms are removed no metal shall be within one (1″) inch of the face of the finished work.

The face forms shall be securely fastened to the studding or uprights in horizontal lines. Any irregularities in the forms which may mar the exposed surface of the concrete shall be removed or filled. Where necessary, temporary openings shall be provided at the base of the forms to facilitate cleaning and inspection immediately before placing concrete.

The inside of the forms shall generally be coated with raw paraffin or non-staining mineral oil, or thoroughly wet with water except in freezing weather.

13. Anchors, Bolts, Etc.

The Contractor shall build into forms all bolts, anchors, ties, wood railing blocks, gratings, etc., as indicated on the drawings or called for in specifications and same shall be attached in such a manner as to prevent their displacement when concrete is placed. He shall also provide all holes and chases for pipes passing through concrete work and make same water tight after pipes are in place.

14. Placing Concrete

Before beginning a run of concrete, all hardened concrete or foreign materials shall be completely removed from the inner surfaces of all conveying equipment.

Before depositing any concrete, all debris shall be removed from the space to be occupied by the concrete, all steel reinforcing shall be secured in its proper location, all forms shall be thoroughly wetted except in freezing weather unless they have been previously oiled, and all form work and steel reinforcing shall be inspected and approved by the Engineer.

Concrete shall be handled from the mixer to the place of finai deposit as rapidly as possible, and by methods of transporting which shall prevent the separation of the ingredients. The concrete shall be deposited directly into the forms as nearly as possible in its final position so as to avoid rehandling. The piling up of concrete material in the forms in such manner as to permit the escape of mortar from the coarse aggregate will not be permitted. Under no circumstances shall concrete that has partially set be deposited in the work.

During and after depositing, the concrete shall be compacted by means of a shovel or other suitable tool moved up and down continuously in the concrete until it has all settled into place and water has flushed to the surface. The concrete shall be thoroughly worked around all reinforcing material so as to completely surround and embed the same. Temporary planking shall be placed at ends of partial layers so that concrete shall not run out to thin edge.

Before depositing new concrete on or against concrete which has set, the forms shall be retightened against the face of the latter, the surface of the set concrete shall be roughened and thoroughly cleaned of foreign matter and laitance, and saturated with water. The new concrete placed in contact with set or partially set concrete shall contain an excess of mortar to insure bond. To insure this excess of mortar at the juncture of the set and newly deposited concrete on vertical or inclined surfaces, the cleaned and drenched surface of the set concrete shall first be slushed with a coating of mortar, not less than one inch thick, composed of one (1) part cement to two (2) parts fine aggregate, against which the new concrete shall be deposited before this mortar has had time to attain its initial set.

15. Concreting in Cold Weather

During cold weather, the concrete at the time it is mixed and deposited in the work shall have a temperature not lower than forty (40) degrees Fahrenheit, and suitable means shall be provided to maintain this temperature for at least seventy-two (72) hours thereafter, and until the concrete has thoroughly set. The methods of heating materials and protecting the concrete shall be approved by the Engineer. The use of any salt or chemical to prevent freezing will not be permitted.

16. Concreting in Water

Where water is encountered without current, but in such quantity that it cannot be lowered to and maintained at the required depth, concrete shall not be placed until the method of placing has been approved by the Engineer.

17. Waterproof Concrete

The Contractor must guarantee that all pits, tunnels, basements, or other concrete to be waterproofed will be absolutely waterproof for a period of one year after the acceptance of the work. He shall use his own discretion as to the manner or method of waterproofing to be used unless a specific method is indicated on the plans.

18. Removing Forms

Forms shall be left in place till the concrete has attained sufficient strength to be self-supporting, and then removed only at Contractor's risk.

19. Finishing and Pointing

Immediately after the forms are removed, if there should be found any small pits or openings on the exposed surface of the concrete above ground or if bolts are used for securing the forms, the ends of which on removing, leave small holes, all such holes, pits, etc., shall be neatly stopped with pointing mortar of cement and fine aggregate in same proportions as used in the concrete. This mortar shall be mixed in small quantities and shall be used before same shall begin to set.

Exposed surfaces shall be made perfectly smooth. Horizontal surfaces shall be level unless otherwise shown on the drawings, and shall be leveled with straight edges. All beveled surfaces and washes shall be made true and uniform.

Where called for on the drawings or in the specifications, exposed surfaces shall be finished as follows: The coarse aggregate shall be carefully worked back from the forms into the mass of the concrete with spades, fine stone forks, or other suitable tools, so as to bring a surface of mortar against the form. Care should be taken to remove all air pockets and to prevent voids in the surface.

The forms shall be carefully removed from the surface to be finished as early as practicable, all joint marks, projections and inequalities chipped off and all voids filled with a mortar made of the same proportions of cement and sand as those of the concrete.

These surfaces shall then be thoroughly wet with water, and while wet, rubbed to a smooth uniform finish with a brick made of one part Portland cement and two (2) parts or two and one-half (2½) parts sand, or with a No. 3 Carborundum brick followed by a No. 30 or with a No. 24 Carborundum brick, as may be necessary to obtain the desired degree of smoothness.

No mortar or cement shall be applied except to fill distinct voids in the surface. Uneven places shall be smoothed by rubbing down and not by plastering. The surface shall be kept moist and protected from rapid drying for not less than three (3) days.

20. Concrete Floors

Concrete floors on fill shall consist of a base of thickness indicated on drawings, composed of one (1) part Portland cement and two and one-half (2½) parts fine aggregate and five (5) parts of coarse aggregate of the size as specified for reinforced concrete.

A finish one (1") inch thick, composed of 1 part cement, 2 parts fine aggregate, and a metallic hardener, shall be applied in accordance with the manufacturer's specifications, before the base has set. This finish shall be floated and troweled to a smooth, hard and even surface, finishing neatly against walls. All floors shall be sloped to drains and finished neatly with same.

21. Concrete Base for Wood Floors

The concrete base for wood floors shall be of thickness indicated on drawings and shall be of the mixture specified above for base for concrete floors.

The filling between floor sleepers or screeds shall be concrete composed of one (1) part cement, four (4) parts fine aggregate and eight (8) parts coarse aggregate.

22. Stairs and Ramps

The surface of landings and treads of all concrete stairs and the surfaces of all ramps shall be finished with No. 30 Carborundum or "Crystalon" grains, using not less than one pound of grain to each square foot of surface, as follows: After the granolithic finish has been placed to within ¼" of the finished surface, float and work to a thickness of about ¼", a dryer mixture of 2 parts of cement, ¾ part trap rock screenings, ¼ part gravel and 1 part of grains. After allowing to set a little, sprinkle and float in clear grains until entire surface is thoroughly coated and impregnated with the grains.

23. Concrete Floors on Wood Joists

Concrete floors on wood joists shall be constructed according to details as shown on the drawings. The joists shall be beveled as shown with 1 in. by 6 in. D&M board filler placed between. Concrete of mixture specified above for concrete floors shall be placed and reinforced as called for on the plans. All such floors shall be finished as specified in paragraph No. 20.

24. Concrete Wall Base

Concrete wall bases for rooms shall be made from a mixture of cement, fine aggregate, and a metallic hardener, finished as specified for cement floors. This base shall be of the contour and height as detailed, and on stud construction shall be reinforced as shown and securely fastened to wall construction by means of metal anchors.

25. Expansion Joints

Where expansion joints are required the bond between the two sections shall be completely broken by a coating of petroleum oil or hot oil tar pitch over the entire joint surface of the first deposited concrete, or by an approved elastic joint filler. No reinforcement shall extend across an expansion joint.

26. Construction Joints

Where construction joints are required such joints shall be located and formed so as to least impair the strength and appearance of the structure. Where so required, by the Engineer, construction joints shall be reinforced as directed in order to secure the necessary bond strength.

Where watertight joints are required, sheet lead or other metal not less than six inches wide and extending the full length of the joint shall be imbedded equally in the two deposits of concrete.

27. Protection and Cleaning

All exposed surfaces of concrete work such as edges, corners, faces, etc., shall be protected during the progress of the work so same will not be marred or chipped. At the completion of the work all concrete shall be cleaned and left in a manner satisfactory to the Engineer.

28. 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 Section 1 of this specification shall be considered to apply with equal force to this section of the specification.

SPECIFICATIONS FOR RAILWAY BUILDINGS

SECTION 5

Brickwork

1. General

The Contractor shall furnish all labor, materials, tools, scaffolding and equipment, except as otherwise noted, necessary to entirely complete any or all classes of brickwork herein specified, according to the class of building and as shown or implied on the accompanying drawings, including all backing, covering of iron and steel, all piers, walls, chimneys and other special work shown, specified, or otherwise implied.

2. Classification of Brickwork

Brickwork shall be classified as either common brickwork or face brickwork. The class of brickwork to be used shall be determined by the class of the building or by notations on the accompanying drawings. Unless otherwise specified common brickwork shall be used on all buildings of mechanical terminals, shops, storehouses, isolated freight houses and similar buildings. In general, face brick shall be used for Passenger Stations and Auxiliary Buildings, Combination Passenger and Freight Stations and Freight Houses built in conjunction with Passenger Stations.

3. Common Brickwork

All common brickwork shall be laid even and true to line, plumb, level and with all joints accurately kept. All brickwork shall be laid with joints not more than three-eighths inch (3/8") thick and bonded together with full headers every sixth course. All brick shall be good, hard, well burned brick free from cracks and uniform in size, shape and quality and shall not absorb more than ten per cent. of their weight of water. They shall be laid in a full bed of mortar with shoved joints, neatly struck on all exposed walls. The bricks used on the face of the wall shall be selected whole bricks of a uniform size and with true, rectangular face.

All brick shall be thoroughly wetted either by immersion or sprinkling before being laid, except in freezing weather.

4. Face Brickwork

The exterior face brickwork shall be laid up with a selected and approved pressed face brick. The Contractor as a basis for his proposal shall figure on a face brick to cost $................per thousand, f. o. b. building site or Company's lines as provided in the Letter of Invitation, and any variation from this price more or less will be adjusted according to the actual cost of the brick. Face brickwork shall be laid with all stretchers unless otherwise shown and shall be bonded either by blind headers or an approved metal wall tie every sixth course.

All pressed brickwork shall be laid true to line, plumb, level and with all joints accurately kept. All work shall be laid so that four courses shall not exceed eleven inches (11″) in height, and joints shall be raked out to a depth of at least three-eighths inch (⅜″) unless otherwise shown on drawings or ordered by Engineer. Where rough face brick is used, instead of raking the horizontal joints, strips shall be placed in those joints as the brick is laid up and after the mortar has hardened properly these strips shall be removed. The vertical joints shall be raked in the usual manner.

The Company reserves the right to deviate from the type of joint specified above so as to conform with the type of brick selected. All brick courses shall be so proportioned that they will work out evenly with height of windows and doors. No split or fractional courses will be permitted. All backing up of pressed face brick shall be as specified under common brickwork.

5. Detail of Brickwork

All brickwork details such as sills, lintels, belt courses and other trim shall be laid up according to details shown on accompanying drawings and as specified under either common brickwork or face brickwork.

6. Samples

The Contractor will furnish samples of all brick to be used, together with prices for the various kinds of face brick submitted for approval of the Engineer. The Engineer also shall have the option of obtaining samples and prices for face brick. The samples selected and approved will be filed with the Engineer and taken as a standard of material to be furnished and all material used in the work must be equal in all respects to the approved samples.

7. Cement

Specifications for Portland cement as given in Section 4—Concrete* shall apply to cement for brickwork.

8. Sand

Sand for all classes of brickwork shall be clean, sharp, coarse and of grains varying in size. It shall be free from sticks or other foreign matter, but it may contain clay or loam not to exceed two per cent. (2%).

Where so required for pressed face brickwork sand shall be clean, sharp, white sand of the very best quality.

9. Lime

All lime used shall be of good quality, in large lumps, free from cinders, or clinkers, must contain less than ten per cent. (10%) impurities and must slake readily in water, making a very soft paste, free from core. Before being used all lime shall be thoroughly slaked with water. No air slaked lime shall be used. The use of hydrated lime of an approved brand will be permitted at the discretion of the Engineer.

10. Mortar Color

A mortar color of an approved brand shall be used to color mortar for face brickwork, color and mixture shall be as approved by the Engineer. The Contractor shall upon request of the Engineer lay up samples of face brickwork with different shades of mortar in order that the Engineer may decide by comparison the proper shade of mortar to use. These samples shall be of a size not to exceed six (6) square feet in area, and the Contractor shall, if requested, build not to exceed six such samples. In general, unless otherwise specified, or ordered by the Engineer, the mortar shall be colored slightly darker than the face brick used.

11. Mortar

Mortar for all common brickwork except where otherwise specified shall be composed of one (1) part Portland cement and four (4) parts sand thoroughly mixed and tempered with lime paste to make it work smoothly. Where directed, the mortar is to be as above specified, omitting lime paste.

Mortar for all pressed brickwork shall be of either of the following mixtures, as directed by the Engineer. One (1) part Portland cement, one (1) part lime putty and two (2) parts sand, the sand and cement to be mixed dry, then wet to proper consistency and the lime putty added. If pressed face brick is to be laid with colored mortar, the following mixture to be used: One (1) part Portland cement to two (2) parts sand with lime paste added to make it work smoothly and colored with approved mortar color as directed by Engineer. No more mortar containing cement shall be mixed at any one time than can be used within thirty minutes after mixing. Retempering cement mortar which has begun to set will not be permitted. No mortar which has frozen shall be used on the work.

In lieu of cement mortar, the Contractor may, when permitted by the Engineer, use a patent cement or a natural cement of a brand acceptable to the Engineer, in which case one part of the patent cement shall be used with two and one-half to three parts of sand. Such mortar shall be mixed and used strictly in accordance with the manufacturer's instructions and these specifications. No more mortar than is required for the current day's work shall be mixed.

12. Water Supply

The water shall be clean, reasonably clear, and free from oil, acid and injurious amounts of vegetable matter, alkalies or other salts. The Contractor shall arrange for his own water supply and shall pay for same.

13. Wood Centerings

The Contractor shall provide wood centers for all openings wherever necessary. Centers shall be strongly constructed, made to fit accurately to the work, be well supported and rigidly braced so as to carry all loads until the brickwork has set. At the completion of the work all centering shall be removed from the premises.

14. Scaffolding, Protection, Etc.

The Contractor shall provide all scaffolding, staging, ladders, etc., necessary for the work. All walls or other parts shall be securely braced and protected against damage by wind and storm during construction.

15. Anchors, Steel, Etc.

The Contractor shall provide chases for all pipes, set bearing plates for beams, etc., and build into the brickwork all anchors, bolts, ties, nailing blocks, etc., as indicated on drawings and will be responsible for accurate location of same.

16. Backing

Where so shown iron, steel and other material shall be backed up with brickwork in a manner indicated on details.

17. Flue Linings

Brick chimneys or flues which are not of such dimensions that fire brick lining is required or called for on detailed plans, shall be provided with a terra cotta flue lining from a point two feet below the lowest smoke pipe entering same to base of chimney cap. All joints in this lining must be completely filled with cement mortar and carefully pointed up. No lime mortar shall be used in laying up tile linings or brick flues.

18. Fire Brick Linings

Brick linings for circular concrete stacks shall be laid up with radial fire brick in cement mortar. The interior surface shall be true, plumb, perfectly smooth and without taper, with bed joints not more than one-eighth inch thick. This lining shall be entirely independent and separate from the stack proper.

19. Vitrified Tile Wall

Vitrified tile wall coping shall be provided where indicated on the accompanying drawings. It shall be best hard burned, salt glazed tile, laid in full bed of mortar of one (1) part cement to three (3) parts sand, omitting all lime.

20. Cast Concrete Coping

All walls where so indicated on the drawings shall be coped with cast concrete coping. This to be of the section as detailed and made in lengths of approximately six feet (6′).

21. Cast Concrete Sills, Lintels, Etc.

Where so indicated on drawings, window and door sills, lintels, chimney caps, etc., shall be of cast concrete according to details shown for same.

22. Requirements for Cast Concrete

Concrete for cast copings, lintels, sills, caps, etc., shall be composed of one (1) part Portland cement, two (2) parts sand and three (3) parts crushed stone or gravel of a size to pass a one and one-fourth inch (1¼") ring. Exposed surfaces shall be troweled smooth and edges shall be smooth and unbroken. Cast concrete copings, sills, lintels, caps, etc., shall be set true, level and plumb and carefully pointed out. No cast concrete member shall be set until the concrete is sufficiently hard to prevent damage. Copings, sills and caps shall be provided with drips.

23. New Masonry Joining to Old

The Contractor shall use special precaution where new masonry work joins up with old masonry work, to see that the old work is sufficiently roughed up, anchors provided and work keyed so that an absolutely tight and neat bond is assured between old and new work.

The Contractor shall do all work in connection with cutting out old brickwork, stone work or concrete where required. Care shall be exercised to see that only such portion of the masonry is disturbed as is necessary.

24. Protection and Pointing Up

The Contractor must keep his work covered and protected from the action of the weather or frost. He shall also protect by boxing all dressed or ornamental work liable to damage. At the completion of the work or at any time when so ordered he shall do all patching in a most satisfactory manner, clean down and point up all brick work, etc., removing all surplus mortar and stains. All window and door frames shall be carefully caulked with oakum and pointed up after they have been inspected and before staff bead is applied.

25. 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 Section 1 of this specification shall be considered to apply with equal force to this section of the specification.

SPECIFICATIONS FOR RAILWAY BUILDINGS

SECTION 6

Stone Masonry and Cut Stone Work

1. General

The Contractor shall furnish all labor, materials, tools, scaffolding and equipment, except as otherwise noted, necessary to entirely complete any or all classes of stone masonry and cut stone work herein specified, according to the class of building and as shown on the drawings.

2. Description of Stone.

All stone specified or shown on drawings shall be sound, durable, well seasoned, from quarries approved by the Engineer and each stone shall be laid on its natural bed. When required by the Engineer samples shall be furnished, which shall be about four (4) inches by seven (7) inches by one (1) inch thick produced so that the large faces shall show the grain or rift of the stone, the finish specified to be indicated on the large faces and at least two of the edges to be rock face. Similar samples shall be provided when select stock is required for certain positions in the building. Samples submitted are to be typical of the extremes which the Contractor proposes to furnish.

3. Cutting and Setting Drawings.

The Cut-Stone Contractor shall prepare and submit to the Engineer for his approval, when required, complete cutting and setting drawings (in triplicate) for all the cut-stone work in this contract. Such drawings shall show in detail sizes and dimensions of stones, the arrangements of joints and bondings, anchoring and other necessary details.

4. Carving.

All carving shall be done by skilled carvers from approved models.

5. Cutting and Finish.

All exposed faces shall be cut true. The stone shall be cut full to the square with joints as required. The arrises shall be full and true. Beds, ends and tops shall be dressed straight and at right angles to the face unless otherwise shown. No patching or hiding of defects will be permitted and Lewis holes shall not be cut on exposed surfaces.

Washes shall be as steep as practical and drips shall be provided on all projecting stones and courses of sufficient depth to shed water.

Specially graded stone acceptable as to hardness, and colour, as per samples to be submitted shall be employed for grade course steps and all other positions exposed to direct wear. Steps shall be cut with a slight pitch to the front.

The finish on exposed surfaces, except rock face work, shall be hand tooled work not less than (10) cuts to the inch.

Where molded work is tooled, the tooling shall run in the direction of the molding and not across.

Rock face work shall have no projection exceeding two (2) inches. Edges shall be pitched to a straight line.

6. Lewis Holes.

Lewis holes shall be cut in all stones weighing more than three hundred (300) pounds. No Lewis or other holes shall come within two and one-half (2½) inches of the exposed face of the stone, unless the stone is less than five (5) inches thick.

7. Mortar.

Mortar for all stone work, except where otherwise specified shall be composed of one (1) part Portland Cement, one (1) part lime putty and two parts sand, the sand and cement to be mixed dry, then wet to proper consistency, and the lime putty added. If stone work is to be laid with colored mortar the following mixture shall be used: One part Portland Cement, two (2) parts sand, with lime paste added to make it work smoothly and colored with approved mortar color. No more mortar containing cement shall be mixed at any one time than can be used within thirty minutes after mixing. Retempering cement mortar which has begun to set will not be permitted. No mortar which has frozen shall be used on the work.

Portland Cement shall be in accordance with the A.R.E.A. Specification.

Sand and Lime specifications as given in Section 5 "Brickwork" shall apply to sand and lime for stonework.

8. Anchors and Dowels.

Proper provision shall be made for anchoring and doweling the stone.

Anchors and dowels shall be of the proper size and shape and thoroughly galvanized, or coated with asphaltum paint.

9. Setting.

All stone shall be thoroughly cleaned on all joints before setting. Mortar shall be kept three-quarters (¾) inch from the face of the stone to allow for pointing. Splashing exposed faces of stone with mortar shall be avoided. All beds and vertical joints shall be of a maximum width of one-quarter (¼) inch unless otherwise indicated. The stone shall be set accurately, true to line and level by competent stone setters. Face stones shall be set on thoroughly wetted wooded wedges which are not to be removed until the building is cleaned and pointed. The ends only of all sills shall be set in a full bed of mortar, balance of sills to be left free until pointed.

10. Broken Coursed Ashlar.

The face stones shall be rock faced edges pitched to a straight line, shall have paralled beds and rectangular joints.

The beds and joints for six (6) inches back from face shall be dressed to lay not over one-quarter (¼) inch joint.

The stones need not be laid up in a regular course, but shall be laid level on their natural beds, shall be well bonded, having at least one header, extending entirely through the wall, for every ten square feet of face surface. Headers shall be placed so that they come half way between the header of the course above and below. No stone shall be less than six (6) inches thick, and no stone shall measure in its least horizontal dimensions less than nine (9) inches.

11. Boulder Masonry.

Where shown on the drawings, foundation walls shall be composed of stone of proper size and thickness. They shall be of fair shape, and spalled so that they will lay with good even bearings on the wall. All stones shall be laid in full beds of mortar, all interstices filled and all exposed faces neatly pointed. All work must be thoroughly done and well bonded. A header, extending entirely through the wall, shall be built in every eight (8) square feet of surface. Each header shall break joint with the headers in the courses above and below.

12. Protection.

Wherever necessary, all projecting individual stones or courses shall be protected against injury during the setting process by wooden covering, which shall be maintained in good and substantial condition until removed for the purpose of cleaning down the stone work.

13. Cleaning and Pointing.

The face of the stone work under this contract shall be thoroughly cleaned upon completion, such cleaning to be done with soap powder boiled in clean water and applied vigorously with stiff fibre brushes. If necessary, clean, sharp, fine white sand may be added to the soap and water mixture. The use of acids will not be permitted for cleaning the stone work.

All face joints shall be brushed out three-quarters (¾) inch in depth and pointed flush with mortar consisting of one part stainless cement, two parts clean white sand and sufficient cold lime putty to make as stiff a mixture as can be worked.

14. General Conditions.

All material 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 Section 1 of this specification shall be considered to apply with equal force to this section of the specification.

SPECIFICATIONS FOR RAILWAY BUILDINGS

SECTION 7

Clay Hollow Tile

1. General.

The Contractor shall furnish all labor, materials, tools, scaffolding and equipment except as otherwise noted, necessary to entirely complete any or all classes of clay hollow tile work herein specified, according to the class of building, and as shown or implied on the drawings.

Provide and erect all hollow tile exterior and interior bearing walls of hard burned hollow tile, true and regular in size.

Tile to which plastering is to be applied shall have all faces scored with special dove tail scoring to present a good bond for the finish.

All sub-dividing, non-bearing partitions, where shown on plans, shall be of hollow partition tile.

2. Hollow Tile Material

All hollow building tile shall be straight, uniform, free from objectionable cracks and burned to such a degree of hardness that it will pass the following requirements:

(a) **Standard Loadbearing Tile** shall have an absorption not to exceed 12 per cent and be capable of sustaining a load of at least 700 pounds per square inch of gross area when designed to be laid with the cells horizontal and when tested in that position, and 1200 pounds per square inch of gross area when designed to be laid with the cells vertical and when tested in that position.

(b) **Finished Face Tile** shall have an absorption not to exceed 10 per cent and be capable of sustaining a load of at least 700 pounds per square inch of gross area when designed to be laid with the cells horizontal and when tested in that position and 1200 pounds per square inch of gross area when designed to be laid with the cells vertical and when tested in that position.

(c) **Vitrified Foundation Tile** shall have an absorption not exceeding 8 per cent, and be capable of sustaining a load of at least 1200 pounds per square inch over the gross area when tested in the same position as when laid in the wall.

3. Laying.

Tile in the exterior walls and interior bearing walls shall be load bearing tile laid to develop their full strength. No vertical or head joints shall be mortared through the wall, but a generous air space shall be left in the center of the walls by buttering the two edges of each tile either before or after it is set in the wall. All tile must be wet before concrete or mortar is placed.

4. Mortar.

All mortar used for laying up the hollow tile shall consist of Portland Cement and clean sharp sand in the proportion of one (1) part cement to three (3) parts sand, well mixed to a smooth, moderately stiff mortar Cold lime putty not to exceed 10 per cent of cement by volume, will be allowed in the mortar.

5. Foundation Tiles.

Where so indicated on the drawings, the foundation walls from top of footings to the underside of first floor beams shall be constructed of hard burned foundation tile. Where columns or piers supporting heavy loads rest on the foundation walls, same shall be filled with concrete from footing to top of walls.

6. Sub-Dividing Partitions.

All partitions shall be started on the structural floor and be wedged against the floor above.

7. Jamb Tile.

Provide for all door and window openings where indicated, jamb tile with rabbitted openings to receive the door or window frame box. Fill well with mortar the space between the tile and the frame box to within one inch of stop bead and calk to stop bead with roofers cement or oakum to prevent the passage of air or moisture.

8. Lintels.

Openings not exceeding five (5) feet in clear span may be spanned with arch lintel tile or with regular tile reinforced with proper steel rods in the lower cells and filled solidly with stone concrete.

Openings over five (5) feet in clear span shall be spanned with reinforced concrete or with steel lintels faced with tile, as shown on drawings.

9. Sills.

Where called for by the drawings sills of special hollow sill-tile shall be used. Special care must be taken to fill all joints so as to prevent moisture working through the same; wood sill of window frame to be set in heavy bed of roofers cement.

10. Arch Openings.

Build all arch openings shown on drawings—2—course row-lock hollow brick header arches, carefully laid on substantial centers. Arches shall spring from the hollow tile and must be well bedded on them.

11. Columns and Piers.

Construct columns and piers, so indicated, on hollow tile to sizes as shown. Where column finish is round, build the same of circular hollow tile column covering, filling the columns with concrete where the second story walls are supported by them. Square columns shall be built of the proper size hollow tile laid as indicated under "Laying."

12. Floor Joist Bearings.

Provide and set tile slabs one (1) inch thick under all floor joists as bearing plates for end construction tile.

13. Wall Plates.

Embed in cement grout into upper courses of wall at intervals of five (5) feet ¾″ bolts projecting six (6) inches above the top of the wall to allow of plate being fastened down with washers and nuts.

14. Floors.

Floors shall be segmental arch, flat arch of hollow tile construction, as indicated on the drawings.

15. Depth of Tile.

Depth of hollow tile will be regulated by span and load to be carried, and as indicated on the drawings.

16. Centers.

Centers must be of such size as to insure against deflecting, and must not be removed before the floor has properly set and under long spans a center line of supports must be maintained for at least three weeks after the floor has been completed.

17. Cleaning, Etc.

Upon completion of this work the Contractor shall repair all damaged tile, clear away all rubbish of every description leaving this part of the work clean and in perfectly good condition.

18. 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 Section 1 of this specification shall be considered to apply with equal force to this section of the specification.

SPECIFICATIONS FOR RAILWAY BUILDINGS

SECTION 8

Architectural Terra Cotta

1. General.

The Contractor shall furnish all labor, materials, tools, scaffolding and equipment, except as otherwise noted, necessary to entirely complete any or all classes of architectural terra cotta work herein specified, according to the class of building, and as shown or implied on the drawings.

2. Quality of Material.

Material for all architectural terra cotta shall be carefully selected clay, to be in perfect condition after burning, of uniform fracture hard enough to resist scratching by knife.

Architectural terra cotta shall develop an average ultimate compressive strength of not less than 5,000 lb. per sq. in.

Coloring shall be as indicated and must be uniform.

3. Defective Work.

All work shall be carefully modeled by skilled workmen, in strict accordance with detail drawings. All pieces shall be perfect when set in place and any work damaged after installation, before acceptance, shall be replaced.

4. Drawings.

The architectural terra cotta contractor shall prepare and submit to the Engineer, for his approval, complete detail and setting drawings (in triplicate) for all terra cotta work covered by this contract. Such drawings shall show in detail, jointing, bonding, anchoring and other construction features. All blocks shall be numbered serially.

5. Models.

If desired by the Engineer full-sized plaster models prepared by experts shall be submitted for his approval. Price for models to be agreed upon.

6. Molding and Fitting.

Templates for molded work shall be made according to details and models. Carving and molding work must be sharp, straight, true and well undercut. Blocks must be straight, true and out of wind. A reasonable number of additional blocks must be provided to prevent delay from defective materials or injury. So far as possible all grinding of joints and fitting of material shall be done at the factory. Provide washes and drips for all projecting courses. Wherever flashing will occur provide raglets. Proper provision shall be made for anchors, tie rods, etc.

7. Mortar.

Mortar for terra cotta work, unless otherwise specified, shall be composed of one (1) part Portland cement, three (3) parts sand, with the addition of sufficient lime putty to make the mortar work smoothly. The sand and cement shall be mixed dry, then wet to the proper consistency and the lime putty added. Where terra cotta is to be laid with colored mortar, the following mixture shall be used: One part Portland cement, two parts sand, with lime paste added to make it work smoothly and colored with approved mortar color. No more mortar containing cement shall be mixed at any one time than can be used within thirty minutes after mixing. Retempering cement mortar which has begun to set will not be permitted. No mortar which has frozen shall be used on the work.

Portland cement shall be in accordance with the A.R.E.A. Specification.

Sand and lime specifications, as given in "Brickwork," shall apply to sand and lime for terra cotta.

8. Setting and Anchoring.

All blocks must be cleaned and wetted before setting.

Mortar shall be kept one-half (½) inch from the face of the terra cotta to allow for pointing. Splashing exposed faces of the terra cotta with mortar shall be avoided.

All beds and vertical joints shall be of maximum width of three-eighths (⅜) inch unless otherwise indicated. The terra cotta shall be set accurately, true to line and level. Face blocks shall be set on thoroughly wetted wooden wedges, which are not to be removed until the building is cleaned and painted.

All terra cotta work shall be thoroughly bonded to masonry backing. Cornices, column caps and blocks with greater projection than bed shall be thoroughly anchored.

Anchors and dowels, rods and hooks shall be of the proper size and shape and thoroughly galvanized or coated with asphaltum paint.

This Contractor shall do all cutting and fitting of terra cotta to accommodate other trades.

9. Protection.

Wherever necessary, all projecting courses or individual blocks shall be protected against injury during the setting process by wooden covering, which shall be maintained in good and substantial condition until removed for the purpose of cleaning down the work.

10. Cleaning and Pointing.

The face of the terra cotta work under this contract shall be thoroughly cleaned upon completion, such cleaning to be done with soap powder boiled in clean water and applied vigorously with stiff fiber brushes. If necessary, clean, sharp, fine white sand may be added to the soap and water mixture. The use of wire brushes or acids will not be permitted for cleaning terra cotta work.

All face joints shall be brushed out one-half (½) inch in depth and pointed flush with mortar consisting of one part stainless cement, two parts clean white sand and sufficient cold lime putty to make a mixture as stiff as can be worked. All joints shall be wetted before pointing.

11. General Conditions.

All material entering into the work and all methods used by this 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 Section 1 of this specification, shall be considered to apply with equal force to this section of the specification.

SPECIFICATIONS FOR RAILWAY BUILDINGS

SECTION 9

Concrete Architectural Stone

1. General.

The Contractor shall furnish all labor, tools, material, scaffolding and equipment, except as otherwise noted, necessary to entirely complete any and all classes of concrete architectural stone work herein specified, according to the class of building and as shown on the drawings.

2. Composition.

Concrete architectural stone shall be composed of Portland cement, meeting the requirements of the specifications for Portland cement of the American Railway Engineering Association, and sound weather-resisting aggregates.

3. Tests.

Concrete architectural stone shall pass the following test requirements:

(a) Compression Test.—The ultimate compressive strength at 28 days must average not less than 1,500 lb. per sq. in. of gross cross-sectional area of stone as used in the wall and must not fall below 1,000 lb. per square inch gross area in any test. The gross area shall be taken as the minimum area in compression.

(b) Absorption.—The amount of water absorbed by the stone at 28 days shall not exceed 5 per cent. by weight after 24 hours' immersion. (Per cent. of absorption is obtained by dividing the weight of the water absorbed by the weight of the dry sample and multiplying the quotient by 100.)

At least three samples shall be tested for compression and three samples for absorption. Whenever practicable, tests shall be made on full-sized samples, but if specimens are too large for testing in the ordinary machine or are in special shapes which cannot be fitted in the machine, smaller or more regular specimens may be used as directed, but these shall be made of the materials and proportions representing fully the manufactured product. The Engineer may require further tests at any time and unless tests are made under the immediate supervision of the Engineer the Contractor shall furnish a certificate of tests made by a laboratory of recognized standing, showing a record of the compressive strength and absorption of the concrete stone.

4. Working Loads and Unit Stresses.

Solid walls built of concrete architectural stone laid up in Portland cement mortar may be loaded not to exceed 300 lb. per sq. in. of actual bearing area. Lintels, mullions and other parts carrying heavy loads shall be reinforced with steel sufficient to take the tensile and shearing stresses and shall be designed in accordance with recognized engineering practice. Where local ordinances do not conflict, the design shall be based on a unit tensile stress of 16,000 lb. per sq. in. in reinforcement and 650 lb. per sq. in. compression on the concrete in flexure.

5. Handling.

Pieces weighing more than 300 lb. shall be provided with lewis holes or have hooks cast into the stone for hoisting purposes. Hooks shall be laid in flush or arranged to fit into depressions in adjoining stones. Hooks or lewis holes shall not be cast in the face of the stone or come within two and one-half (2½) in. of the face of the stone.

6. Surface Finish and Carving.

A sample or samples of the architectural stone which the Contractor proposes to furnish and erect shall be submitted to the Engineer along with a diagram showing arrangement of joints, various sizes of units and bonding to be employed.

If a surface finish of exposed special aggregate is specified this special facing must be not less than one-half inch thick on the exposed surface. Exposed surfaces shall be rubbed, tooled, scrubbed or acid washed or otherwise treated to expose the aggregate and obtain the desired architectural results. All carving shall be done by skilled carvers from approved models, photographs or drawings.

7. Mortar.

Portland cement shall satisfy the requirements of the A.R.E.A. specifications for Portland cement.

Sand and lime specifications as given in the specifications for "Brickwork" shall apply to sand and lime used for concrete architectural stone.

Mortar for concrete architectural stone work, except where otherwise specified, shall be composed of one part Portland cement and three parts sand, with the addition of sufficient lime putty to make the mortar work smoothly. The sand and cement shall be mixed dry, then wet to the proper consistency, and the lime putty added. Where colored mortar is to be used, the mortar shall be composed of one part Portland cement, and two parts sand, with lime putty added to make it work smoothly, and colored with approved mortar color. No more mortar shall be mixed at any one time than can be used within 30 minutes after mixing. Re-tempering cement mortar which has begun to set shall not be permitted. Mortar that has frozen shall not be used on the work.

8. Anchors and Dowels.

Where anchors and dowels ars required they shall be of the proper size and shape, thoroughly galvanized or painted with asphaltum paint.

9. Setting.

Stone shall be thoroughly cleaned on all joints before setting. The exposed faces of the stone shall not be splashed with mortar. All beds and vertical joints shall be a minimum thickness of ¼ in. unless otherwise indicated. The stone shall be set true to line and level. These stones shall be set on thoroughly wetted wooden wedges which shall not be removed until the building is cleaned and pointed. The ends only of sills shall be set in a full bed of mortar, leaving the remainder of sills free until pointed.

10. Cleaning and Pointing.

The face of concrete architectural stone shall be thoroughly cleaned upon completion. The use of acids will not be permitted for cleaning unless specifically directed by the Engineer.

All face joints shall be raked out ¾ in. in depth and pointed flush with mortar consisting of one part Portland cement, two parts of clean white sand and only sufficient cold lime putty to make a workable mixture, or with colored mortar as specified in paragraph 7.

11. Protection.

Wherever necessary, all projecting courses or individual blocks shall be protected against injury during the setting process by wooden covering, same to be maintained in good and substantial condition until removed for the purpose of cleaning down the work.

12. Guarantee.

The Contractor for concrete architectural stone shall guarantee the surface to be free from efflorescence, crazing, crumbling or fading for a period of two years after completion of the building.

13. General Conditions.

All material 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 Section 1 of this specification shall be considered to apply with equal force to this section of the specification.

SPECIFICATIONS FOR RAILWAY BUILDINGS

SECTION 10-a

Concrete Roofing Tile

1. General.

The Contractor shall furnish all labor, materials, tools and equipment needed to entirely complete the concrete tile roofing, including all valleys and flashing as specified or shown on drawings.

2. Types.

Concrete roofing tile shall be divided into the following types:

(1) Small tile supported directly on roofing paper and roof sheathing.
(2) Large tile spanning between purlins.
Large tile shall be specified as
(a) Interlocking tile for pitched roofs and
(b) Flat tile.

3. Materials.

Concrete roofing tile shall be composed of Portland Cement in accordance with specifications for Portland Cement of the A.R.E.A.. and clean, hard coarse sand or crushed rock. Large tile shall have suitable metal reinforcement. If colored tile are specified, the color must be obtained by the use of pure mineral oxides, pure red oxide of iron for red, and chromium oxide for green. The coloring material shall be reground with the cement in a small ball mill or other closed grinder so that at least seventy-eight (78) per cent. of the combined cement and coloring material will pass a 200-mesh sieve as determined by samples.

4. Manufacture.

Small concrete roofing tile shall be made on approved cast iron or strong steel pallets and upon an improved machine developing a pressure at the rollers or tampers of at least 100 lb. per sq. in. Pallets shall be straight and free from warps. Large tile shall be made in smooth substantial molds to produce tile true to dimensions. Troweling bar shall have tapered channels which produce a compressive action.

The colored cement for colored tile shall be either mixed with sand and deposited as a facing in the molds or dusted dry onto the face of the tile and troweled in by special shaped tools or rollers to give a dense, permanent even colored surface, or else applied in liquid form as the tile leaves the rollers.

As the tile are taken from the machine or molds the lower edge shall be painted with a mixture of colored cement and water applied with a brush, except where color is incorporated into or through the body of the tile when painting may be omitted. Tile shall stand for not less than three hours on cars or racks before placing in curing chambers and shall be preferably cured in moist steam or under fog nozzles for 24 hours. In cold weather the temperature in the curing chamber shall be maintained not less than 75 deg. F. The tile shall then be taken from the pallet and stacked on end, kept under cover for 10 days and well wetted down at least twice a day. They shall then be stacked in the open air for 20 days more and sprinkled daily.

5. Dimensions.

Tile shall be true and of even thickness. The thickness of small concrete tile shall be not less than ⅜-in. and edges and ends shall be smooth and clean. Tile shall be not warped more than ⅛-in. and shall not vary more than 1/16-in. in thickness. Starter tile shall be flanged and eave tile shall be made on special pallets that show solid edges.

Interlocking tile shall be .... by .... inches and 1-in. thick for the flat portion. The surface exposed to the weather shall be .... by .... allowing 4-in. end laps.

The tile must weigh not over 16 lb. per sq. ft. and shall not vary from the specified thickness more than 1/16-in. nor be warped more than ⅛-in.

Large flat tile shall be .... by .... in. and 1½ in. thick. The ends of the tile shall be recessed so as to shoulder on the supports. The tile shall not weigh over 17 lb. per sq. ft. and shall not vary in thickness more than 1/16-in. nor be warped more than ⅛-in.

6. Tests.

All tests shall be made in a laboratory of recognized standing and a certified copy of the tests shall be furnished by the manufacturer. Tests shall be on full sized samples and at least 6 samples representing the ordinary commercial product shall be tested.

Concrete roofing tile shall not absorb more than 5 per cent. of its own weight of water in 24 hours. Absorption from the face of the tile shall not exceed two per cent. by weight in 24 hours with the face of the tile sample in contact with the water.

Tile shall be tested with weather face up. The tile shall be supported under the lugs near the ends of the tile if the tile have lugs, but in no test shall the span be less than 13 in. for small tile nor less than .... in. for large tile. The support under one end shall be rigid and the support under the other end shall rest on a roller bearing to allow for variation in the under surface of the tile. The load for small tile shall be applied in the center of the tile by placing a rigid bar having a semi-circular bearing midway between the supports. From this cross-bar shall be suspended a bucket-like receptacle which shall be loaded with shot, sand or other suitable material until the tile breaks. The breaking load shall average not less than 150 lb. per tile when the load is applied in accordance with the method described above. Lots of tile intended for building construction may be rejected if more than 10 per cent. of the samples tested break at loads less than 100 lb.

Large interlocking tile shall withstand a uniformly distributed load of 100 lb. per sq. ft. Lots of tile intended for building construction may be rejected if more than 10 per cent. of the samples tested break at loads less than 100 lb. per sq. ft.

Flat tile shall withstand a uniformly distributed load of 150 lb. per sq. ft. when supported on supports .... feet apart. Lots of tile intended for building construction may be rejected if more than 10 per cent. of the samples tested break at loads less than 100 lb. per sq. ft.

7. Laying.

Small roofing tile shall be laid in accordance with the following specifications:

Over the sheathing apply approved felt roofing paper, weighing not less than 14 lb. per sq. ft. laid parallel to eaves. Cap all hips longitudinally with extra ply of felt at least 12 in. wide. In valleys lay one extra ply full sheet wide, longitudinally. Where felt extends against vertical walls, it shall be carried at least 6 in. on vertical surface under counter flashing. The roof shall be water-tight after applying the felt. Over felting lay $\frac{3}{16}$-in. strips on 18-in. centers from eave to ridge. Nailing strips ¾ by 1¾ in. shall be nailed above lath. The roof shall be accurately laid out with rule and chalk line by the roofer and when finished, courses shall present a straight and uniform appearance when viewed vertically, horizontally or diagonally. All hip and ridge roll shall be laid accurately and bedded in 1:3 Portland cement mortar colored with approved mineral color to match balance of roof.

Large interlocking tile shall be self fastening and shall be held in place by a hanger at the upper end, and laid on purlins spaced as directed by the manufacturer. The tile shall lock sideways by means of the side roll and rabbet, which shall be integral parts of the tile. Gable ends shall be finished with end finishing tile with the tile wing flat against the end walls of the building. Where gable end walls extend above the roof the roofing Contractor shall arrange that a 4 by 4-in. chase at the line of the top of purlins be provided for the reception of the tile. The roof ridge shall be finished with an interlocking ridge roll of the same material as the standard tile, properly cemented to the main roof. The spacing between tops of ridge purlins shall not exceed 8 in. Hip roofs shall be finished with interlocking hip roll of same material as standard tile and laid in Portland cement to fit tightly on main roof. Bearing for interlocking hip roll shall be provided to height of purlin tops to properly support the roof tile.

Where necessary, flashing plates of the same material as the standard tile shall be provided. All tile when laid shall be properly pointed with cement.

The joints of large flat tile shall be pointed where necessary so as to provide a smooth surface for the application of the composition roofing which is to be applied with a high-melting-point adhesive.

Gutters for pitched roofs shall be formed with standard reinforced flat tile to conform with drawings.

8. Provision for Ventilation.

Provision shall be made for the proper ventilation for the underside of tile roofing to prevent the formation of condensation.

9. Guarantee.

The roofing Contractor shall furnish an unqualified guarantee, with good and sufficient bond, covering the maintenance of the roof in a watertight condition for a period of .... years from date of completion.

10. General Condition.

All material 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.

The General Conditions as given in Section 1 of this specification shall be considered to apply with equal force to this section of the specifications.

SPECIFICATIONS FOR RAILWAY BUILDINGS

SECTION 10-b

Clay Tile Roofing

1. General.

The Contractor shall furnish all labor, materials, tools, scaffolding and equipment, unless otherwise noted, necessary to complete any or all classes of clay tile roofing, herein specified, according to the class of building and as shown or implied on the drawings.

2. Materials.

All pitched roofs so indicated on the drawings shall be covered with .... pattern clay tile, as made by ...., or approved equal, with stock fittings suitable for each pattern.

Clay tile shall be hard burned, true in shape and of uniform natural deep color, in accordance with samples submitted to and approved by the Engineer. The Contractor shall submit with his bid representative samples of the clay tile to be used, and the tiles subsequently furnished must be equal in quality to the samples.

3. Flashings.

All raglets or special flashing tiles of every description, in connection with this roof, shall be furnished and placed by this Contractor. Metal flashings will be furnished and placed by the sheet metal contractor.

4. Roofing Felt.

The roofer shall cover the roof sheathing with one thickness of approved roofing felt weighing not less than .... lb. to the square, laying same with a three (3) in. lap and securing in place with capped nails not over ten (10) in. apart. The felt should be laid parallel with the eaves and lapped over all valleys about four (4) in. and laid under all hips and ridge flashings about six (6) in.

5. Laying Tile.

Tiles shall be fastened with copper nails, and shall be well locked together and lay smoothly, and no attempt shall be made to stretch the courses.

The tiles must be laid so that the vertical lines are parallel with each other and at right angles to the eaves. The tiles that verge along the hips shall be cut close against the hip board, and a water-tight joint made by cementing cut hip joint to hip board with best quality elastic cement. Each piece of hip roll shall then be nailed to the hip board and the hip rolls cemented where they lap each other. No broken or cracked tiles shall be used or left in the roof when complete.

Gable rakes shall be furnished with special detached gable rake fittings

6. 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 of .... years from date of completion.

7. 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 Section 1 of this specification shall be considered to apply with equal force to this section of the specification.

SECTION 10-C

Slate Roofing

SECTION 10-D

Built-up Roofing

Materials

Type A-1
" A-2
" B-1
" B-2
" C-1, Class A and Class B.
" C-2, " A " " B.

SECTION 11

Sheet Metal Work

SECTION 12

Structural Steel and Iron Work

SPECIFICATIONS FOR RAILWAY BUILDINGS

SECTION 13

Carpentry and Millwork

1. General

Under the heading of "Carpentry and Millwork" shall be included all woodwork of every description, except lath, which forms a part of the completed building. The sizes of all timbers and lumber shall conform to the sizes shown on the plans or specified hereinafter, 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 in accordance with the American Railway Engineering Association "Specifications for Lumber and Timber to be used in the Construction and Maintenance of Way Departments of Railroads" and shall be subject to inspection as received at the site. Rejected lumber shall be promptly removed from the site by the Contractor.

2. Seasoning

All framing lumber and timbers shall be thoroughly air seasoned before being used, and all finishing lumber, flooring, ceiling, moulded casing, base and window and door jamb shall be kiln dried. 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.

3. Species and Grades

The lumber used in the various parts of the work shall be of the species and conform to the grades listed below:

Description of Lumber	*Species*	*Grade*
Timbers and framing lumber		
Window, transom and door frames		
Exterior finishing lumber		
Interior finishing lumber		
Flooring		
Ceiling		
Moulded casings, base, window and door jambs		
Roof and storm sheathing		
Drop and bevel siding, weatherboards		
Fencing		
Shingles		
Sash		
Doors		
Blinds		

4. Dressing

Unless otherwise shown on the plans, all lumber used throughout the work shall be sized on four sides to uniform widths and thicknesses, except that sills may be rough and platform joists need be dressed on two edges only.

5. Treated Lumber

Where called for on the plans, lumber treated with a preservative such as creosote oil or zinc chloride 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, delivered on cars at the nearest available track to the building, and the Contractor shall provide for unloading, framing and erecting such lumber in his proposal, quality of workmanship to be the same as for other carpenter work under this specification. The Railway Company will furnish sufficient preservative and the Contractor shall apply two brush coats of this material to all parts of the lumber that have been framed. The preservative material shall be heated before application if directed by the Engineer.

6. Framing

All framing throughout shall be of the dimensions shown on the plans and shall be placed as indicated. The framing shall be done in a neat, workmanlike manner to give close joints and shall be securely nailed, spiked and bolted. 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 four feet 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 generally be in two pieces, each of the same dimensions as the studding, breaking joints. All joints shall come over studs and not between studs.

7. Joists

Joists shall be of the dimensions shown on the plans, and spaced as indicated. Through partitions carried from the ground floor up shall have a joist run close up against the same on either side at each floor. Joists carrying partitions, 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 bridging of the size shown crossed both ways between each joist, and placed at least every six feet. Ceiling joists shall be firmly spiked with the roof, and when not supported on intermediate partitions shall be in one piece.

8. Roof Framing

Roofs shall be framed and built in accordance with the detail plans, accurately fitted and securely nailed, spiked or bolted. 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 plans. They shall be carefully cut and set, and have a solid bearing over wall plates, beams, and at ridge pieces, and be well spiked 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.

9. Sheathing and Siding

Storm sheathing, when called for by the plans, shall be laid diagonally or horizontally as detailed, and nailed twice at every bearing. Sheathing boards shall be of 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 boards. All siding shall be drawn tight, secret nailed if called for. and when complete shall be wind and rain proof.

10. Flooring

Rough flooring shall be of the dimensions shown on the plans (tongued and grooved if called for), evenly laid, in long lengths and securely nailed throughout, all joints to come on joists. Finished flooring shall be dressed and matched, of the dimensions shown on the plans, with not more than two joints together, and shall be secret nailed with wire or cut floor nails as directed by the Engineer. It shall be smoothed by hand or machine to the final finish. No floor board, except in closets, shall be less than four feet in length. Finished floors shall not be laid until the plastering is finished. Where maple flooring is called for as the finished flooring in warehouses and shops, it shall be of the dimensions shown but square edged and end matched, and unless otherwise directed shall be face nailed with wire floor nails.

Flooring shall be tightly driven up before nailing so that joints are absolutely tight. Where wood floors are laid over concrete subfloors, a coat of approved liquid waterproofing compound shall be mopped over the concrete filling and screeds before the rough flooring is laid.

11. Building and Sheathing Papers, Etc.

Where called for on the plans, storm sheathing and sub-flooring shall be covered with one layer of waterproof building paper, weighing not less than 5 pounds per 100 sq. ft. Paper shall be lapped at least two inches at all joints, and carried underneath all corner boards, casing, etc., making a windtight finish throughout.

12. Furring and Grounds

Interior surfaces of stone, brick or concrete walls which are to be plastered, also all studded partitions and ceilings where studs or joists are more than sixteen inches on centers, shall be furred with one by two inch furring strips placed sixteen inches 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.

13. Window and Door Frames

Window and door frames shall be substantially built to details, of kiln dried lumber, all 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, and shall be anchored into masonry walls by wrought iron ties attached to the frames with screws; and if in wood walls, shall be firmly fixed into reveals with wood blocks built in. Frames with transoms and mullions shall be made in one frame with transom bar and mullion mortised in. All frames shall be of proper size to receive sash and doors, and shall be weatherproof. Frames for double hung windows shall have sash pulleys built in as specified under "Hardware."

Where called for on the plans window frames shall be built to receive "winter" or "storm" sashes, and door frames to receive "storm" doors. Frames shall be built to receive screens where required. Plank frames for masonry walls shall have a break strip built into wall and nailed to frame around head and jambs.

14. 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 ploughed into risers, and risers into the under side of treads, and both housed into the wall stringer and tightly wedged. In general for all stairways, 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.

15. Outside Finish and Trim

Outside trim and finish shall be neatly and accurately fitted. All necessary base boards, water table, corner trim, casings, facias, frieze boards, cornice and mouldings, and everything necessary to make a complete, finished piece of work shall be furnished and erected.

16. Platform Shelters

Where platform shelter sheds have wood posts supported on concrete foundations, the posts shall be set in and bolted to a cast iron base which shall be securely anchored to the foundation. If treated wood posts are called for these shall be set in the ground and anchored and braced as detailed. Corners of posts, brackets and purlins shall be stop chamfered, and posts up to a height of 5 ft. above the top of platform shall have the corners protected by steel angles. All braces and brackets shall be securely bolted, using beveled washers under bolt heads and nuts where required. Brackets for overhanging roofs shall be built as detailed and in locations shown, and shall be securely bolted to walls and set true against solid bearings. Where no ceiling is used on the under side of sheds and shelters, the roof sheathing shall be tongued and grooved, and of size and design shown on drawings. All necessary facia boards and moulds shall be provided, and ends of show rafters shall have scroll cut ends.

17. 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 with mitred joints 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.

18. Cabinets, Counters, Etc.

Provide in place all cabinets, counters, drawers, lockers, shelving, etc., called for on the plans, fitted up with all hardware as specified under that heading. All lumber for this work shall be kiln dried, and of same species and grade as interior finish. Cabinet work shall be done in an approved manner, securely nailed and glued, and all drawers and cabinet doors shall work easily and fit accurately. Tops of counters shall be accurately joined, hand dressed, scraped and sandpapered so that joints will not show. Shelving shall be securely and rigidly built in place, supported by necessary brackets and cleats.

19. Toilet Partitions

Where wood water closet partitions are called for on the plans, they shall be provided by the Carpenter, together with all metal fittings and hardware; also doors in accordance with the details. In general these partitions shall begin at a point 6 in. above the floor and extend to a point 6 ft. above the floor, and may consist of either standard ceiling fitted into ploughed stiles and rails, or panelled sections supported and fastened by nickel plated toilet partition fittings.

20. Sash

Sash shall be accurately made to fill openings, dressed and sanded to a smooth finish, pinned and through tenoned with muntins, etc., as detailed. They shall be checked for glass and moulded and shall be properly hung, hinged or pivoted as required. Sash for exterior windows shall have small groove cut around sash to make a watertight fit. Double hung windows shall have the sash carefully balanced and counterweighted with cast iron or lead weights hung on approved sash cord or sash chains of proper strength. Sash shall be fitted so as 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 rebates at jambs, head and meeting stiles. Glass sizes, thicknesses, widths of rails and stiles will be shown on the plans. Where glass sizes only are given, widths of rails, stiles and muntins shall be in accordance with standard mill practice.

21. 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 mortised together, backing rigidly fastened, and fitted with sash where shown.

Unless metal doors are called for, fire doors shall in general be built of three thicknesses of tongued and grooved boards nailed together in opposite directions with core laid diagonally and covered on both sides and all edges with asbestos sheets covered with sheets of tin. Fire doors shall be hung to close automatically in accordance with the standard practice of the National Board of Fire Underwriters.

A special schedule of hinged doors, showing thicknesses, sizes, design, panelling, glazing, etc., will be furnished to supplement this specification where needed. In general all panelled doors shall be 1¾ in. thick, except interior doors in minor buildings, which may be 1⅜ in. thick, stiles and rails to be through tenoned and pinned and 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 plans.

22. Shingles

Where called for on the plans, roofs and exterior walls of buildings shall be covered with shingles of the species and grade herein specified. Unless otherwise provided for, shingles shall be 4 in. x 16 in. in size, laid 4½ in. to the weather, thoroughly nailed with coated shingle nails. No split shingles or pieces shall be used. Shingles shall be laid in courses which are truly horizontal or parallel with eaves, all joints truly vertical or perpendicular to eaves, joints alternating with courses below. Shingles at eaves and base shall be started with double course projecting one inch below the sheathing. Valleys shall have shingles cut parallel to valleys, leaving flashing exposed not less than 12 in., and hips shall have shingles worked into Boston hips unless otherwise provided. All necessary saddle boards on ridge cap shall be provided and when completed, shingle roofs shall be watertight.

23. Miscellaneous Carpentry

The Carpenter shall provide in place all miscellaneous woodwork not above specified, such as wood foundation blocks and posts, fencing, latticing, 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 leave the work in a complete, finished and orderly condition.

24. 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 Section 1 of this specification shall be considered to apply with equal force to this section of the specification.

SPECIFICATIONS FOR RAILWAY BUILDINGS

SECTION 14

Lathing and Plastering

1. General

Under this heading shall be included all metal furring and cross furring, all wood and metal lathing, all plain and ornamental plastering and all stucco work. The Contractor shall provide all scaffolding, tools, labor and materials, and everything necessary to complete the plastering and stucco work shown on the drawings or required to complete the building.

2. Metal Furring

The Contractor shall furnish and set all metal furring, cross furring, forms, anchors and ties for all suspended ceilings, cornices, coves, mouldings, etc., called for on the plans Where ceilings are hung below the beams of floor or roof systems, they shall be formed on steel channels of sizes indicated and spaced as shown, and securely fastened by means of hangers to the floor or roof members. Hangers shall be flat iron of dimensions shown, securely bolted and clamped to the beams and channels. Ceilings shall be cross furred as noted with one inch (1″) angles, channels or tees spaced twelve inches (12″) on centers. Cross furring shall be secured by approved clips to furring channels and beams.

3. Metal Lathing

Metal lath shall be painted or galvanized expanded metal, No. 24 gage, painted or galvanized after expansion, and of a make approved by the Engineer. All metal lath shall be drawn tight over steel furring, studs or joists, lapped not less than three inches (3″) at all sides where joints occur, and laced together and to the furring at intervals not to exceed six inches (6″) with No. 18 galvanized soft wire. Ends of wire shall be well twisted and bent up beyond lower line of lath. Lathing shall be left in perfect condition to receive plaster—level, true and rigid.

4. Painting

All metal furring, cross furring, ties, hangers and clips shall be painted on all sides before erection with one coat of approved lead and oil paint.

5. Wood Lath

Wood lath shall be of cypress, white pine, spruce, fire or hemlock, No. 1 quality, and shall be well seasoned and free from sap, bark and dead knots. Before putting up any lath the lather shall test and check all studding, furring and grounds to see that they are all true and properly prepared for his work. Lath shall be securely nailed at every bearing, using two nails at ends, and shall break joints every sixth course. No lath shall be set vertical to fill out corners and no lath shall extend beyond any corner or angle. Where laths cross a bearing over two inches in width a strip or lath shall be put under the laths so there will be a space back of the laths for the plaster to key. Laths over doors or other openings shall have as few vertical joints as possible and where practicable laths shall extend across such openings. Laths shall be spaced ⅜ in. apart for ordinary lime mortar and ¼ in. apart for patent or hard plasters. At the junction of all walls covered with wood lath and unfurred brick or tile walls, and at all angles in walls covered with wood lath, a strip of metal lath not less than twenty-four (24") inches wide shall be securely fastened over the entire length of the joint or angle, lapping twelve (12") inches on each side.

6. Corner Beads

Except where rounded corners are specifically indicated, all exposed vertical corners where plastering occurs shall be provided with metal corner beads, securely fastened in place.

7. Interior Plastering

In general all plastering on lathed surfaces shall consist of a scratch coat, a brown coat, and the finishing coat. On unfurred brick or tile surfaces the scratch coat will be omitted. Each coat shall be permitted to dry thoroughly before the next coat is applied. Before beginning his work the plasterer shall test and prove the lathing and grounds so that the finished plaster will be plumb, true, level and waveless. Plastering shall run up behind all sill aprons, wainscoting, etc., and shall extend behind all bases.

Stone, brick or terra cotta walls to be plastered and all wood lath shall be thoroughly drenched with water before applying the first coat of plaster.

In hot dry weather, especially if windy, close all openings in the building while plastering, to prevent too rapid drying. In winter the temperature in the rooms being plastered shall be kept above the freezing point while plastering and until the plaster has hardened.

The scratch coat shall be well rubbed in and troweled against brick and tile and into lathed surfaces so as to form a perfect bond, and shall be scored and scratched in both directions to form a key for the brown coat.

The brown coat shall be applied to the scratch coat and brought flush with the grounds, with all surfaces straight, true, plumb, level and waveless.

The finishing coat shall be applied to the brown coat and may be a sand float or white trowel finish as specifically designated. If a white trowel finish is called for, it shall be made of Keene's cement and lime putty troweled to a smooth hard finish free from trowel or brush marks.

The plasterer shall run all plaster moulds, cornices, coves, etc., in accordance with models or full-sized profiles; all angles to be carefully and accurately mitred. Run work shall be carefully and accurately formed from templates to form continuous, unbroken, level lines. Ornamental enrichments shall be firmly secured in place with plaster of Paris, white lead and galvanized wire nails.

Unless otherwise permitted by the Engineer, all plastering shall be done with "Patent" or hard wall plaster of a brand specifically approved by the Engineer and mixed and applied in accordance with the Manufacturer's directions. Plaster shall be delivered at the site in the original unbroken packages and stored in a dry place until used.

Lime putty used for plastering shall be made from first quality pure lump lime, screened and free from impurities, and shall be mixed at least two weeks before being used.

Sand for plastering shall be sharp and angular and free from dirt, oil, or impurities that will stain the plaster. It shall be screened, washed and dried.

8. Patching

The plasterer shall do all necessary patching of plaster after the other mechanics have finished their work and shall leave same complete and perfect in every respect.

9. Exterior Stucco Work

The work required under this heading comprises the stuccoing of all exterior wall surfaces, as shown on the drawings and hereinafter described. Fresh stucco shall be protected from the weather and no stucco in which cracks, pits, streaks, discolorations or other defects may occur will be accepted. Cement shall be Portland cement for the under coats and white Portland cement for the finish coat in accordance with specifications for Portland cement described in the section of these specifications covering "Concrete." Aggregate for the under coats shall be thoroughly clean sand, graded from fine to coarse grains with the coarse grains predominating, and shall be free from loam, salt, vegetable and other deleterious matter. Aggregate for the finish coat shall be thoroughly clean yellow gravel grit, marble or granite screenings, as directed by the Engineer. Hydrated lime and coloring compounds shall be first quality, of a brand acceptable to the Engineer. Hair shall be first quality long cattle or goat hair.

Mortar for the first and second coats shall be composed of one part Portland cement, three parts sand and one-tenth (1/10) part of hydrated lime by volume with sufficient hair added to bond the mortar to the lath.

Mortar for the finishing coat shall be composed of one part white Portland cement, three parts of aggregate and one-tenth (1/10) part by volume of hydrated lime. This coat shall be brought to the tone selected by the addition of dry coloring compound not exceeding ten (10%) per cent. of the weight of the cement.

Mixing shall be done on a watertight platform, the different constituents thoroughly mixed dry to a uniform color, water then added to obtain the proper consistency, and the whole turned over until the mass is uniform in color and consistency. No retempered mortar shall be used and no more mortar shall be mixed than can be used in thirty minutes. The dry color in the finishing coat shall be carefully weighted or measured and thoroughly mixed with the sand. The cement and lime shall then be added and the entire mass thoroughly mixed by shovelling from one side of the platform to the other through a ¼-in. mesh screen, and when the batch is of uniform color, the water shall be added.

The stucco shall be applied in three coats, each coat not less than ¼-in. nor more than ⅜-in. in thickness, the whole finishing ⅞-in. thick beyond the normal masonry line or 1 in. thick over the furring strips. The plastering shall be carried on continuously in one general direction without allowing the mortar to dry at the edge. Where this is impossible the joints shall be made at a break, an opening, or other natural division of the surface. Stucco shall not be applied when the temperature is below freezing. Masonry surfaces shall be cleaned and wet before the first coat is applied and brick walls shall have the joints raked out about ½-in. The first coat shall be applied under pressure so as to secure a perfect bond with the masonry wall or lathed surface. After the first coat has set, but before it has dried, the second coat shall be applied and floated to a true plane. The under coats shall be cross scratched and scored before the initial set has taken place and shall be thoroughly wetted before the succeeding coats are applied. The finishing coat shall be kept damp for at least 4 days, either by sprinkling after the mortar has hardened sufficiently to permit it or by hanging wet burlap over the surface.

After the second coat has set, but before it has dried, the finishing coat shall be applied and finished in accordance with one of the methods hereinafter specified as directed by the Engineer.

Exposed Aggregate (Integral Method).—The finishing coat shall be ⅜-in. thick and, within 24 hours after it has been troweled to an even surface, shall be scrubbed with a stiff brush until the aggregate has been uniformly exposed. Should the cement be too hard to be readily removed by water, a solution of 1 part muriatic acid to 5 parts of water may be used; but as soon as the aggregate has been exposed, particular care shall be taken to remove all trace of acid by spraying thoroughly with clean water from a hose.

Smooth Troweled.—Finishing coat shall be smoothed with a metal trowel, with as little rubbing as possible.

Stippled.—Finishing coat shall be smoothed with a metal trowel, with as little rubbing as possible, and then shall be lightly patted with a brush of broom straw to give an even stippled surface.

by the addition of dry coloring compound not exceeding ten (10%) per cent. of the weight of the cement.

Mixing shall be done on a watertight platform, the different constituents thoroughly mixed dry to a uniform color, water then added to obtain the proper consistency, and the whole turned over until the mass is uniform in color and consistency. No retempered mortar shall be used and no more mortar shall be mixed than can be used in thirty minutes. The dry color in the finishing coat shall be carefully weighted or measured and thoroughly mixed with the sand. The cement and lime shall then be added and the entire mass thoroughly mixed by shovelling from one side of the platform to the other through a ¼-in. mesh screen, and when the batch is of uniform color, the water shall be added.

The stucco shall be applied in three coats, each coat not less than ¼-in. nor more than ⅜-in. in thickness, the whole finishing ⅞-in. thick beyond the normal masonry line or 1 in. thick over the furring strips. The plastering shall be carried on continuously in one general direction without allowing the mortar to dry at the edge. Where this is impossible the joints shall be made at a break, an opening, or other natural division of the surface. Stucco shall not be applied when the temperature is below freezing. Masonry surfaces shall be cleaned and wet before the first coat is applied and brick walls shall have the joints raked out about ½-in. The first coat shall be applied under pressure so as to secure a perfect bond with the masonry wall or lathed surface. After the first coat has set, but before it has dried, the second coat shall be applied and floated to a true plane. The under coats shall be cross scratched and scored before the initial set has taken place and shall be thoroughly wetted before the succeeding coats are applied. The finishing coat shall be kept damp for at least 4 days, either by sprinkling after the mortar has hardened sufficiently to permit it or by hanging wet burlap over the surface.

After the second coat has set, but before it has dried, the finishing coat shall be applied and finished in accordance with one of the methods hereinafter specified as directed by the Engineer.

Exposed Aggregate (Integral Method).—The finishing coat shall be ⅜-in. thick and, within 24 hours after it has been troweled to an even surface, shall be scrubbed with a stiff brush until the aggregate has been uniformly exposed. Should the cement be too hard to be readily removed by water, a solution of 1 part muriatic acid to 5 parts of water may be used; but as soon as the aggregate has been exposed, particular care shall be taken to remove all trace of acid by spraying thoroughly with clean water from a hose.

Smooth Troweled.—Finishing coat shall be smoothed with a metal trowel, with as little rubbing as possible.

Stippled.—Finishing coat shall be smoothed with a metal trowel, with as little rubbing as possible, and then shall be lightly patted with a brush of broom straw to give an even stippled surface.

samples shall be finished as specified for the work and there shall be separate samples for each finish.

The completed work shall be equal to the approved samples as to quality, color, markings and finish.

3. Thickness.

All marble shall be thick enough to be amply strong for its size and location and no slabs shall be less than seven-eighths (⅞) inch in thickness.

All returns of eight (8) inches or less projection shall be from stock of sufficient thickness to form solid angles without vertical joints, angle pieces may be cut with hand saw, provided the position of joints is not altered from that shown on drawings. All molded or ornamented members shall be from stock sufficiently thick to permit of the finished work being an exact reproduction of the models or drawings without flattening. Projecting angles throughout shall be slightly rounded to prevent the edges chipping.

4. Setting and Anchoring.

All slabs shall be set free from backing surfaces using brick furring on vertical surfaces, and other approved materials elsewhere. All bearing edges shall be bedded solidly and continuously their entire length and no material other than pure plaster of Paris and pure non-staining Portland cement shall be used in setting. Each piece of marble throughout the entire work shall be securely fastened in place with brass or bronze dowels, clamps and tees, which must be provided and used in ample numbers to make a rigid and permanent job. No tees shall be fastened to the marble or walls by cement or plaster only, but each must fit into a properly drilled seat, shaped to retain the setting mortar.

In no case shall any metal fastening show on the exposed faces unless specially mentioned herein or shown on the drawings. Specially made metal fastenings shall be used where necessary, or as may be directed.

5. Finish.

The finishes to be given marble are as follows:

(a) All floors and floor borders, stair treads, risers and landings and door saddles are to be honed.

(b) All marble, except as noted in (a) above, to be highly polished.

6. Joints.

All joints shall be close, showing only a hair line and each piece of marble shall be worked to absolutely perfect edges. The exposed surfaces of all marble shall be worked to true planes so that abutting edges cannot be felt. Any surface dressing necessary to obtain these results shall be continued the full length and width of the piece affected, so that the dressing cannot be felt or seen, and this shall include any dressing required after the marble is set in place.

7. Supports for Marble Work.

The Marble Contractor shall provide and set all steel supports of every description required specially for the proper setting of his work. Wherever this special steel framing is supported on the framing furnished and set by others, the Contractor for the marble shall furnish to such other contractors, within a reasonable time, carefully prepared drawings showing all required framing connections in detail so that provision may be made for the proper construction of the work, without unnecessary cutting and drilling, but if such framing is already in place, the Contractor for the marble work shall do all cutting, fitting and drilling required to properly connect his work to such framing.

All steel supports furnished by this contractor shall be given three coats, one shop coat and two field coats, of approved paint.

8. Floors and Floor Borders.

Wherever floors, floor borders or panel divisions are specified or shown they shall be not less than seven-eighths (⅞) inch in thickness, and at all openings shall be increased in width to meet the door saddles or filling pieces, which take the place of saddles.

9. Terrazzo (Monolithic).

Floors are to be divided into panels, as indicated on the drawings. Wherever shown borders of different colored terrazzo are to be run, and panels are to be formed by strips of colored terrazzo.

Floors shall be composed of Portland cement and selected first quality chips of marble. Chips shall be of a reasonable uniform size, perfectly clean and uniformly distributed over the surface, and showing the greatest possible proportion of marble in the finished state.

Wherever terrazzo base is indicated it shall be of the height required above the floor, finished with a one (1″) inch radius cove at the intersection with the floor.

10. Terrazzo (Tile).

All rooms so indicated on drawings shall have terrazzo tile floors and base as manufactured by................................or equal. The pressure used in the manufacture of all tile for the work shall not be less than 2500 lb. to the square inch. All tile shall be 12″x12″ for the field and have a double border. All tile to be not less than one inch (1″) in thickness. All rooms having terrazzo tile floors shall have a six-inch (6″) terrazzo cove base as detailed. All doors shall have terrazzo plinths in connection with terrazzo base. Tile must be so made that their structure will be free from air bubbles, and when rubbed to a finished surface must present a solid body. No tile, the surface of which has been filled or otherwise treated after rubbing, shall be used. The tile shall be laid in a true and level plane at elevations shown on drawings, in a first class and workmanlike manner. Great care shall be taken to have all lines and spacings true and straight, and all joints of even width, not exceeding one-sixteenth (1/16″) of an inch. Provide terrazzo thresholds at all doors in connection with terrazzo tile floors, unless thresholds of other materials are called for.

Tile shall be set on a bed of mortar composed of two (2) parts Portland cement and three (3) parts sand. Tile to be rammed to a solid and even bed, grouted and rubbed.

Before depositing bedding mortar, the entire surface shall be cleaned and well saturated with water to prevent too rapid absorption of water from bedding mortar.

After tile is laid and properly grouted, all tile floors shall be holystoned to reduce inequalities of surface. All tile for floors and base shall be made with marble chips of kind and color selected by the Engineer. Contractor shall submit samples of tile and setting plan for approval before getting out any work.

Contractor shall guarantee all terrazzo work for a period of one year after completion against defects of workmanship or material.

11. Marble for Floors.

Marble floors and floor borders shall be composed of marble tile not less than seven-eighths (⅞) inch in thickness, cut with full faces, sawn bed, and all edges rubbed to the exact size required.

Each piece of marble shall be set in full bed of Portland cement mortar, and when set, all joints shall butt and match perfectly and closely and shall be perfectly flush. All pieces shall be selected and located in the floor according to character of veinings and color.

12. Vitrified Tile.

(a) On Walls.—Tile for walls shall be salt glazed white tile laid in cement with hair line joints absolutely plumb and true without waves. Where trim of other material is not specified, the tile shall be returned into all riveals and soffits and the angle shall be formed of angle tile with corner rounded to a radius of about one (1″) inch. Where tile wainscot is called for there will also be required a sanitary tile base eight (8″) inches high.

(b) Floor Tile.—To be hexagonal or other approved shapes of vitrified tile, set in cement mortar. Border of two (2″) inch square tile to be laid at the intersection of floor with base.

13. Beds.

The distance from the finished floor to the rough floor will be not less than two (2″) inches and this Contractor shall fill in on top of the rough floors to the desired line with concrete composed of one part Portland cement, two parts sand and four parts crushed stone or gravel to form bed for flooring material.

14. 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 Section 1 of this specification shall be considered as to apply with equal force to this section of the specification.

SPECIFICATIONS FOR RAILWAY BUILDINGS

SECTION 16

Painting and Glazing

1. General.

Under the heading of "Painting" shall be included the following:

(a) Painting and finishing exterior and interior woodwork.
(b) Painting structural steel and iron work and all ornamental iron work.
(c) Painting exposed sheet metal work and rain conductors.
(d) Painting plastered surfaces.
(e) Painting brick and concrete wall surfaces and concrete ceilings.
(g) Painting and lettering signs, and lettering on doors, etc.
(h) Painting radiators, piping, etc.

Under the heading of "glazing" shall be included the furnishing and setting of glass in window, door, transom and ceiling sash, including metal sash, and furnishing and setting glass in skylights and marquises.

The Contractor shall furnish all labor, tools, equipment and everything necessary to complete the painting and glazing required. The equipment shall include all ladders, scaffolding or staging necessary to execute the work. No ladders, scaffolding or staging shall be placed where they will interfere with the safe operation of trains and in buildings partially or wholly occupied by the Company and in which painting is in progress, the Contractor shall take proper precautions to protect the public and employees of the Company from any and all damage from his operations.

2. Materials.

Paints, stains and varnishes shall be of a brand acceptable to and approved by the Engineer, and shall be delivered at the site in the original unbroken factory containers with labels intact. Paints shall be furnished in ready mixed form and shall be thinned only in accordance with the directions furnished by the manufacturers or as directed by the Engineer. Thinners shall be pure raw linseed oil or pure spirits of turpentine or a mixture of these two. Benzine, naphtha, gasoline or coal oil will not be allowed on the work or mixed with any of the materials used. Paints not otherwise specified may consist of pure raw linseed oil and white lead, properly tinted, each coat to be of slightly different shade, and the final coat to be of a shade and color approved by the Engineer.

Enamels shall consist of long oil, easy flowing, durable varnishes, that remain white, set dust free in six hours and hard in twelve hours, capable of being rubbed in two days.

Interior wood stains shall be of pure color, with linseed oil vehicle, permanent as to shade, sharp and clear in tone and capable of deeply penetrating the surface.

Shingle stains shall be of a pure color with creosote or other wood preservative as the vehicle, and shall be permanent as to shade and deeply penetrating.

Varnishes shall be oil and gum goods that will withstand hard use and not show white or dust from the surface.

3. Application of Paint.

Only careful and skilled workmen shall be employed and special care shall be taken to avoid spattering, or setting of pots where they will disfigure the finished work. Canvas and building papers shall be spread where directed by the Engineer in order to protect finished or unfinished work. Paint shall be kept thoroughly stirred while being applied.

4. Preparing the Surface.

Woodwork shall be carefully hand-smoothed and nail holes, cracks or other imperfections of the surface shall be puttied after the priming coat is applied.

Paints, fillers, stains or varnishes must not be applied to wet, frosty or rusty surfaces, to wood showing sand paper marks or to surfaces not properly prepared. Knots, pitch pockets or sap shall be completely coated with first quality pure orange shellac before any paint is applied. Castings shall be filled with an iron filler and smoothed with emery and all imperfections treated and faced before applying the first coat of paint.

Brick, concrete, and plastered surfaces shall be absolutely dry before any paint is applied. Such surfaces shall be thoroughly cleaned with brushes to remove any loose material. Concrete floor surfaces shall be absolutely dry and free from oil, grease, dust, loose particles or any foreign matter that will in any way interfere with the most perfect penetration of the paint into the pores of the surface.

5. Time for Drying.

Each coat of paint shall be given sufficient time to dry hard before the next coat is applied.

6. Weather and Temperature.

Exterior painting shall not be done during damp or freezing weather, and all fresh work shall be protected from damage. For interior work the temperature shall not be allowed to fall below sixty (60) degrees Fahrenheit, while paint is being applied or while it is drying.

7. Priming Coats.

In general all exterior woodwork shall be given one priming coat of the same paint that is to be used for the finishing coats, thinned with pure spirits turpentine and pure raw linseed oil, as directed. This priming coat shall be applied as early as possible after such woodwork is erected, and well brushed into the pores of the wood.

Priming coats for window and door frames, structural steel and iron work, and the back of paneled wainscoting and partitions shall be applied in the shop before the wood or metal is subjected to dampness.

Priming of interior woodwork, plastered, concrete and brick surfaces will depend on the nature of the surfaces and the finishing coats to be used, as hereinafter specified.

8. Painting Exterior Wood Surfaces.

All exterior wood surfaces of every description, unless otherwise noted, shall receive, in addition to the priming coat, two (2) coats of lead and oil paint of approved brand and color. The third coat shall consist of the ready mixed paint as it comes from the container used without thinning.

Unless otherwise directed, exterior doors shall be painted three (3) coats on both sides, except where interior woodwork is to be varnished, in which case the outside only will be painted and the inside finished as described in paragraph 11. Tops and bottoms of doors shall be painted three (3) coats.

9. Finishing Interior Woodwork.

Interior wood surfaces shall be finished by one of the following methods or by a combination of these methods, as may be designated or as directed by the Engineer:

1. Painting with three coats of lead and oil paint.
2. Finishing in natural wood colors.
3. Staining and varnishing
4. Enameling.

10. Painting Interior Wood Surfaces.

Where interior wood surfaces are to be painted, such surfaces shall receive, in addition to the priming coat, two (2) coats of an approved brand of lead and oil paint, using such colors as will conform to the Company's standard practice or as may be directed by the Engineer.

11. Staining and Varnishing Interior Wood Surfaces.

Where interior wood surfaces are to be finished with varnish, the work shall be done as follows:

(a) Natural Finish:

i. (For Open Grain Woods, Such as Mahogany, Ash, Chestnut, etc.):

The surface shall be sandpapered smooth and all nail holes stopped with putty, using putty colored to match the wood. Then apply one coat of paste filler and before the filler has hardened, rub off clean, rubbing across the grain. Allow the filler to harden 24 hours and sandpaper with fine sandpaper. Next apply one coat of orange or white shellac, depending on whether a dark or light finish is desired, and two coats of first quality interior varnish. At least 48 hours shall be allowed for drying between coats. The final finish shall be dull or polished, as directed by the Engineer. For a dull finish, rub with powdered pumice and water 72 hours after the final coat is applied.

2. For finishing close grained woods, such as pine, cypress, birch, maple, etc., use the method described for open grained woods with the omission of the paste filler.

(b) Stain and Varnish Finish:

1. (For Open Grain Woods).—After sandpapering the surface and puttying nail holes, apply one coat of oil stain wiped off, one coat of filler rubbed off, one coat of orange or white shellac, and two coats of first quality interior varnish. After filler has hardened 24 hours, sandpaper as described in paragraph (a) of this section, and finish final coat of varnish with either dull or gloss finish, as directed.

2. (For Close Grain Woods).—Apply one coat of approved oil stain, one coat of shellac and two coats of interior varnish, allowing each coat to dry before another is applied. Finish final coat of varnish with dull or gloss finish as directed.

12. Exterior Varnishing.

Where exterior woodwork is to be finished with varnish, or with stains and varnish, first apply one light coat of a mixture of 25 per cent. pure linseed oil and 75 per cent. pure spirits of turpentine, allow to dry and sandpaper, and then follow the specifications as given in paragraph 11, except that exterior spar varnish shall be used and the coat of shellac omitted.

13. Enameled Finishes on Wood or Plastered Surfaces.

Where enameled finishes are called for on wood or plastered surfaces, these surfaces shall be given five (5) coats of an approved enamel, thinned and applied in accordance with the manufacturer's instructions.

14. Finishing Wood Floors.

Wood floors shall be finished by one of the following methods as directed by the Engineer:

(a) Oiling with linseed oil (for woods such as maple or yellow pine).

Floors to be oiled shall be given three (3) coats of linseed oil, heated as nearly as possible to the boiling point. Ample time for absorption shall be allowed between each coat, and the floor shall not be used until the third coat has thoroughly dried.

(b) Finishing with varnish (for woods such as yellow pine, oak, etc.).

Floors to be finished with varnish shall be given one coat of floor varnish, thinned by adding one pint of turpentine to each gallon of varnish, and two coats of first quality elastic floor varnish. The floor shall be lightly sandpapered with fine sandpaper after the first varnish coat is dry. Oak floors shall be given one coat of paste filler, rubbed off, before the first varnish coat is applied.

15. Painting Structural Steel and Iron Work.

All structural steel and iron work, including pipe railings and castings, in addition to the shop priming coat specified in the section of these specifications covering "Steel and Iron Work" shall be given two (2) coats of the Company's standard exterior or interior paint as directed. Surfaces in contact or inaccessible after erection shall be given one (1) field coat before assembly or erection.

16. Painting Sheet Metal Work.

All sheet metal work (other than copper), including flashings, gutters, rain conductors, skylight frames, and metal roofs, shall be given three (3) coats of an approved metal paint, of such colors as may be directed by the Engineer. Surfaces of tin or galvanized sheet metal work and iron and steel in connection therewith, shall be thoroughly cleaned of grease, oil and traces of soldering flux before any paint is applied. Surfaces that will be unexposed after being placed and the under side of metal roofing shall be given one coat of paint before being installed. Before the priming coat is applied to galvanized sheet metal work, the surfaces shall be washed with a weak solution of vinegar, or a solution of sal-soda and water, using one pound of soda to three gallons of clean water. This wash shall be allowed to dry twenty-four (24) hours before the priming coat of paint is applied. Surfaces inaccessible after erection shall be given a priming coat and one other coat before being erected. Paint shall be applied with hand brushes and well rubbed in. No dipping will be permitted.

17. Painting Plastered Surfaces.

After they are thoroughly dry, plastered walls and ceilings shall be given one coat of approved alkali-proof wall size and two (2) coats of approved interior wall paint with flat or eggshell finish, applied strictly in accordance with the manufacturer's directions. Each coat shall be allowed to dry not less than twenty-four (24) hours before the next coat is applied.

18. Painting Brick and Concrete Walls.

Interior brick and concrete wall surfaces except in basements and roundhouses shall be given three (3) coats of lead and oil flat wall paint of colors selected by the Engineer. Care shall be taken to see that these surfaces are free of all moisture before any paint is applied.

19. Painting Piping and Radiators.

Exposed piping and radiators in waiting rooms, offices, living rooms, lavatories, etc., shall be given one priming coat and two finishing coats of paint of an approved brand and color. Surfaces subjected to heat, such as steam piping and radiators, shall be painted with heat-resisting paints.

Exposed piping in basements, shop buildings, etc., and concealed piping which is not to be covered shall be painted two (2) coats.

Covered piping shall be given one coat of paint before the covering is applied, and the covering when in place shall be given two (2) coats of paint of approved brand and color.

20. Painting Interior of Roundhouses.

The interior walls, posts, etc., of frame roundhouses and all wood framing and sheathing of all roundhouses shall be given two coats of light colored fire-resisting paint. For a distance of six (6) feet above the floor all walls, posts, etc., shall be given two (2) coats of lead and oil paint of a dark color as selected by the Engineer.

All interior brick and concrete walls in roundhouses shall be given one (1) coat of light colored cold water paint or whitewash from a point six (6) feet above the floor to the under side of the roof, and three (3) coats of dark colored lead and oil paint from the floor to a height of six (6) feet. Cold water paint must be carefully brushed in so that one application will entirely cover the masonry surfaces with an opaque coat.

21. Staining Shingles.

All shingles on roofs and walls shall be dipped or given two brush coats of approved creosote shingle stain. The stains shall be kept thoroughly stirred and shall be applied without dilution or adulteration to the thoroughly dry shingles. In dipping all shingles shall be immersed butt end first to a depth of three-fourths the length of the shingle.

22. Sign Painting and Lettering.

The Contractor shall paint all necessary names, letters and numbers on all doors, signs, notice boards, etc. Letters and numbers shall conform to the Company's standard as to size and style, and the work shall be done by skilled sign painters.

23. Samples of Painting.

Before beginning any painting the Contractor shall submit for the approval of the Engineer two (2) samples of every kind of finish on wood blocks, and the final finishes shall conform to the approved samples.

24. Glazing.

The Contractor shall furnish and set all glass of every description for window, door, transom, and ceiling sash, including metal sash and all glass in skylights and marquises. Sash must be primed and thoroughly dry before any glass is set.

All putty, excepting for metal sash, shall be first quality white lead putty mixed with pure linseed oil.

Unless otherwise marked on the drawings glass for wood sash shall be American, double strength, Class "A."

Glass for main entrance doors shall be polished ¼ inch plate glass.

Glass for skylights, marques, metal sash and metal doors, unless otherwise specified or called for on the drawings, shall be one-quarter inch (¼") factory ribbed wire glass.

Where opaque or figured glass is called for on the drawings, this shall be Florentine, Maze, or other "approved" figured glass.

Samples of all glass to be used shall be submitted to the Engineer for approval, and all glass to be used in the work must conform strictly in quality with the approved samples.

Glazing in Metal Sash.—Glass in metal sash and doors shall be bedded in litharge putty, then clips or stops applied, back puttied and neatly face puttied; finished surface of putty shall show absolutely smooth, true and free from sags or wrinkles.

Glazing in Wood Sash.—Glass in wood sash shall be back puttied, securely fastened with glaziers' points and neatly face puttied.

Glazing in Doors.—Glass in wood doors shall be fastened in place with removable wood stops.

Glazing Skylights and Marquises.—Glass in skylights and marquises shall be secured in place by the use of copper strips and copper screws and shall be made watertight.

25. Final Cleaning.

Before the building is tendered for final acceptance all broken glass shall be replaced, all glass of every description shall be thoroughly cleaned, and all paint stains removed from floors, walls, brickwork, marble and finished surfaces.

26. Application of 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 Section 1 of this specification shall be considered to apply with equal force to this section of the specification.

SPECIFICATIONS FOR RAILWAY BUILDINGS

SECTION 17

Hardware

1. General

The contractor shall provide and set all rough and finish hardware necessary for the operation of all doors, windows, blinds, screens, screen doors, toilet partition doors, cabinets, drawers, gates, ticket windows, etc., and for completely equipping the building. Hardware shall be neatly and accurately fixed in place by skilled mechanics, with screws or bolts, which shall match the hardware and shall be left in perfect working order, free from rust, scratches and other defects. The Contractor shall provide such hardware as screws, bolts, coat and hat hooks and other minor articles, although not specifically mentioned or shown, but necessary for the ordinary operation of the building. All hardware required in connection with slate or marble toilet partitions shall be furnished by the Plumbing Contractor. Hardware for toilet partition doors will be furnished and fitted to the marble or slate partitions by the Plumbing Contractor, but the doors will be hung by the Carpenter. Where wood toilet partitions are called for, all necessary hardware shall be furnished and set by the Carpenter and such hardware shall be included in this schedule. All escutcheons, push plates, kick plates, push bars, etc., shall be set after the wood finishing and varnishing are completed.

2. Finish Hardware

Finish hardware shall be selected by the Engineer. As a basis for bids the Contractor shall include in his proposal the sum of ....dollars ($..........) to cover the purchase cost of all finishing hardware, together with freight on same to the building. Any difference between actual cost and this sum will be added to or subtracted from the lump sum amount of the contract as the case may require. The cost of placing the finish hardware shall not be covered by the above amount, but shall be included by the Contractor in his proposal.

3. Rough Hardware

The Contractor shall furnish all rough hardware of every description and shall include the cost of furnishing and setting such hardware in his proposal. Rough hardware shall include nails, spikes, screws, bolts and washers, sash pulleys, sash weights, sash cord or chain, sliding door hardware, fire door hardware, special operating devices for rolling doors, horizontal cross folding doors and all windows requiring special operating devices. In general special hardware will be noted on the plans or described in a supplement to this specification, but where not so shown and described it shall be furnished and placed if necessary for the operation and use of the building. Hardware for sliding doors shall include all track, hangers, bumpers, stops, stay rollers, chafe and binder strips, door pulls and locks.

Hardware for fire doors shall be of an automatic type approved by the National Board of Fire Underwriters.

Sash weights shall be of cast iron or lead and of proper weight to exactly counterbalance the sash, and shall be properly proportioned to fit in the weight boxes.

Sash pulleys shall be of an anti-friction type, of proper size and with approved face. Sash weights and pulleys shall be fitted to the sash and frames at the mill manufacturing same.

Hardware for special doors such as engine house doors shall be of extra heavy design to prevent sagging of doors. All rough hardware shall be of substantial construction and of a make approved by the Engineer.

4. 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 Section 1 of this specification shall be considered to apply with equal force to this section of the specification.

SPECIFICATIONS FOR RAILWAY BUILDINGS

SECTION 18

Plumbing

1. General.

The Contractor shall furnish all labor, material, tools and equipment, except as otherwise noted, to entirely complete the plumbing work, as specified or shown on drawings, including fixtures, drains, water supply and piping and sewers to a point five feet outside of building, all of which shall be considered as included in the plumbing work. Piping and sewers beyond a point five feet outside of building will be paid for on a unit price basis.

2. Excavation.

The Contractor shall do all necessary excavation of every description in connection with the plumbing work. The bottom of all trenches shall be carefully shaped to give uniform bearing for pipes. No backfilling shall be done until test and inspection have been made by the Engineer. Trenches shall be filled by ramming and puddling, the filling being brought to the proper grade.

3. Arrangement of System.

The arrangement of the system shall be as direct as possible, avoiding unnecessary bends and offsets. Vertical runs of cast iron pipe shall be firmly secured in position with strong iron pipe hooks placed under each hub, and stacks must be properly supported at the bottom. Horizontal runs under floors must be placed in position and tested before floors are laid.

Changes in direction of soil and sewer pipe shall be made by means of one-eighth (⅛) bends and "Y" branches and not with one-quarter (¼) bends.

Fittings receiving risers shall be set with the top of fitting at the surface of the finished floor and shall be securely clamped in position.

All horizontal runs of sewers 6 inches or less shall have a minimum fall of ⅛ inch per foot.

4. Cast Iron Pipe and Fittings.

Concealed soil, waste, drain, sewer and vent pipes in building shall be extra heavy cast iron soil pipe. Pipe shall have the maker's name cast thereon and shall be in lengths not less than five (5) feet. It shall be sound and free from defects and with the inner and outer surfaces concentric and smooth and of the following weights per linear foot.

2 inches	5½ lb.	6 inches	20 lb.
3 inches	9½ lb.	7 inches	27 lb.
4 inches	13 lb.	8 inches	33½ lb.
5 inches	17 lb.	10 inches	45 lb.

Fittings for cast iron pipe shall be extra heavy cast iron of the same make as the soil pipe, and shall be of the same inside diameter as pipe with which they are connected. Unless otherwise specified, cast iron pipe and fittings must be coated with hot asphaltum both inside and outside by dipping. Fittings for the junction of cast and wrought iron pipe shall be cut at one end with full threads, and fittings, supporting risers shall have proper shoes cast on them.

Water supply pipes larger than 2½ inches diameter located below ground shall be Class "B" cast iron pipe, in accordance with the specifications of the American Water Works Association, unless local conditions require the use of heavier pipe.

5. Wrought Iron Pipe.

Wrought iron pipe shall be galvanized, genuine wrought iron of Standard weights and dimensions cut with full threads with all burrs carefully reamed out before connecting. Fittings used with wrought iron soil and waste pipe shall be recessed cast iron drainage fittings. Fittings used with galvanized water supply pipe, shall be heavy beaded galvanized malleable iron except where brass is specified.

All exposed soil, waste and vent pipes in the building shall be genuine wrought iron.

6. Lead Pipe.

Lead pipe shall be of the weight known as "Strong" lead pipe. All water supply pipes 2½ inches or smaller, located below ground, shall be lead pipe.

7. Brass Pipe.

All exposed supply or waste pipe to fixtures, including connections to faucets, etc., shall be nickel plated brass, unless otherwise specified.

Brass pipe for water supply shall be seamless drawn semi-annealed brass pipe of iron pipe sizes, heavily nickel plated. Brass pipe fittings shall be heavy beaded cast brass heavily nickel plated.

8. Fixtures.

The Contractor shall furnish and install complete, in proper working order, the following fixtures, locations of which are shown on the drawings. Fixtures shall be as manufactured by ....

or approved equal, and shall conform to the typical types of fixtures, shown in Appendix "A" of this specification.

List of Fixtures

....

....

....

9. Joints and Connections.

Joints for cast iron pipe shall be made with picked oakum and molten lead, and shall be air and water tight. Twelve ounces of lead shall be used for each inch of diameter of pipe for each joint. Each joint must be filled at one pouring.

Connections between iron and lead pipes shall be made with brass ferrules and neatly wiped joints. Connections between outlet of fixtures and vertical soil pipes may be made by means of sanitary tees, but all connections between horizontal runs must be made by means of "Y" branches. Openings for connections shall be closed with plugs until tested. Hand holes shall be closed immediately upon completion of each portion of the work and all sewers kept clean.

10. Suspended Sewers and Risers.

All suspended sewers, wastes and downspouts, also risers in buildings, shall be genuine wrought iron pipe, and points of support shall not be more than five (5) feet apart for horizontal runs.

11. Drains.

The Contractor shall install the piping for all drains of every description, including all branches, traps and accessories necessary to make the plumbing system complete.

12. Valves.

In cases where there is danger of backwater from the sewer, all sewer and drain lines shall be equipped in the building with a backwater valve, properly set in a pit for accessibility. Shutoff valves throughout the plumbing system except in connection with fixtures shall be extra heavy gate valves, equipped with iron hand wheels. Valves 2 in. and under shall be brass of best quality, larger valves shall have iron bodies and brass trimmings. All valves shall be located in convenient and accessible places.

13. Sizes of Pipes.

The following shall be the minimum sizes of pipe for water supply in the cases listed:

Main supply to building	(...)
To toilet rooms	¾ in.
To individual sill cock	¾ in.
To individual sink	¾ in.
To individual urinal	½ in.
To individual lavatory	½ in.
To individual closet	½ in.
To heating boiler	¾ in.

Air chambers shall be provided in the water supply pipe at its connection to each fixture, to prevent water hammer. This chamber shall be equal, in capacity, to one foot of the supply pipe.

The minimum size of waste pipes for fixtures shall be as follows:

From individual closets	4 in.
From individual lavatories	1½ in.
From individual urinals	2 in.
From individual slop sinks	3 in.

The minimum sized vent pipes shall be as follows:

For closet traps	2 in.
For lavatory	1½ in.
For urinals	2 in.
For slop sinks	2 in.

14. Openings in Floors or Walls.

Wherever exposed plumbing pipes pass through floors or walls they shall be provided with galvanized iron pipe sleeves with nickel plated brass floor or ceiling plates. Wherever pipes pass through concrete or masonry, the contractor shall provide iron pipe sleeves of the requisite size, locating these for the masonry contractor, and assume all responsibility for their correct location.

15. Soil and Vent Stacks.

Main stacks shall be extended through roof of building and to a height not less than twelve inches (12") above the top thereof. Stacks extending through the roof must increase their diameter two (2) inches at a point six (6) inches below the roof. No stack extending through the roof shall be less than four (4) inches in diameter.

Fixtures shall be revented except in cases where but a single fixture is attached to a stack, in which case this fixture need not be revented. Vent fittings shall be combination fittings of a type that will comply with local ordinances. Branch vents shall be cast iron and must be connected into the main vent stack below the roof. That portion of the stack above the roof shall be properly flashed with four (4) pound sheet lead with fifteen-inch (15") square collar. Flashing shall be turned down into the top of stack, and shall be made watertight.

16. Meter, Pressure Regulator, Etc.

The Contractor shall install in a suitable concrete pit a water meter of an approved type, and make the necessary connection to the water main. Where the pressure in the main exceeds forty (40) pounds he shall install in connection with the meter a water pressure regulator of an approved type, properly adjusted to protect the fixtures in the building. Provide and set on the main supply line a stop and waste cock which will drain the entire piping system in the building. Provide in the pit with the meter a valve which will cut off the entire water supply from the building.

17. Traps and Cleanouts.

Approved traps with cleanouts, equipped with brass plugs, shall be placed under each fixture. Brass plugs for cleanouts shall be placed at the foot of each soil and waste riser above the floor and at all changes in direction of soil and waste pipes. Cleanouts connected below floors must be brought up level with floors by means of "Y" fittings and one-eighth (⅛) bends. All plugs must be full size of pipes.

18. Pipe Covering.

Hot water piping shall be covered with ¾-in. wool felt covering of an approved brand, lined with asbestos on the inside and covered with eight-ounce canvas jacket, banded with three (3) lacquered bands to each section.

Cold water pipe, in concealed positions, behind plastered walls or ceilings or carried in tunnels with steam or hot water heating pipes, shall be covered as described above, except that the lining shall be of tarred felt instead of asbestos. Fittings shall be covered with hair felt, with canvas jackets. All covering shall be applied in a manner to prevent sweating.

19. Slate Compartment Work.

The Contractor shall furnish and set all slate compartment work called for on drawings, complete, in accordance with details. Slate shall be black ribbed slate, of best quality. Trimmings, including coat hooks and toilet paper holders, shall be nickel-plated brass.

Doors for slate water closet stalls will be furnished and installed by carpenters, but hardware for same shall be furnished by the plumbing contractor. Doors for wooden closet stalls will be furnished and installed by carpenter, complete with hardware.

20. Tests.

The system shall be subject to the following test, to be made entirely at the expense of the Contractor:

After all pipes are "roughed in" and before the final connections are made with fixtures and sewer, all openings shall be closed and pipes filled with water to roof line. The water shall be maintained at this level until the job has been inspected and approved.

Should any defect appear, it shall be remedied and any defective material shall be replaced with sound material. After the water has been turned on and the traps filled, a peppermint test shall be made by placing two ounces of oil of peppermint in each stack. The system, with all traps full, must retain the peppermint odor from all parts of the building.

These tests shall be repeated until the work is approved by the Engineer.

21. Gas Piping.

The Contractor shall install piping for gas with outlets located where shown on drawings. The supply line shall be of a size recommended by Gas Company supplying the service and all piping shall meet the approval of the Gas Company. Pipes shall be coated with asphaltum after installation. A meter shall be installed as required by the rules of the Gas Company, with necessary valves and shutoff. Gas piping shall be tested as required by the Gas Company and certificate of inspection delivered to the Railway Company. The gas meter shall be placed in a convenient and accessible location.

22. Fire Protection.

The Contractor shall install, complete, all supply lines required for fire protection, including all connections to water main, and all fire hydrants and connections as indicated on the drawings or specified.

All pipe for outside fire protection lines shall conform to and be laid in accordance with the American Water Works Association Specifications for cast iron water pipe and special castings.

Where the size of fire lines is 6 in. or larger, 6-in. two-way standard hydrants equipped with drain and auxiliary valves shall be used. Where fire-fighting apparatus is to be provided inside the building, independent standpipes, 2½ in. or larger, shall be installed so as not to be more than 200 ft. apart on each floor. Each standpipe shall be equipped with a standard 2½-in. threaded hose connection located five (5) feet above the floor level. Each standpipe shall be provided with a 2½x1½-in. reducing coupler, an approved hose reel, or rack, together with hose, nozzle and couplings, as specified. Not more than 100 ft. of hose shall be provided for each connection, but the lengths must be such that every part of each floor may be reached.

Where buildings are heated Underwriters' 1½-in. linen hose must be used. Where buildings are not heated Underwriters' 1½-in. cotton rubber-lined hose must be used. Hose for outside use shall be Underwriters' approved 2½-in. double jacket fire hose.

Nozzles for outside hose shall be Underwriters' play pipe with 1⅛-in. orifice. Each hose inside of buildings shall be equipped with a brass nozzle 12 in. long, with a ½-in. orifice.

All fire-fighting apparatus shall be in conformity with the requirements of the National Board of Fire Underwriters. It shall also conform to the requirements of the Local Fire Department so far as hose connections are concerned.

23. Local Rules and Ordinances.

The Contractor shall comply in all cases with the local sanitary, gas and fire protection ordinances, and shall obtain and pay for all permits and inspection fees.

24. 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 Section 1 of this specification shall be considered to apply with equal force to this section of the specifications.

The Committee offers as information the following types of plumbing fixtures for guidance in use of these plumbing specifications to be used as Appendix "A," referred to in paragraph 8, Fixtures.

TYPICAL PLUMBING FIXTURES
FOR
RAILWAY BUILDINGS
APPENDIX A
SUPPLEMENTING PLUMBING SPECIFICATIONS

TYPICAL PLUMBING FIXTURES

INDEX

Lavatory No. 1 - Enameled Cast Iron Wall Type
Lavatory No. 2 - Enameled Cast Iron Corner Type
Lavatory No. 3 - Vitreous Wall Type
Lavatory No. 4 - Vitreous Corner Wall Type
Lavatory No. 5 - Double Battery Type
Closet No. 1 - Syphon Jet Seat Operating Flush Valve Type
Closet No. 2 - Syphon Jet Seat Operating Type
Closet No. 3 - Wash Down Jet Seat Operating Type
Closets No. 4&5 - Frost Proof Types
Closet Stall No. 1 - Slate Type Without Doors
Closet Stall No. 2 - Slate Type With Doors
Closet Stall No. 3 - Wood Type With Doors.
Urinal No. 1 - Floor Type
Urinal No. 2 - Automatic Trough Type
Urinal No 3 - Automatic One Piece Trough Type
Urinal No. 4 - Syphon Jet Vitreous Type
Drinking Fountain No. 1 - Pedestal Type
Drinking Fountain No 2 - Wall Type
Slop Sink With Back.

ENAMELED IRON ROLL RIM CORNER LAVATORY OF FORM AND DIMENSIONS AS SHOWN ON THIS DRAWING & EQUIPPED AS FOLLOWS

Cast Iron Lavatory enameled inside and painted outside, having Slab Back Bowl and overflow integral

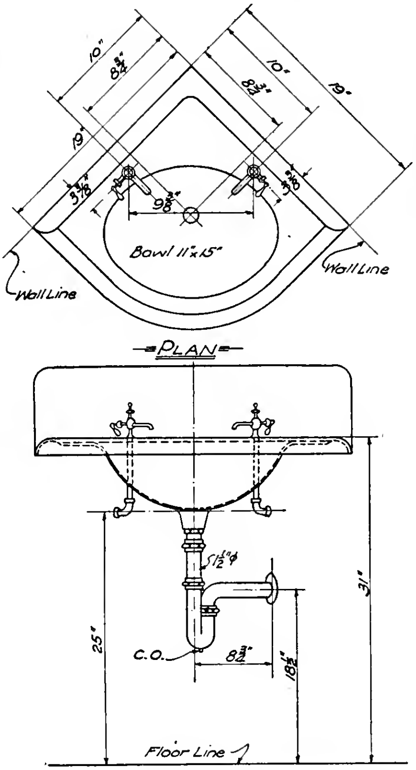
Concealed Galvanized Iron Wall Hangers.

2 - Nickel Plated Fuller Faucets

2 - Crawford Connections

1-1½" Nickel Plated "P" Trap No Vent.

1 – 1½" Sweat Bushing



FRONT ELEVATION

For use in Section Houses
Less Important Stations,
Freight Rooms, and Offices
and Shops

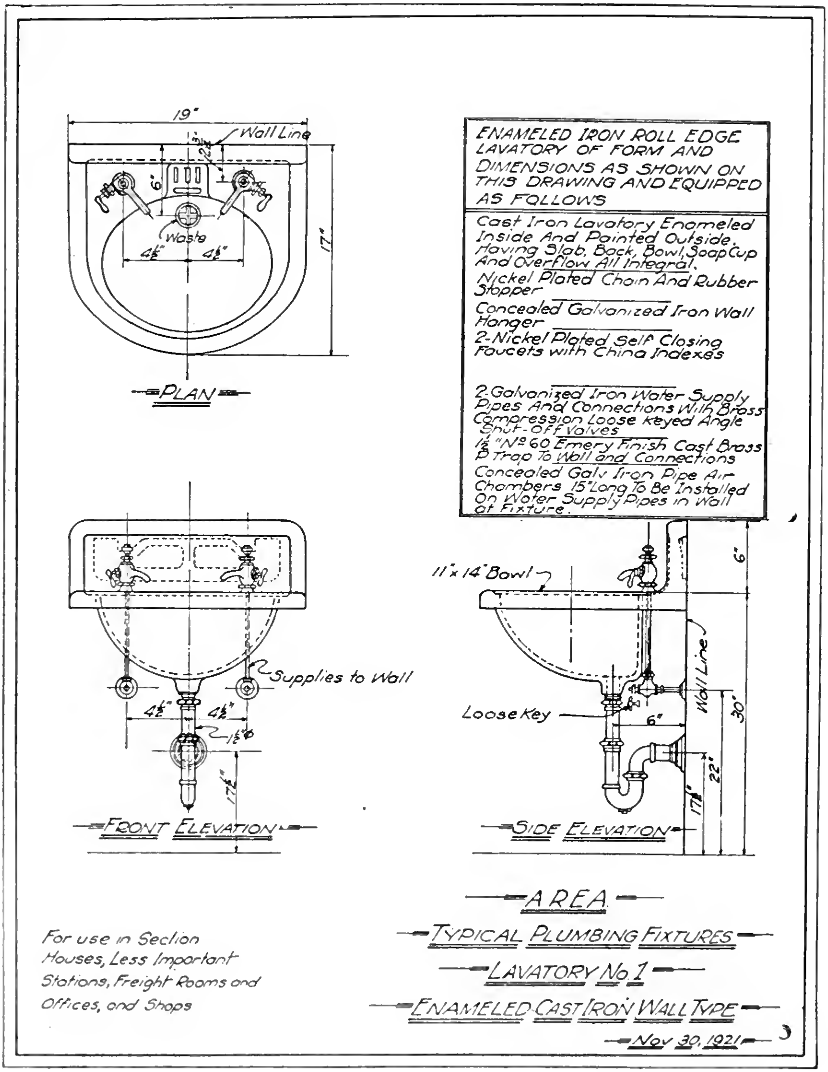
A.R.E.A.

TYPICAL PLUMBING FIXTURES

LAVATORY No. 2

ENAMELED CAST IRON CORNER TYPE

Nov 30, 21.



ENAMELED IRON ROLL EDGE LAVATORY OF FORM AND DIMENSIONS AS SHOWN ON THIS DRAWING AND EQUIPPED AS FOLLOWS

Cast Iron Lavatory Enameled Inside And Painted Outside. Having Slab, Back, Bowl, Soap Cup And Overflow All Integral.

Nickel Plated Chain And Rubber Stopper

Concealed Galvanized Iron Wall Hanger

2-Nickel Plated Self Closing Faucets with China Indexes

2-Galvanized Iron Water Supply Pipes And Connections With Brass Compression Loose keyed Angle Shut-Off Valves

1½" Nº 60 Emery Finish Cast Brass P Trap To Wall and Connections

Concealed Galv Iron Pipe Air Chambers 15" Long To Be Installed On Water Supply Pipes in Wall at Fixture.

For use in Section Houses, Less Important Stations, Freight Rooms and Offices, and Shops

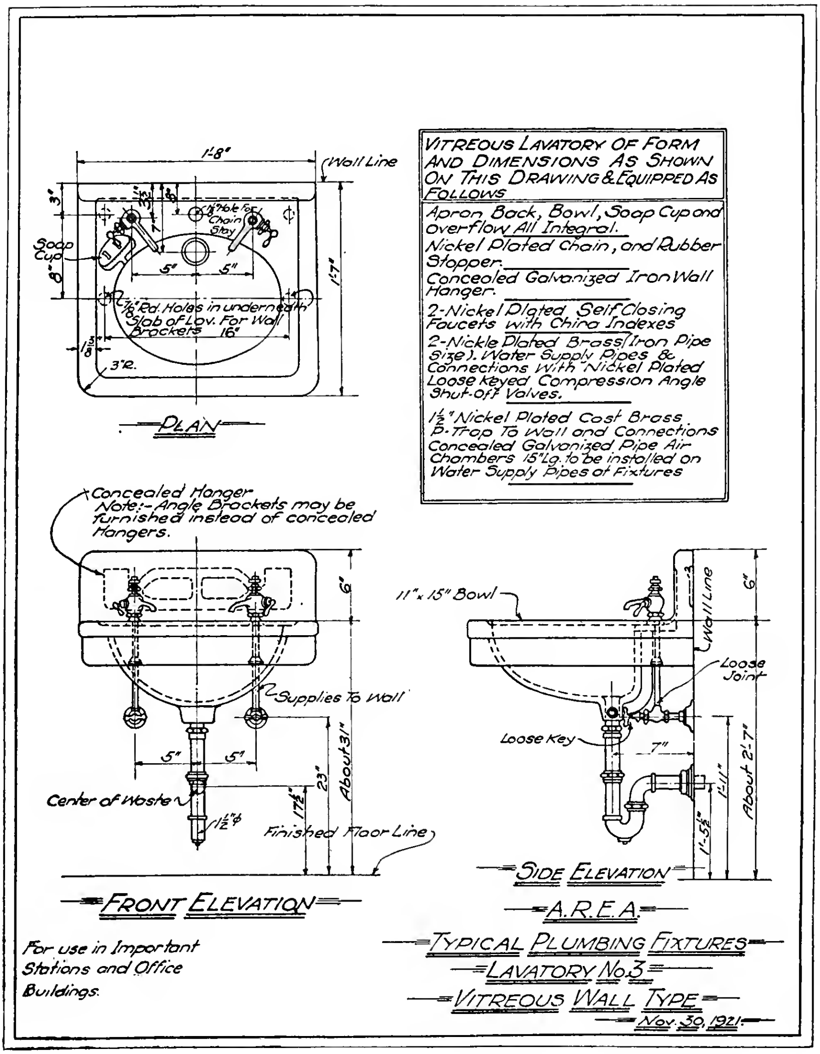
AREA

TYPICAL PLUMBING FIXTURES

LAVATORY No. 1

ENAMELED CAST IRON WALL TYPE

Nov 30, 1921



VITREOUS LAVATORY OF FORM AND DIMENSIONS AS SHOWN ON THIS DRAWING & EQUIPPED AS FOLLOWS

Apron Back, Bowl, Soap Cup and Overflow All Integral.

Nickel Plated Chain, and Rubber Stopper.

Concealed Galvanized Iron Wall Hanger.

2-Nickel Plated Self Closing Faucets with China Indexes

2-Nickle Plated Brass (Iron Pipe Size). Water Supply Pipes & Connections With Nickel Plated Loose Keyed Compression Angle Shut-Off Valves.

1½" Nickel Plated Cast Brass P-Trap To Wall and Connections Concealed Galvanized Pipe Air Chambers 15" Lg. to be installed on Water Supply Pipes of Fixtures

For use in Important Stations and Office Buildings.

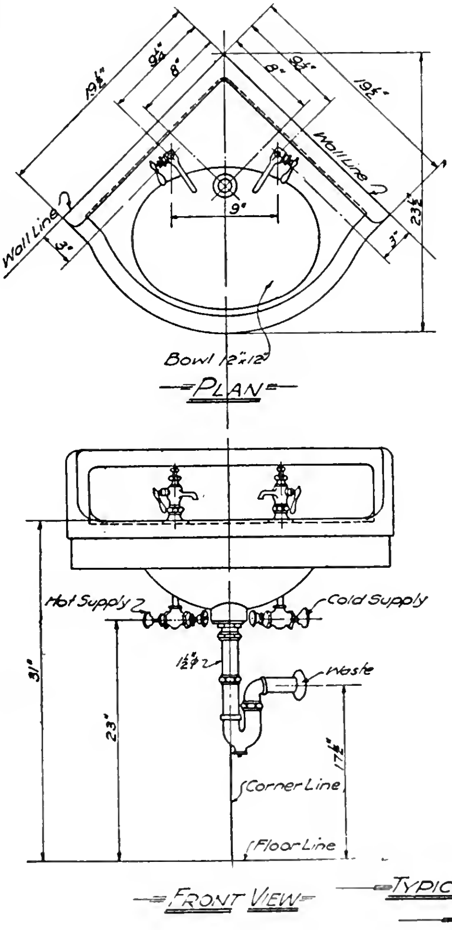
A.R.E.A.

TYPICAL PLUMBING FIXTURES

LAVATORY No. 3

VITREOUS WALL TYPE

Nov. 30, 1921.



VITREOUS CORNER LAVATORY OF FORM AND DIMENSIONS AS SHOWN ON THIS DRAWING AND EQUIPPED AS FOLLOWS

Vitreous Corner Lavatory with Apron 6" high Back and integral overflow

Concealed Galvanized Iron Hanger

Two Nickel Plated Self Closing Basin Cocks

Two ⅜" Nickel-Plated Supplies to Wall. with Wheel Handle Stop Valves.

1½" Nickel Plated Cast Brass "P" Trap.

One — 1½" Sweat Bushing

Plug and Chain

For use in Important Stations and Office Buildings

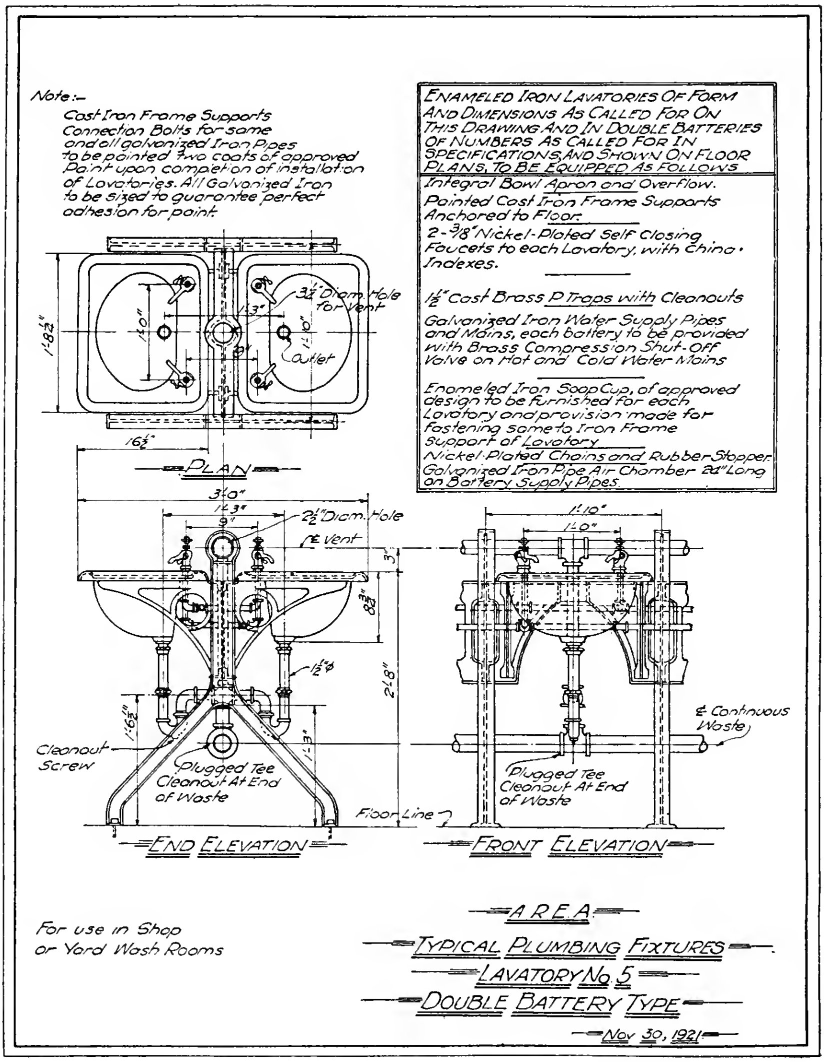
AREA

TYPICAL PLUMBING FIXTURES

LAVATORY No. 4

VITREOUS CORNER WALL TYPE

Nov 30, 1921



Note:—
Cast Iron Frame Supports
Connection Bolts for same
and all galvanized Iron Pipes
to be painted two coats of approved
Paint upon completion of installation
of Lavatories. All Galvanized Iron
to be sized to guarantee perfect
adhesion for paint.

ENAMELED IRON LAVATORIES OF FORM AND DIMENSIONS AS CALLED FOR ON THIS DRAWING AND IN DOUBLE BATTERIES OF NUMBERS AS CALLED FOR IN SPECIFICATIONS, AND SHOWN ON FLOOR PLANS, TO BE EQUIPPED AS FOLLOWS

Integral Bowl Apron and Overflow.

Painted Cast Iron Frame Supports Anchored to Floor.

2-3/8" Nickel-Plated Self Closing Faucets to each Lavatory, with China Indexes.

1½" Cast Brass P Traps with Cleanouts

Galvanized Iron Water Supply Pipes and Mains, each battery to be provided with Brass Compression Shut-Off Valve on Hot and Cold Water Mains

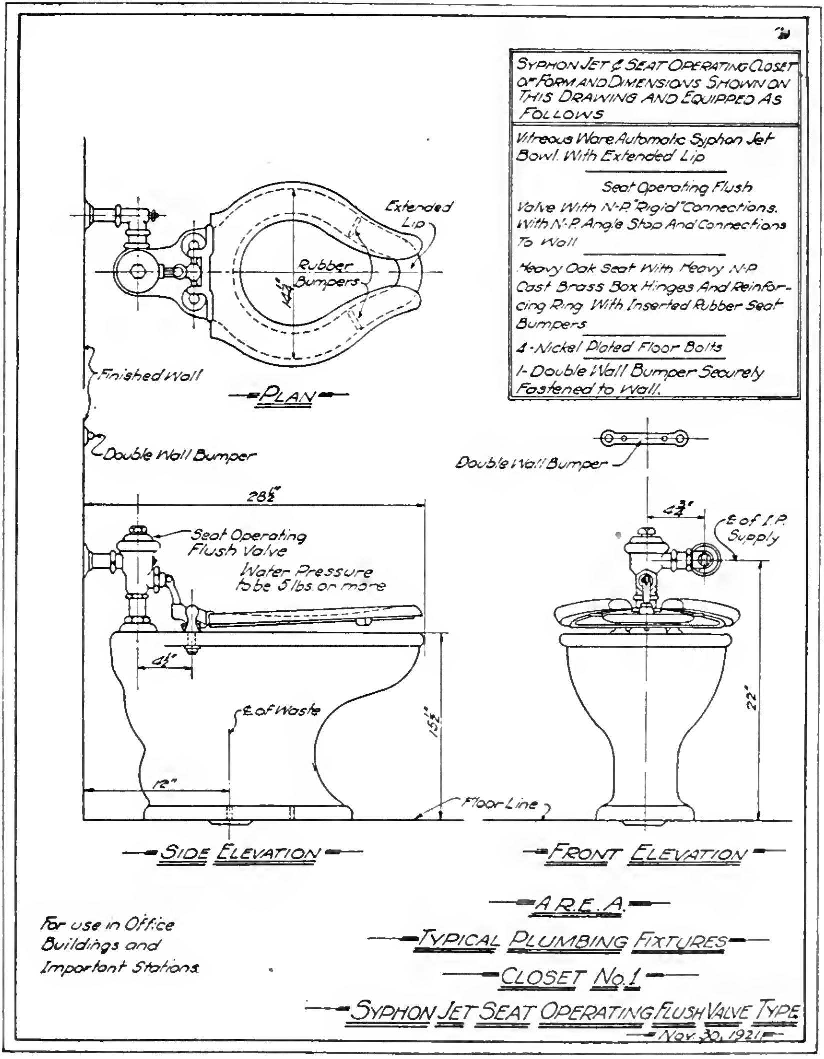
Enameled Iron Soap Cup, of approved design to be furnished for each Lavatory and provision made for fastening same to Iron Frame Support of Lavatory

Nickel-Plated Chains and Rubber Stopper.

Galvanized Iron Pipe Air Chamber 24" Long on Battery Supply Pipes.

For use in Shop
or Yard Wash Rooms

AREA
TYPICAL PLUMBING FIXTURES
LAVATORY No. 5
DOUBLE BATTERY TYPE
Nov 30, 1921



SYPHON JET & SEAT OPERATING CLOSET OF FORM AND DIMENSIONS SHOWN ON THIS DRAWING AND EQUIPPED AS FOLLOWS

Vitreous Ware Automatic Syphon Jet Bowl. With Extended Lip

Seat Operating Flush Valve With N-P. "Rigid" Connections. With N-P. Angle Stop And Connections To Wall

Heavy Oak Seat With Heavy N-P Cast Brass Box Hinges And Reinforcing Ring With Inserted Rubber Seat Bumpers

4-Nickel Plated Floor Bolts

1-Double Wall Bumper Securely Fastened to Wall.

For use in Office Buildings and Important Stations

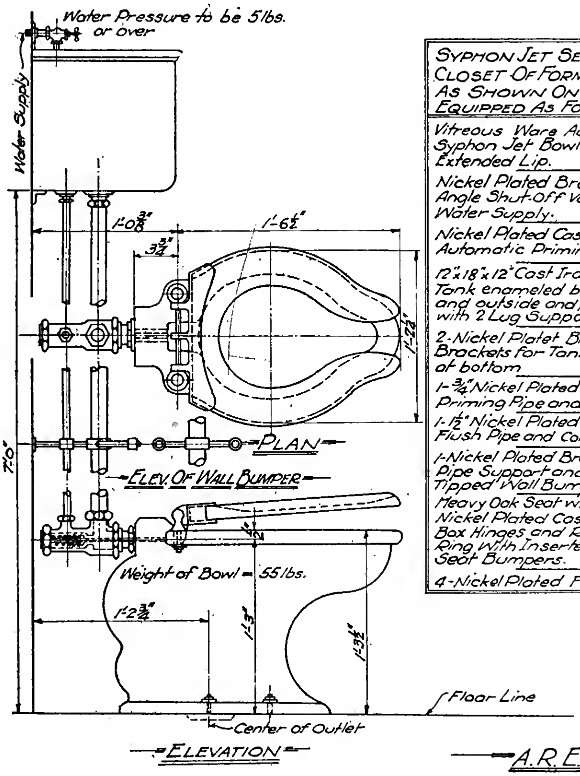
A.R.E.A.

TYPICAL PLUMBING FIXTURES

CLOSET No. 1

SYPHON JET SEAT OPERATING FLUSH VALVE TYPE

Nov. 30, 1921



SYPHON JET SEAT OPERATING CLOSET OF FORM & DIMENSION AS SHOWN ON THIS DRAWING & EQUIPPED AS FOLLOWS

Vitreous Ware Automatic Syphon Jet Bowl with Extended Lip.

Nickel Plated Brass Compression Angle Shut-Off Valve for Water Supply.

Nickel Plated Cast Brass Automatic Priming Valve.

12"x18"x12" Cast Iron Flush Tank enameled both inside and outside and provided with 2 Lug Supports at top.

2-Nickel Platet Brass Angle Brackets for Tank Support at bottom

1-¾" Nickel Plated Brass Priming Pipe and Connections

1-1½" Nickel Plated Brass Flush Pipe and Connections

1-Nickel Plated Brass Combination Pipe Support and Twin Rubber Tipped Wall Bumper

Heavy Oak Seat with Heavy Nickel Plated Cast Brass Box Hinges and Reinforcing Ring With Inserted Rubber Seat Bumpers.

4-Nickel Plated Floor Bolts

For use in Office Buildings and Important Stations

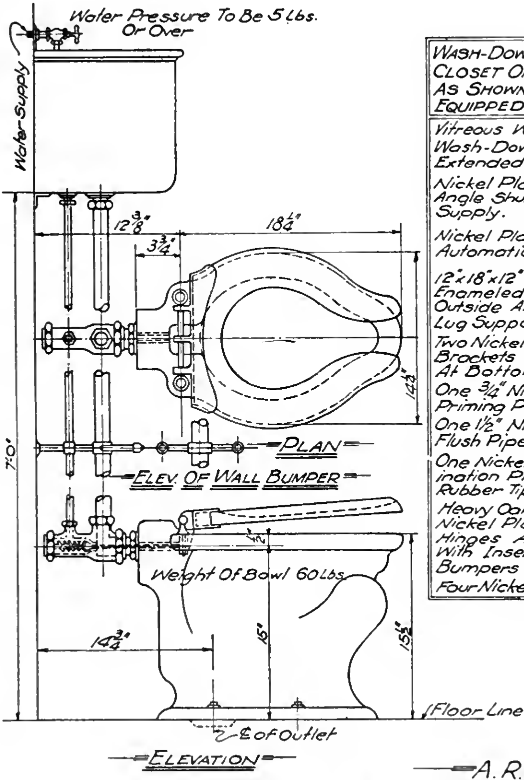
A.R.E.A.

TYPICAL PLUMBING FIXTURES

CLOSET No. 2

SYPHON JET SEAT OPERATING TYPE

Nov. 30, 21.



WASH-DOWN JET SEAT OPERATING CLOSET OF FORM & DIMENSION AS SHOWN ON THIS DRAWING & EQUIPPED AS FOLLOWS.

Vitreous Ware Automatic Wash-Down-Jet Bowl With Extended Lip.

Nickel Plated Brass Compression Angle Shut Off Valve For Water Supply.

Nickel Plated Cast Brass. Automatic Priming Valve.

12"x18"x12" Cast Iron Flush Tank Enameled Both Inside And Outside And Provided With Two Lug Supports At Top.

Two Nickel Plated Brass Angle Brackets For Tank Support At Bottom.

One 3/4" Nickel Plated Brass Priming Pipe & Connections.

One 1 1/2" Nickel Plated Brass Flush Pipe & Connections.

One Nickel Plated Brass Combination Pipe Support And Twin Rubber Tipped Wall Bumper

Heavy Oak Seat With Heavy Nickel Plated Cast Brass Box Hinges And Reinforcing Ring With Inserted Rubber Seat Bumpers

Four Nickel Plated Floor Bolts

For use in Freight Rooms,
Freight Offices, Shops and
Less Important Stations

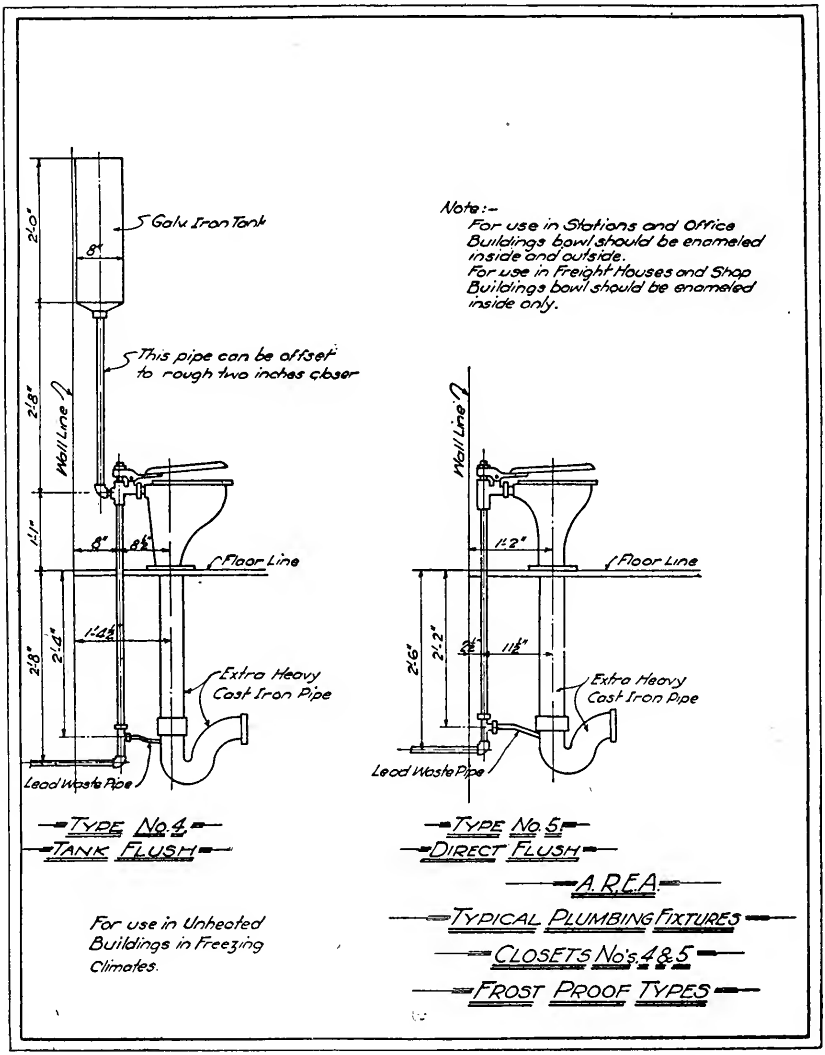
A. R. E. A.

TYPICAL PLUMBING FIXTURES

CLOSET No. 3.

WASH-DOWN-JET SEAT OPERATING TYPE

Nov. 30, 1921



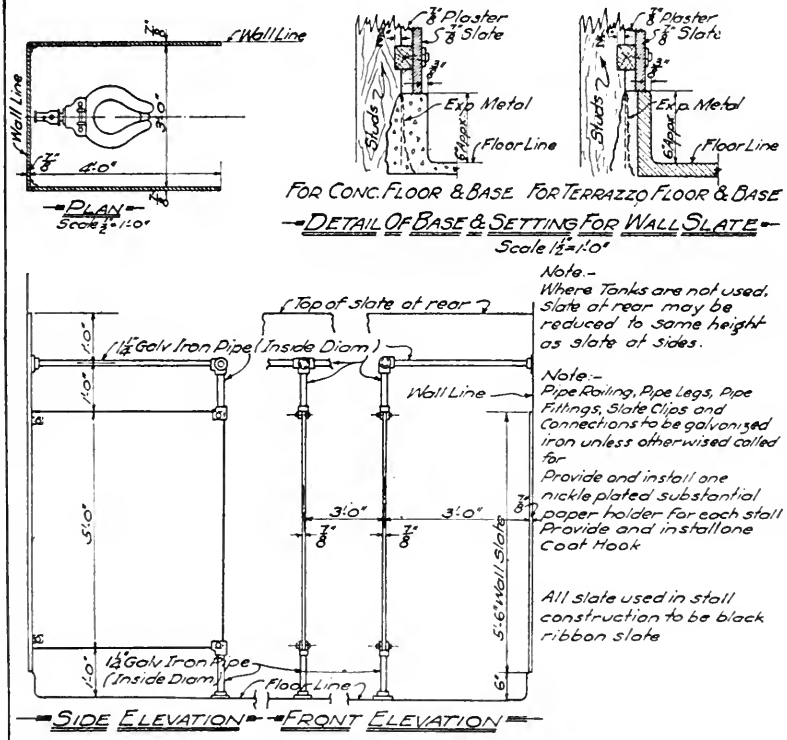
Note:-
For use in Stations and Office Buildings bowl should be enameled inside and outside.
For use in Freight Houses and Shop Buildings bowl should be enameled inside only.

TYPE No. 4
TANK FLUSH

TYPE No. 5
DIRECT FLUSH

For use in Unheated Buildings in Freezing Climates.

A.R.E.A.
TYPICAL PLUMBING FIXTURES
CLOSETS No's. 4 & 5
FROST PROOF TYPES



Note.— Where Tanks are not used, slate at rear may be reduced to same height as slate at sides.

Note:— Pipe Railing, Pipe Legs, Pipe Fittings, Slate Clips and Connections to be galvanized iron unless otherwised called for

Provide and install one nickle plated substantial paper holder for each stall

Provide and install one Coat Hook

All slate used in stall construction to be black ribbon slate

For use in Shop and Yard Toilet Buildings and Ware Room Portion of Freight Houses

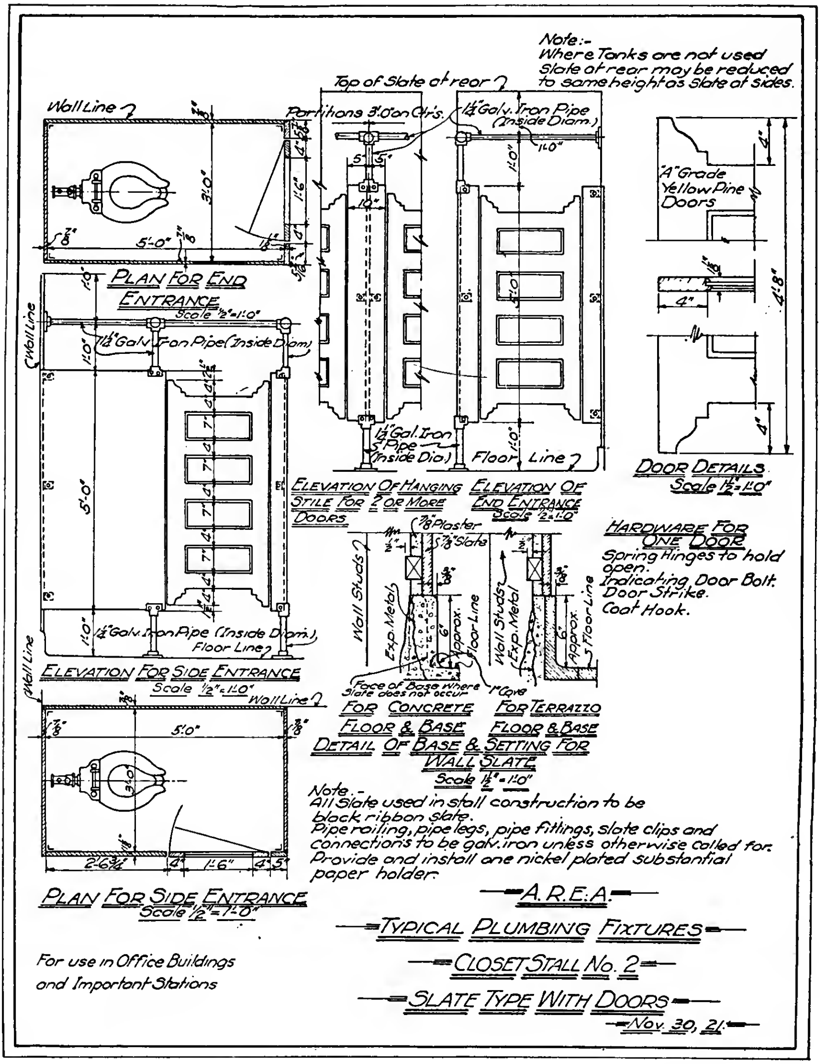
A.R.E.A.

TYPICAL PLUMBING FIXTURES

CLOSET STALL No. 1

SLATE TYPE WITHOUT DOORS

Nov. 30, 1921



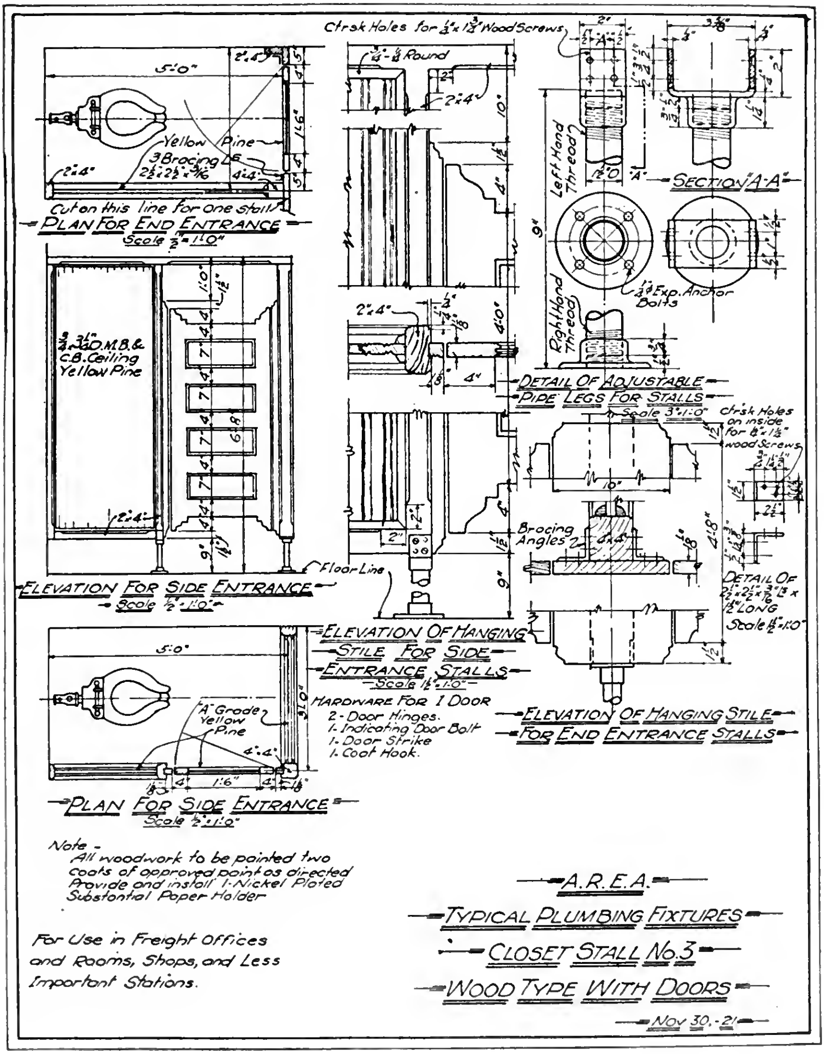
Note:- Where Tanks are not used Slate at rear may be reduced to same height as Slate of sides.

HARDWARE FOR ONE DOOR
Spring Hinges to hold open.
Indicating Door Bolt.
Door Strike.
Coat Hook.

Note.- All Slate used in stall construction to be black ribbon slate.
Pipe railing, pipe legs, pipe fittings, slate clips and connections to be galv. iron unless otherwise called for.
Provide and install one nickel plated substantial paper holder.

For use in Office Buildings and Important Stations

A.R.E.A.
TYPICAL PLUMBING FIXTURES
CLOSET STALL No. 2
SLATE TYPE WITH DOORS
Nov. 30, 21.

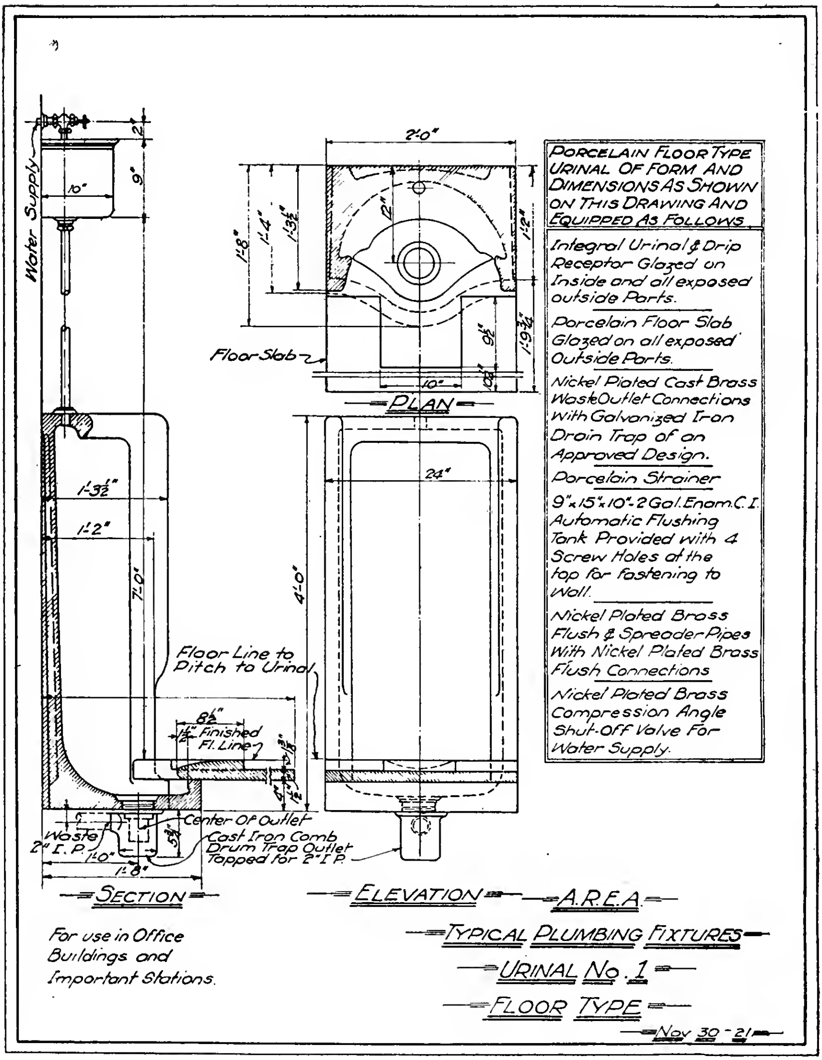


HARDWARE FOR 1 DOOR
2-Door Hinges.
1-Indicating Door Bolt
1-Door Strike
1-Coat Hook.

Note -
All woodwork to be painted two coats of approved paint as directed
Provide and install 1-Nickel Plated Substantial Paper Holder

For Use in Freight Offices and Rooms, Shops, and Less Important Stations.

A.R.E.A.
TYPICAL PLUMBING FIXTURES
CLOSET STALL No. 3
WOOD TYPE WITH DOORS
Nov 30-21



PORCELAIN FLOOR TYPE URINAL OF FORM AND DIMENSIONS AS SHOWN ON THIS DRAWING AND EQUIPPED AS FOLLOWS.

Integral Urinal & Drip Receptor Glazed on Inside and all exposed outside Parts.

Porcelain Floor Slab Glazed on all exposed Outside Parts.

Nickel Plated Cast Brass Waste Outlet Connections With Galvanized Iron Drain Trap of an Approved Design.

Porcelain Strainer

9"x15"x10"-2 Gal. Enam. C.I. Automatic Flushing Tank Provided with 4 Screw Holes at the top for fastening to Wall.

Nickel Plated Brass Flush & Spreader Pipes With Nickel Plated Brass Flush Connections

Nickel Plated Brass Compression Angle Shut-Off Valve For Water Supply.

For use in Office Buildings and Important Stations.

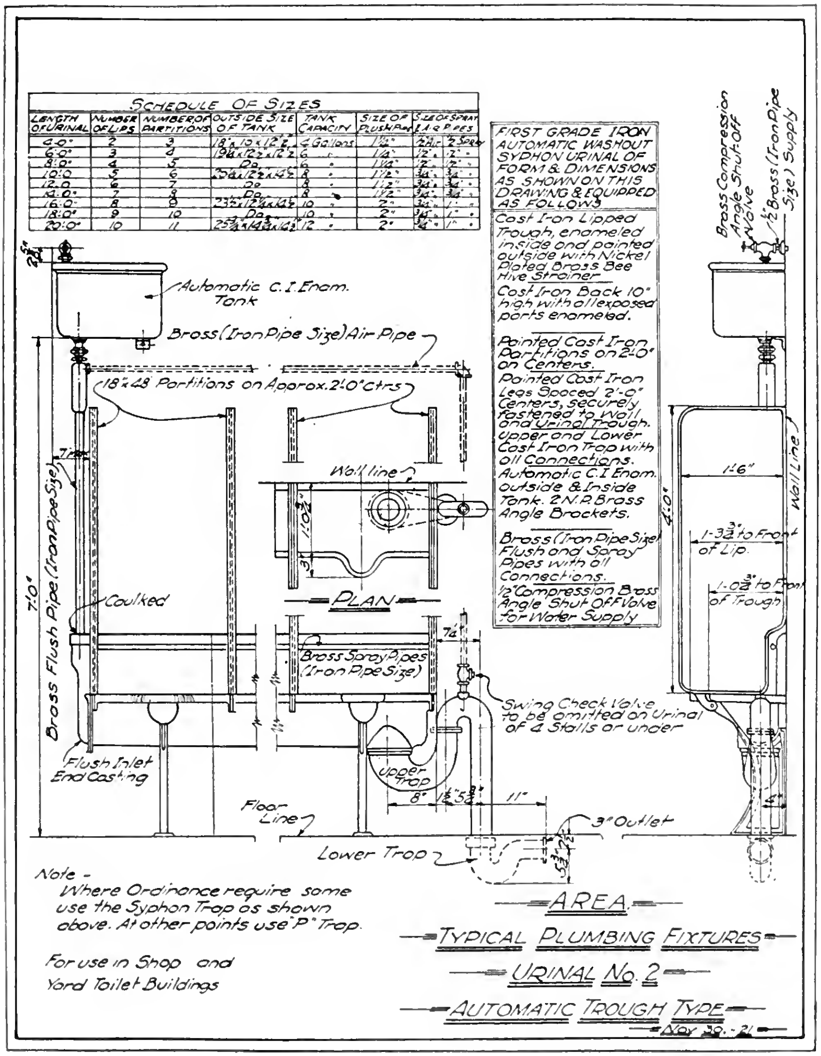
A.R.E.A.

TYPICAL PLUMBING FIXTURES

URINAL No. 1

FLOOR TYPE

Nov 30-21



SCHEDULE OF SIZES

LENGTH OF URINAL	NUMBER OF LIPS	NUMBER OF PARTITIONS	OUTSIDE SIZE OF TANK	TANK CAPACITY	SIZE OF FLUSH PIPE	SIZE OF SPRAY & AIR PIPES	
4'-0"	2	3	18" x 10 x 12½"	4 Gallons	1¼"	½ Air	½ Spray
6'-0"	3	4	19¼ x 12½ x 12½	6 "	1¼"	½ "	½" "
8'-0"	4	5	Do.	6 "	1¼"	½ "	½" "
10'-0	5	6	25¼ x 12½ x 14½	8 "	1½"	¾ "	¾" "
12'-0	6	7	Do.	8 "	1½"	¾ "	¾" "
14'-0"	7	8	Do.	8 "	1½"	¾ "	¾" "
16'-0"	8	9	23½ x 12¼ x 14½	10 "	2"	¾ "	1" "
18'-0"	9	10	Do.	10 "	2"	¾ "	1" "
20'-0"	10	11	25¾ x 14¾ x 16½	12 "	2"	¾ "	1" "

FIRST GRADE IRON AUTOMATIC WASHOUT SYPHON URINAL OF FORM & DIMENSIONS AS SHOWN ON THIS DRAWING & EQUIPPED AS FOLLOWS

Cast Iron Lipped Trough, enameled inside and painted outside with Nickel Plated Brass Bee Hive Strainer

Cast Iron Back 10" high with all exposed parts enameled.

Painted Cast Iron Partitions on 2'-0" on Centers.

Painted Cast Iron Legs Spaced 2'-0" Centers, securely fastened to Wall and Urinal Trough.

Upper and Lower Cast Iron Trap with all Connections.

Automatic C. I. Enam. outside & Inside Tank. 2 N. P. Brass Angle Brackets.

Brass (Iron Pipe Size) Flush and Spray Pipes with all Connections.

½" Compression Brass Angle Shut Off Valve for Water Supply

Note -
Where Ordinance require same use the Syphon Trap as shown above. At other points use "P" Trap.

For use in Shop and Yard Toilet Buildings

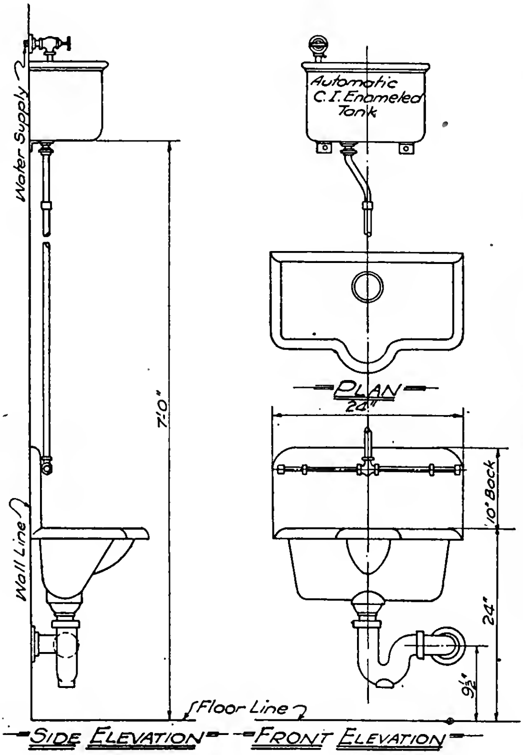
AREA

TYPICAL PLUMBING FIXTURES

URINAL No. 2

AUTOMATIC TROUGH TYPE

Nov. 30.-21



FIRST GRADE CAST IRON AUTOMATIC FLUSHING ROLL-RIM URINAL OF FORM AND DIMENSIONS AS SHOWN ON THIS DRAWING AND EQUIPPED AS FOLLOWS.

Cast Iron Lipped Trough Enameled Inside And Painted Outside With Integral Back Having All Exposed Parts Enameled.

Nickel Plated Brass Bee Hive Strainer.

Concealed Galvanized Iron Wall Supports For Urinal.

2" Painted Cast Iron "P" Trap To Wall With Clean out.

18"x10"x12½" Automatic C.I. Enameled outside and inside Tank, 2" N.P. Brass Angle Brackets.

½" Compression Nickel Plated Brass Angle Shut Off Valve for Water Supply.

1¼" Nickel Plated Brass (Iron Pipe Size) Flush Pipe And Connections.

½" Nickel Plated Brass (Iron Pipe Size) Spreader With Nickel Plated Brass Caps And Connections.

For use in Freight Offices, Freight Rooms, Shops, and less important Stations.

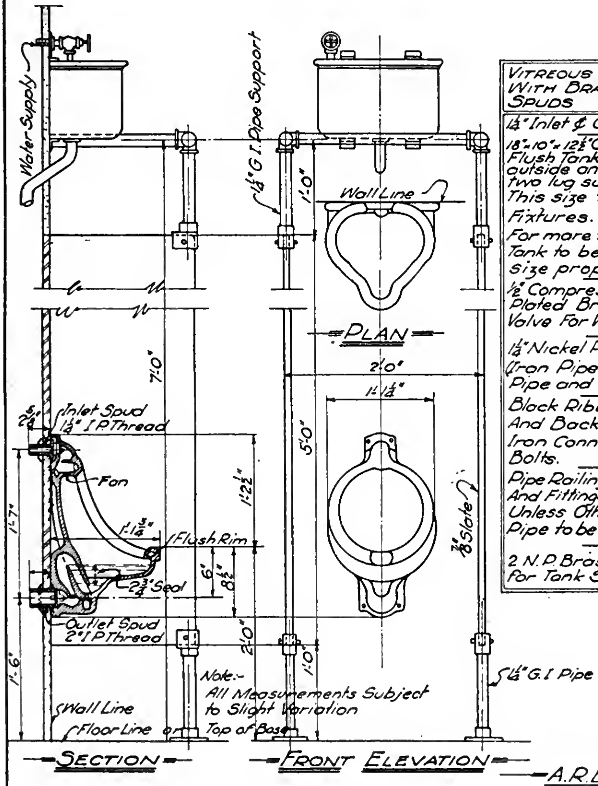
A.R.E.A.

TYPICAL PLUMBING FIXTURES

URINAL No. 3

AUTOMATIC ONE PIECE TROUGH TYPE

Nov. 30, 1921.



VITREOUS SYPHON JET URINAL WITH BRASS INLET & OUTLET SPUDS

1¼" Inlet & Outlet

18"×10"×12½" Cast Iron Automatic Flush Tank. Enameled inside and outside and provided with two lug supports at top This size tank for 1 to 3 Fixtures.

For more than 3 fixtures Tank to be Increased in size proportionately.

½" Compression Nickel Plated Brass Angle Shut-Off Valve For Water Supply.

1¼" Nickel Plated Brass (Iron Pipe Size) offset Flush Pipe and Connections

Black Ribbon Slate Partitions And Back, with Galvanized Iron Connecting Clips and Bolts.

Pipe Railing, Legs, Rail Over Top And Fittings, to be Galv. Iron Unless Otherwise called for. Pipe to be 1¼" inside diameter.

2 N.P. Brass Angle Brackets for Tank Support at bottom.

For use in Freight Offices, Freight Rooms, Shops, and less important Stations.

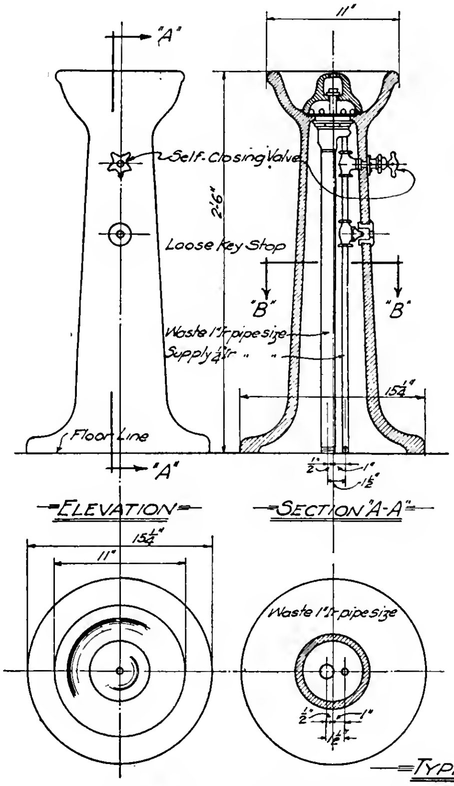
A.R.E.A.

TYPICAL PLUMBING FIXTURES

URINAL No. 4

SYPHON JET VITREOUS TYPE

Nov. 30,-21



ELEVATION

SECTION "A-A"

PLAN

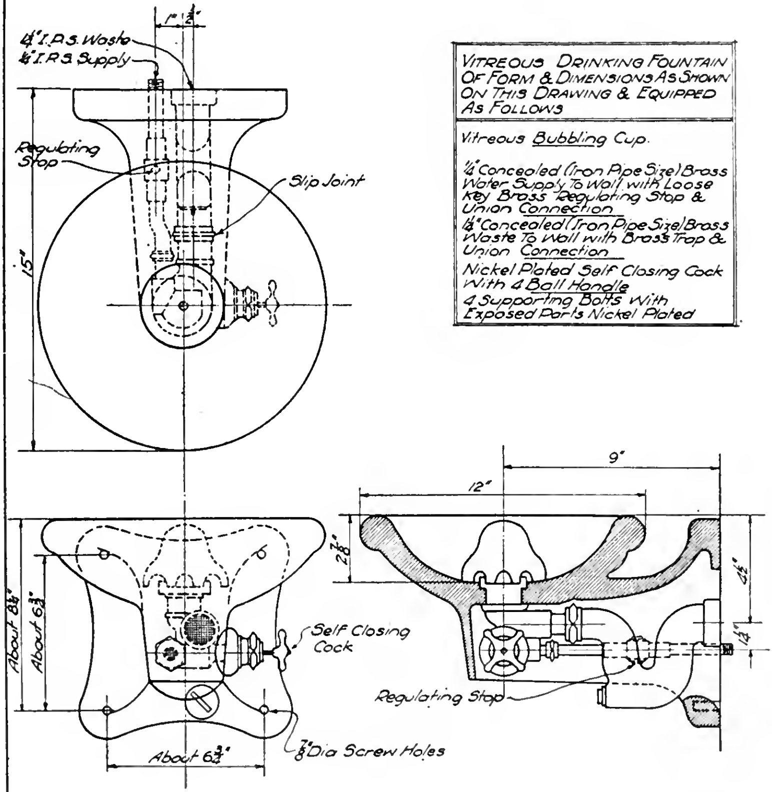
SECTION "B-B"

For use in Office
Buildings and
Stations.

VITREOUS PEDESTAL SANITARY
DRINKING FOUNTAIN, WITH
VITREOUS CHINA BUBBLING CUP

Constructed of One Piece thruout and Glazed all over with White Vitreous Glazing with Waste and Supply concealed, fitted with Waste and Supply Pipe from Bowl to Floor; the water supply being carried to the Fountain below the floor line and operated by Self-Closing Cock set at a convenient point.
Fountain is fitted with a loose Key Valve to control flow of water

AREA
TYPICAL PLUMBING FIXTURES
DRINKING FOUNTAIN No. 1
PEDESTAL TYPE
Nov. 30, 21.



VITREOUS DRINKING FOUNTAIN OF FORM & DIMENSIONS AS SHOWN ON THIS DRAWING & EQUIPPED AS FOLLOWS

Vitreous Bubbling Cup.

¼" Concealed (Iron Pipe Size) Brass Water Supply To Wall with Loose Key Brass Regulating Stop & Union Connection

1¼" Concealed (Iron Pipe Size) Brass Waste To Wall with Brass Trap & Union Connection

Nickel Plated Self Closing Cock With 4 Ball Handle

4 Supporting Bolts With Exposed Parts Nickel Plated

For use in Office
Buildings and
Stations

A.R.E.A.

TYPICAL PLUMBING FIXTURES

DRINKING FOUNTAIN No. 2

WALL TYPE

Nov 30,-21.

FIRST GRADE ROLL RIM IRON SLOP SINK OF FORM & DIMENSIONS AS SHOWN ON THIS DRAWING AND EQUIPPED AS FOLLOWS

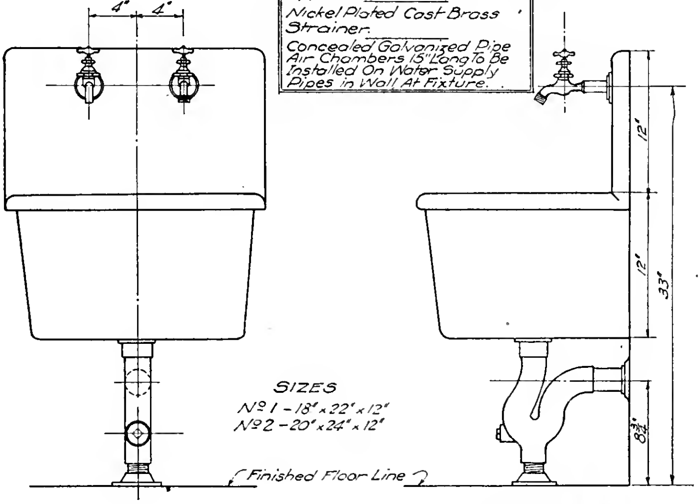
Cast Iron Slop Sink Enameled Inside And Painted Outside With Sink And Deep Roll Back Integral.

2-5/8" Nickel Plated Compression Faucets With Stuffing Boxes And Integral Flanged Shanks, Threaded For Iron Pipe.

3" Adjustable Cast Iron Trap to Wall. Enameled Inside With 3" Outlet. Tapped For Iron Pipe

Nickel Plated Cast Brass Strainer.

Concealed Galvanized Pipe Air Chambers 15" Long To Be Installed On Water Supply Pipes in Wall At Fixture.



SIZES
Nº 1 - 18" x 22" x 12"
Nº 2 - 20" x 24" x 12"

AREA.

TYPICAL PLUMBING FIXTURES

SLOP SINK WITH BACK

Nov 30, -21

SPECIFICATIONS FOR RAILWAY BUILDINGS

SECTION 19

Heating

(a) Hot Water Heating System, Two-Pipe Gravity.
(b) Steam Heating System, One-Pipe Gravity.
(c) Steam Heating System, Two-Pipe Gravity.

1. General (Water and Steam).

Heating work to be done under this contract shall consist of furnishing and installing a heating system complete as hereinafter described.

2a. Checking of Drawings. (Water or Steam.)

The Contractor shall check all drawings and must report all discrepancies before starting the work. No allowances will be made by the Company for errors or discrepancies discovered by the Contractor after the work has been started.

3a. Laying Out Work. (Water or Steam.)

All dimensions on drawings shall be verified at the site of the work by the Contractor and he shall assume all responsibility for their accuracy.

4a. System (Water).

The system of heat transmission to be used will consist of a two-pipe gravity hot water heating system, complete in all details, whether specifically mentioned or not.

Direct radiation to be used at all points and in such units as are shown on drawings.

4b. System (Steam).

The system of heat transmission to be used will consist of a $\substack{\text{one-}\\ \text{two-}}$pipe low pressure steam heating system, complete in all details, whether specifically mentioned or not, steam being circulated to all parts of the building and condensation brought back to the boiler under gravity conditions. No mechanical device of any kind shall be used to aid circulation. Direct radiation is to be used at all points and in such units as are shown on drawing.

5a. Boiler (Water).

The Contractor shall furnish and install in boiler room where shown on drawing....................one (1)............................, as manufactured by the..or equal.

The boiler shall be provided with all necessary castings, doors, shaking grates, firing and cleaning tools, etc., ready for operation.

Grates shall be furnished to enable...............to be used as fuel.

The Contractor shall also furnish the following:

One high duty direct contact thermometer for registering the temperature of water; this thermometer to have white enamel face and red liquid. One altitude gauge for registering the proper height of the water in the expansion tank.

One "Syphon" water regulator or equal of required size for correct temperature control.

The Contractor shall also make necessary connection to the water supply where found in the building and shall provide draw-off valves to enable the system to be drained.

The boiler shall be covered with a covering of approved make, as outlined in paragraph No. 17 of these specifications, unless otherwise specified.

This boiler is to be tested for any defects in castings before any covering is applied. Boiler shall be installed in accordance with manufacturer's specifications.

5b. Boiler (Steam).

The Contractor shall furnish and install in boiler room where shown on drawing...............one (1)......................................
as manufactured by the....................................or equal.

The boiler shall be provided with all necessary castings, doors, shaking grates, firing and cleaning tools, etc., ready for operation.

Grates shall be furnished to enable................to be used as fuel. The boiler shall be furnished with approved type of steam gauge with syphon safety valve of sufficient capacity to take care of boiler, also water gauge and gauge cocks.

For correct regulation, this boiler shall be equipped with a "Syphon" steam regulator or equal.

The Contractor shall also make necessary connection to the water supply where found in the building, and shall provide draw-off valves to enable the system to be drained.

The boiler shall be covered with a covering of approved make as outlined in paragraph No. 17 of the specifications, unless otherwise specified. The boiler is to be tested for any defects in castings before any covering is applied.

Boiler shall be installed according to manufacturer's specifications.

6. Breeching. (Water or Steam.)

This boiler shall be connected to chimney by a smoke breeching of No............gauge black iron, provided with necessary dampers and cleanout openings. These cleanout openings shall be of ample size and they shall be so arranged that the entire length of the breeching can be cleaned without dismantling same.

This breeching shall be of the required size and shall be painted both inside and outside with two coats of asphaltum varnish. This breeching shall be covered as specified in paragraph No. 17 of these specifications.

The Contractor shall support this breeching in a substantial manner. Where the breeching enters the chimney, it shall be increased in area at least ten (10) per cent.

Breeching shall be installed in such a manner as to maintain a minimum distance between nearest wall and breeching of eighteen (18) inches.

7a. Piping System (Water).

The system of piping to be used in this installation will be what is known as a two-pipe system with $\genfrac{}{}{0pt}{}{\textbf{basement}}{\text{overhead}}$ supply main and $\genfrac{}{}{0pt}{}{\textbf{up}}{\text{down}}$ feeds to all radiators. All piping is to be supported in a substantial manner.

Whenever possible, the piping is to be arranged in such a manner that the first radiator on the supply circuit will be the last on the return circuit. The system shall be provided with vents and drains at all points where required.

The supply and return piping is to be arranged in such a manner as to allow for proper circulation to all parts of the system without crowding or forcing.

All piping exposed in the building, with the exception of that in the boiler room, and where same is subjected to low temperatures, shall remain uncovered. All piping not exposed to public view, such as where located in boiler room, attic space, basement, concealed in walls, or exposed to low temperatures, shall be covered, as outlined in paragraph No. 16 of these specifications. Piping is to be concealed unless otherwise specified. Concealed piping is to be tested for leaks and defects before covering is applied.

Contractor shall ream the ends of all pipes used in connection with this installation, so that the flow will not be restricted.

No control valves are to be installed on supply or return mains or radiators, unless otherwise specified. Radiators requiring venting shall be equipped with air valves of the lock and shield compression type.

7b. Piping System (Steam).

The system of piping to be used in this installation will be a $\genfrac{}{}{0pt}{}{\text{two}}{\text{one}}$ pipe system with $\genfrac{}{}{0pt}{}{\text{overhead}}{\text{basement}}$ supply main and $\genfrac{}{}{0pt}{}{\text{down}}{\text{up}}$ feeds to all radiators. All piping is to be supported in a substantial manner.

The system is to be provided with vents and drips at all points where required.

Care shall be taken when laying out piping system, that the condensation shall flow in the same direction as the steam and the use of a wet return to the boiler is to be avoided wherever possible.

The piping is to be arranged in such a manner as to allow for proper circulation to all parts of the system without crowding or forcing.

All piping exposed in the building, with the exception of that in the boiler room and where subjected to low temperatures, shall remain uncovered. Piping not exposed to public view, such as where located in boiler room, attic space, basement, concealed in walls or exposed to low temperatures, shall be covered as outlined in paragraph No. 16 of these specifications. Contractor shall ream the ends of all pipes used in connection with this installation so that the flow will not be restricted.

Steam shall be taken from the boiler into a main leader and circulated through the building by means of supply mains. At each point where a supply main is taken off the main header, a control valve shall be installed.

Returns shall be brought back to a manifold header, which in turn shall be connected to the boiler. At each point where a return main is connected to the manifold header, a control valve shall be installed.

At the end of each supply and return main or where same drops to a lower level, an automatic vent shall be installed, so located that it can be inspected.

All concealed piping is to be tested for leaks and defects before covering is applied.

8. Expansion Tank. (Water.)

Contractor shall furnish and install in most suitable location, or as indicated on drawing, one.............Expansion Tank............... gallons capacity.

Expansion tank shall be properly vented, care being taken that vent is installed in such a manner as to prevent syphonage.

The expansion pipe shall be connected to the return main in the most suitable location.

The overflow pipe from the expansion tank shall be installed so that it will discharge to the drain in the boiler room.

Expansion tank is to be arranged so that it will be circulating if deemed necessary.

All necessary supports, piping, valves and connections for expansion tank are to be provided and installed by this Contractor.

9. Radiators. (Steam or Water.)

All radiators used in connection with this installation shall be of the following type according to location in which placed.

Floor pattern ....or equal.
Wall pattern ....or equal.

Contractor shall state make of radiators he proposes to furnish and no substitution will be allowed from that mentioned in proposal.

10. Hangers for Radiators. (Steam or Water.)

All radiators of wall pattern shall be so supported as to thoroughly take care of expansion and contraction by means of the................ hanger as made by......................................

The hangers shall be fastened to the walls in their respective locations by heavy expansion bolts firmly secured in the walls.

Should the design of the trim of the building be such that hangers cannot be fastened directly to the walls, this Contractor shall provide the necessary material to install hangers. Lumber used for this purpose shall conform to the trim of the building in all respects and be of neat finish.

11. Location of Radiators. (Water or Steam.)

The location of the radiators as shown on the drawing shall be construed as being approximately correct. Should conditions at the building prove such as to make any changes necessary in the location of the radiators, from that shown on the drawing, such change will not alter price agreed upon in contract.

12. Connections to Radiators. (Water or Steam.)

All connections to radiators shall be taken from the $^{\text{bottom}}_{\text{top}}$ of the supply main by 45° fittings and the distance between the supply main and the center of the radiator connections and shall not be less than thirty (30") inches. All return connections from the radiators shall be taken in at the side or top of the return main.

13a. Valves on Radiator. (Water.)

Radiator control valves when specified, shall be on return connection of radiator only.

Valves to be used shall be what are known as the quick operating water radiator valves, with a one-sixteenth of an inch (1/16") hole drilled in the conical shell, to allow for a slight circulation in the event the valve is closed and thus prevent a possible freezing of the radiator. All valves shall have rough body and nickel plated trimmings equipped with union connections and hard wood handle unless otherwise specified.

Air valves are to be installed on radiators where required and shall be of the lock and shield compression type.

Contractor shall state make of radiator and air valves he proposes to install and no substitution will be allowed from that mentioned in proposal. Each radiator is to be equipped with a valve of approved make, on flow and return.

13b. Valves on Radiator. (Steam, Two-Pipe.)

Valves shall be of radiator type with rough body, nickel plated trimmings, union connections and hardwood handles, unless otherwise specified.

Valves to be equipped with hard rubber disc of.................... make or equal.

Each radiator and point of the system requiring venting are to be equipped with non-adjustable automatic air valves of approved make.

Contractor shall state make and type of radiator and automatic air valves he proposes to furnish and no substitution will be allowed from that mentioned in proposal.

13c. Valves on Radiator. (Steam, One-Pipe.)

Each radiator shall be equipped with a valve of approved make. Valves shall be of radiator type and with rough body and nickel trimmings, union connections and hard wooden handles, unless otherwise specified. Valves to be equipped with hard rubber disc of......................... make or equal.

Each radiator and points of the system requiring venting shall be equipped with automatic non-adjustable air valves of approved make.

Contractor shall state make and type of radiator and automatic air valves he proposes to furnish and no substitution will be allowed from that mentioned in proposal.

14. Support for Pipe. (Water or Steam.)

All piping shall be firmly and neatly secured with proper provision for expansion and contraction. The horizontal lines shall be hung on neat trapeze expansion hangers placed at proper intervals while all other lines shall be provided with suitable hangers, best adapted to the existing conditions to make a good appearing and substantial job.

Anchors shall be placed at points on lines to take care of the expansion from central points to ends. The use of perforated bar or strap hanger will not be permitted.

Contractor when submitting his layout for approval, shall submit details of all hangers for the approval of the Engineer.

15. Expansion and Contraction. (Water or Steam.)

The expansion and contraction of all supply and return mains must be taken care of in the design of the system. The use of the mechanical slip joint will not be permitted in connection with this installation.

16. Material to Be Used. (Water or Steam.)

All pipe used in connection with this installation shall be new, strictly genuine wrought iron pipe as made by the..or equal.

Valves shall be of type made by..............................or equal.

Fittings shall be of fine grained grey cast iron.......................make or equal, with threads clean cut, tapering and smooth.

Thread joints shall be iron to iron without the use of red lead or cement, all flanged fittings shall be made with....................padding or gaskets or equal.

Unions shall be of the Railroad pattern, metal to metal, no gaskets to be used.

On all pipe lines three inches (3") and up, flanged fittings shall be used and below that threaded fittings shall be used.

All materials used in connection with this installation shall be the best of their respective kind, and be put together by skilled mechanics under competent supervision.

All piping to be insulated in connection with this heating system shall be covered with................covering as made by the..or equal.

This pipe covering shall be of standard thickness with metal bands at ends and center of sections. Fittings shall be covered with plastic material of quality described below and shall also have canvas jackets All piping installed underground shall be covered and encased in conduits as called for.

No covering is to be applied on any piping exposed in portion of building used by public unless otherwise specified.

Contractor shall state make and grade of covering he proposes to furnish and no substitutions will be allowed from that mentioned in proposal.

17. Plastic Covering. (Water or Steam.)

The boiler and smoke breeching in the boiler room shall be provided with a plastic asbestos covering of the above make, unless otherwise specified. This plastic covering shall be applied first in the form of asbestos blocks 1½″ thick and then with ½″ thick hard finish of asbestos cement, neatly secured in place, followed by a canvas jacket neatly pasted on.

The covering on the smoke breeching shall be in the form or 1″ asbestos blocks applied on ½″ mesh black iron wire cloth with 1″ "V" iron attached to form air space and fastened directly to the iron, with finishing coat of cement followed by canvas jacket neatly pasted on.

18. Insulation Through Walls, Floors and Partitions. (Water or Steam.)

Where pipes pass through floors or run through partitions galvanized iron sleeves with proper air space between the walls of the sleeves and the pipes shall be placed. Where they pass through bearing walls, sleeves of wrought iron pipe shall be used with proper provision for air space. At all points where sleeves are used, proper nickel plated floor and ceiling plates shall be used.

Contractor shall pay special attention that there shall be no ragged holes appearing where any pipes pass through walls or floors.

19a. Guarantee. (Water.)

This Contractor must guarantee the perfect operation of the system as heretofore described and indicated on drawings that it will be capable of warming the rooms in the building to the following temperatures, with the temperature of the water in the radiators not to exceed 170° F.

Room	Outside Temp.	Inside Temp.
....	....	....
....	....	....
....	....	....
....	....	....
....	....	....

That it will circulate freely, without crowding or forcing, to all parts of the system and should any defects appear in same within the course of one year of actual operation, the Contractor shall make good at his own expense.

If in the opinion of the Contractor the amount of radiation and size of boiler as set forth on the drawings is not sufficient to fulfill his guarantee, he shall state in his proposal, the amount of additional radiation and additional boiler capacity which in his judgment is necessary and quote prices for same.

Any omissions in these specifications or the drawings accompanying same, do not relieve the Contractor of his obligation to install the system complete in every respect to fulfill his guarantee.

19b. Guarantee. (Steam.)

The Contractor must guarantee the perfect operation of the system heretofore described and indicated on drawing, that it will be capable of warming the rooms in the building to the following temperatures with a steam pressure of from two (2) to five (5) pounds per square inch by gauge on the boiler and a drop in pressure in the piping not to exceed eight (8) ounces.

Room	Outside Temp.	Inside Temp.
....	....	....
....	....	....
....	....	....
....	....	....
....	....	....

That it will circulate freely to all parts of the system without crowding or forcing, and should any defects appear in same within the course of one year of actual operation, the Contractor shall make good at his own expense.

If in the opinion of the Contractor, the amount of radiation and size of the boiler as set forth on the drawing, is not sufficient to fulfill his guaranty, he shall state in his proposal, the amount of additional radiation and additional boiler capacity which in his judgment, is necessary, and quote price for same.

Any omissions in these specifications or on the drawings accompanying same, do not relieve the Contractor of his obligations to install the system complete in every respect and fulfill his guaranty.

The minimum amount of direct radiation which will be acceptable in the building will be.............square feet.

If the Contractor considers it necessary to deviate from the plans in order that his guaranty may be fulfilled, he may do so only upon the written permission from the Engineer.

20. Preliminary Tests and Cleaning. (Water or Steam.)

The Contractor shall make a thorough test of the plant to ascertain whether there are any leaks in the boiler, piping, etc., after completion, he shall also arrange to remove all sediment, rust and dirt out of the system. In order to do this, the boiler is to be operated for a period of not less than twenty-four (24) hours and during this operation, the boiler is to be blown off frequently until the water blown down from the boiler is reasonably clear.

21. Test. (Water or Steam.)

Upon notification from the Contractor, the Company shall within two weeks, make a test of the complete system, and it will be accepted only after test is satisfactory to the Company, all leaks and defects have been repaired and all conditions of these specifications have been fully and satisfactorily complied with. The Contractor shall furnish a complete set of written instructions neatly framed and glazed, covering the operation of the plant for reference purposes.

22. Completion. (Water or Steam.)

At the completion of the installation and its acceptance by the Company, the Contractor must give instructions as to the operation of the plant, showing in detail all points that require attention and turn same over to the Company. He shall also furnish for the Company's file, one complete set of tracings or VanDyke negatives on cloth, showing in detail, the complete installation.

23. Cleaning. (Water or Steam.)

At the completion of the work, the Contractor shall remove all construction equipment, scaffolding, staging, erection platforms, and all surplus material from the premises, leaving the building in a clean and acceptable condition. If any equipment, material or debris is not removed with sufficient promptness, the Company may remove it at the expense of the Contractor.

24. General Conditions. (Water or Steam.)

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 Section 1 of this specification shall be considered to apply with equal force to this section of the specification.

SPECIFICATIONS FOR RAILWAY BUILDINGS

SECTION 19-d

Hot Air 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 or shown on drawings.

2. Furnace.

The Contractor shall furnish, set up and properly connect, where shown on the drawings, ... No. .... Furnace (s), as manufactured by .... or equal, equipped with .... control. Furnace shall be provided with all necessary, castings, doors, shaking grates, firing and cleaning tools, waterpan, etc., ready for operation; grates shall be furnished to enable .... to be used as fuel.

3. Smoke Pipe.

The smoke pipe is to be .... inches in diameter, of .... gage galvanized steel, properly fastened in place, and equipped with a tight damper and check-draught. Woodwork within eighteen (18) in. of smoke pipe shall have a protection at least thirty (30) in. wide of one-fourth (¼) in. asbestos board with two (2) in. open air space between the protection and the woodwork, or otherwise to meet requirements of local building code.

4. Supply Pipes and Register Boxes.

The Contractor shall furnish and install all necessary pipes and register boxes to properly heat the building and they shall be made of tin of .... gage; all joints shall be made tight. Each supply pipe shall be equipped with a control damper adjacent to the furnace. The pitch of all supply pipes shall be such that the flow of air will circulate freely to all parts of the system without being forced. Supply pipes, register boxes and register faces shall be of ample size to permit the proper amount of air being delivered to the room and the registers shall have sufficient free area and be designed to be shut-off at will.

5. Insulation.

The outside jacket of the furnace and all supply piping or hot air pipes shall be properly insulated with .... ply asbestos paper.

6. Return Air Pipes.

The Contractor shall furnish and install return air pipes and inlet boxes equipped with a register of sufficient size to provide proper circulation. The return pipes shall enter the furnace at its base.

7. Openings.

All openings are to be cut true, and not more than one-fourth (¼) in. larger than the dimensions of the register boxes to be used. The Contractor shall pay special attention that there shall be no ragged holes appearing where registers are installed.

8. Register Faces.

The Contractor shall furnish and install register faces or grilles of approved design and pattern, and set and fit same in place. Contractor shall state in his proposal size and type of register faces or grilles he proposes to furnish and install in the various rooms.

9. Guarantee.

The Contractor must guarantee the perfect operation of the system as heretofore described, that it will be capable of heating the rooms in the building to the following temperatures:

Room	*Outside Temperature*	*Inside Temperature*
....	....	....
....	....	....
....	....	....
....	....	....
....	....	....
....	....	....

The Contractor shall state sizes of supply pipes leading to each room, free area of register faces, size of return pipes, also any other information having any bearing on design of system, and shall guarantee the same to circulate freely, without crowding or forcing, to all parts of the system and should any defects appear in same within the course of one year of actual operation, the Contractor shall make good such defects at his own expense. Any omissions in these specifications or the drawings accompanying same, do not relieve the Contractor of his obligation to install the system complete in every respect to fulfill his guarantee.

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 will be considered as finally accepted until all of the work is completed and accepted.

The General Conditions as given in Section 1 of this specification shall be considered to apply with equal force to this section of the specification.

SPECIFICATIONS FOR RAILWAY BUILDINGS

SECTION 19-e

Hot Blast Heating System

1. General.

The Contractor shall furnish all labor, material, tools and equipment, except as otherwise noted, to entirely complete the heating work as hereinafter specified or shown on drawings.

2. Checking Drawings.

The Contractor shall check all drawings and must report all discrepancies before starting the work. No allowances will be made by the Company for errors or discrepancies discovered by the Contractor after the work has started.

3. Laying Out Work.

All dimensions on drawings shall be verified at the site of the work by the Contractor, and he shall assume all responsibility for their accuracy.

4. System.

The system of heat transmission to be used will consist of a hot blast or blower system, complete in all details, whether specifically mentioned or not.

The hot air is to be distributed to the different parts of the building by means of a fan driven by a steam engine or electric motor, through a system of air ducts as shown on drawings.

Steam to be used in the heater shall be exhaust or live steam at reduced pressure according to local conditions.

Condensation from the heater shall be returned to boiler plant by means of a vacuum pump.

5. Steam Supply Lines to Heater and Engine.

The steam supply for the heater shall be obtained from the point shown on drawings.

Where exhaust steam is used in the heater, the Contractor shall make connections to existing exhaust mains, of points shown on drawings, install an oil separator, if necessary, and then carry piping from the source of supply to the steam header of the heater in the heater room.

In order to insure an adequate supply of steam when exhaust steam is used, the Contractor shall provide a high pressure steam connection with pressure reducing valve, so arranged as to open and admit steam into the exhaust steam supply main when there is insufficient exhaust steam to supply the heater.

When live steam at reduced pressure is used in the heater, the Contractor shall make connections to high pressure steam main where shown on drawings, install a pressure reducing valve, and carry piping to steam header of heater.

Where a steam engine is used for operating the fan the steam supply for this engine shall be obtained from the high pressure steam line where indicated. This steam line shall be of required size to supply sufficient steam to operate the engine.

6. Return Mains and Drips from Exhaust Steam Main.

The return line from the heater shall be connected to the vacuum pump, which shall be located where indicated on drawing.

All drips taken from the exhaust header shall be connected to the return line in a suitable manner.

7. Exhaust Connections for Summer Use.

In case it is desired to use the blower system in the building as a ventilating medium during the summer months, this contractor shall provide for the diversion of the exhaust steam from the fan engine to the atmosphere. This exhaust pipe shall be provided with a back pressure valve, also an exhaust head, both of which shall be of .... make, or equal; this exhaust head shall be of cast iron.

8. Vacuum Pump and Specialties.

The Contractor shall furnish and install in the location indicated on the drawings .... vacuum pump(s), complete in all details including suction strainer and all specialties.

This pump shall be of .... pattern .... x .... size of .... Company's make, or equal.

The pump shall be equipped with a cast iron drip pan with all drains properly connected to existing sewers.

This pan shall be set on a concrete foundation twelve (12") in. above the floor level. Foundation bolts and foundation shall be provided by the Contractor.

The pump shall be equipped with a mechanical oil pump of sufficient size of .... make, or equal. The oil pump shall be applied at the factory.

The steam for this (these) pump(s) shall be taken from the location indicated on the drawings, and the exhaust shall be connected to the exhaust main.

The discharge from this (these) pump(s) shall be connected as indicated on the drawings, or as directed by the Engineer.

Pump(s) shall be controlled by a governor of .... make, or equal; governor to be by-passed to enable pump(s) to be operated by hand in the event the governor becomes inoperative.

All piping, fittings, valves, gages, etc., required to connect the pump to the heating system and discharge the condensation to the boiler plant and place same in proper operation, shall be furnished and installed by the Contractor.

9. Air Ducts.

All metal air ducts installed in connection with this work shall be furnished and installed by this Contractor, but any air ducts other than metal will be provided by others.

10. Radiation in Heater.

The heating unit used in connection with this installation shall be a .... heater as manufactured by the .... Company, or equal. The heater shall contain .... sq. ft. of radiation, arranged to suit the requirements under which the heater is to operate. Steam to be used in the heater shall not exceed three (3 lb.) pounds per sq. in. gage pressure. Each stack of the heater is to be controlled independently by a control valve.

All necessary piping, fittings, valves, specialties, etc., required for the correct installation and operation of the heater shall be furnished and installed by this Contractor.

11. Vacuum Traps.

The vacuum system specialties, which in this case refer principally to the style of trap used on the return connections from the heater, shall be those made by the .... Company, or equal.

All necessary specialties required to connect the heater to the vacuum system shall be furnished and installed by this Contractor.

12. Heater Casing.

The heater casing and connection to fan inlet shall be of No. .... gage black iron, reinforced with angle and tee iron shapes designed in accordance with drawing No. ....

13. Fan.

The fan to be used in this installation shall be of multiblade type, of Size No. ...., Design No. ...., of .... Company's make, or equal.

This fan is to be directly connected to steam engine by coupling of the "safety" flange type with concealed bolt heads and nuts.

The fan is to be equipped with runner of .... in. diameter and is to be operated at a peripheral speed of .... ft. per minute It is to be of $\left\{\begin{matrix}\text{single}\\\text{double}\end{matrix}\right\}$ inlet .... housed, $\left\{\begin{matrix}\text{single}\\\text{double}\end{matrix}\right\}$ width, ... discharge, with approximate capacity of .... cu. ft. per minute at .... static pressure.

14. Steam Engine.

Where a steam engine is used the fan is to be driven by direct connected $\left\{\begin{matrix}\text{vertical}\\\text{horizontal}\end{matrix}\right\}$ steam engine operating at .... revolutions per minute, with a steam pressure not exceeding .... lb. per sq. in. at the engine throttle This engine is to operate against a back pressure of five (5) lb. per sq. in., and it is to be provided with a steam separator, governor, and all necessary lubricating devices, of approved make.

The engine installed shall be of sufficient capacity to develop at least fifty (50) per cent. overload.

The exhaust steam from engine is to be passed through an oil separator and utilized in the heater. All drips from the engine and oil separators shall be connected to a blowoff basin, which shall also be furnished and installed by the Contractor.

All necessary piping, fittings, valves, traps, etc., required for the correct installation of the steam engine shall be furnished and installed by this Contractor.

15. Foundation and Trenches.

The Contractor shall furnish and install all necessary foundations, foundation bolts, trenches, wells, checkered plate covers, etc., required for the installation of the heater, fan and fan engine.

16. Motor.

When the electric drive is used, the fan is to be driven by a

$$\begin{matrix}\text{Constant speed}\\\text{Variable speed}\end{matrix}\left\{\begin{matrix}\text{direct driven}\\\text{belt driven}\\\text{silent chain}\\\text{driven}\end{matrix}\right\}\text{electric motor of}\left\{\begin{matrix}\text{squirrel cage}\\\text{slip ring}\end{matrix}\right.$$

type of .... Company's make, or equal.

This motor shall be of .... H.P. at a speed of .... R.P.M., and it shall be designed to allow for a maximum rise in temperature of forty deg. (40°) Cent. above the surrounding atmosphere. after a continuous operation under full load for two (2) hours.

The starter or controller to be used in connection with this motor shall be of the .... Company's make, or equal.

All electrical connections between the motor and starter, or controller, shall be furnished and installed by this Contractor, but all other connections between starter, or controller, and service box will be made by others.

All electrical equipment used in connection with the work shall be designed to suit .... $\left\{\begin{matrix}\text{volt}\\ \text{volt}\end{matrix}\right\}$ .... phase .... cycles $\left\{\begin{matrix}\text{direct}\\ \text{alternating}\end{matrix}\right\}$ current, and shall conform to the rules and regulations of the National Board of Underwriters, and shall be subject to the approval of the Electrical Engineer of the Railway Company.

The motor shall be provided with a $\left\{\begin{matrix}\text{sliding}\\ \text{solid}\end{matrix}\right\}$ base, and shall be securely bolted to a suitable foundation.

17. Pressure Reducing Valves.

Pressure reducing valves shall be of .... make, or equal. Each valve shall be by-passed. The valve on by-pass shall be of lock and shield pattern, to prevent it from being opened by unauthorized persons.

The pressure reducing valve is to be provided with a safety valve on low pressure side. Safety valve to be set at .... lb. per sq. in. pressure.

Contractor shall also furnish necessary pressure gage and connections with each valve, and piping, fittings, valves, etc., to properly install pressure reducing valve.

18. Steam Traps.

Steam traps shall be of .... make, or equal. They shall be by-passed and suitable for the service in which they are installed.

All necessary piping, fittings, valves, etc., required for the correct installation of steam traps shall be furnished and installed by the Contractor.

19. Oil Separators.

Wherever a connection is made to an exhaust steam line for heating purposes, the Contractor shall furnish and install an oil separator at the point where such connection is made.

Oil separators shall be of the .... Company's make, or equal, and suitable for the service for which they are installed.

Each separator is to be drained through an oil trap of required size. The oil trap shall be by-passed so that the separator may be drained directly through the oil trap to blowoff basin.

Place oil traps on floor at lowest possible point, with check valve in horizontal connection to trap.

20. Overhead Pipe Supports.

Any overhead mains outside the building shall be supported on adequate pipe supports set on concrete bases. These supports shall be of required strength to support the sizes of piping carried, and they shall be designed so as to allow the pipe to expand and contract.

They shall be spaced so as to prevent sag in the pipe line, with a minimum clearance under pipe line of twenty-two (22) ft. above top of rail.

21. Supports for Pipes.

All piping shall be firmly and neatly secured, with proper provision for expansion and contraction. The horizontal lines shall be supported on neat trapeze expansion hangers at proper intervals, while all other lines shall be provided with suitable hangers best adapted to the existing conditions, to make a good appearing and substantial job.

Anchors shall be placed at points on lines to take care of the expansion from central points to the ends. The use of perforated bar or strap hanger will not be permitted.

The Contractor, when submitting his layout for approval, shall submit details of all hangers for the approval of the Engineer.

22. Underground Conduit and Insulation.

Where steam and return piping are run underground, they shall be installed in a waterproof conduit, preferably of the culvert or open type, equipped with interior drain, similar in design to the .... Company's make, or equal.

The conduit shall be built complete with necessary expansion and anchor pits, and drain connection to the nearest sewer at the low end. The minimum distance between the top of the conduit and the ground level shall be ...., and the floor of the conduit shall be graded to secure a good run-off for drainage. Material excavated to enable conduit to be constructed shall be used as backfill.

Concrete used in the construction of this conduit shall be in accordance with A.R.E.A. Standard Building Specifications, of .... mixture, and all other materials shall be of standard grades of approved make

All piping installed in conduit shall be insulated with pipe covering of make specified in paragraph "Materials to Be Used."

Insulation used on high pressure steam mains shall be "..........." covering, of .... thickness.

Insulation used on low pressure steam mains shall be "..........." covering, of .... thickness.

Insulation shall be installed as specified, and shall be painted with two (2) coats of waterproof paint.

23. Expansion and Contraction.

The expansion and contraction of all supply and return mains must be taken care of in the design of the system.

24. Material to Be Used.

All pipe used in connection with this installation shall be new, strictly genuine wrought iron pipe, as made by the ...., or equal.

Valves shall be of the type made by ...., or equal.

Fittings shall be of fine grained gray cast iron, ... make, or equal, with threads clean cut, tapering and smooth.

Thread joints shall be iron to iron without the use of red lead or cement. All flanged fittings shall be made with .... padding or gaskets, or equal. Unions shall be of the Railroad pattern, metal to metal, no gaskets to be used.

On all pipe line three (3) in. and up, flanged fittings shall be used, and below that size threaded fittings shall be used.

All materials used in connection with this installation shall be the best of their respective kinds, and shall be put together by skilled mechanics under competent supervision.

All piping to be installed in connection with this heating system shall be covered with .... covering, as made by the ...., or equal. This pipe covering shall be of standard thickness, with metal bands at ends and center of sections. Fittings shall be covered with plastic material of quality described below, and shall also have canvas jackets.

All piping installed underground shall be covered and encased in conduits as called for.

All overhead outside piping shall be covered with double thickness covering of the above mentioned quality, same to be equipped with an approved weatherproof jacket.

No covering shall be applied to any piping until the pipe lines have been tested.

The Contractor shall state make and grade of covering he proposes to furnish, and no substitutions will be allowed from that mentioned in his proposal.

25. Insulation Through Walls, Floors and Partitions.

Where pipes pass through floors or run through partitions, galvanized iron sleeves, with proper air space between the walls of the sleeve and the pipes, shall be used. Where they pass through bearing walls, sleeves of wrought iron pipe shall be used with proper provision for air space. At all points where sleeves are used, proper nickel plated floor and ceiling plates shall be provided. Contractor shall pay special attention so that there will be no ragged holes appearing where any pipes pass through walls or floors.

26. Guarantee.

The Contractor must guarantee the perfect operation of the system described above and indicated on the drawings, that it will be capable of warming the building to .... degrees Fahrenheit temperature when the outside temperature is .... degrees, with a steam pressure of from two (2) lb. to five (5) lb. per sq. in. by gage in the heater, and also that it will circulate freely to all parts of the system without crowding or forcing. Should any defects appear in the system within the course of one year of actual operation, the Contractor shall make such defects good at his own expense.

If, in the opinion of the Contractor, the amount of radiation in the heater, size of fan and steam engine, as set forth on the drawings, is not sufficient to fulfill his guarantee, he shall state in his proposal the amount of additional radiation in heater, size of fan and steam engine, which, in his judgment, is necessary, and quote price for same.

The minimum amount of direct radiation which will be acceptable in the heater will be..................square feet.

Any omissions in these specifications or on the drawings accompanying same, do not relieve the Contractor of his obligations to install the system complete in every respect and fulfill his guarantee.

If the Contractor considers it necessary to deviate from the plans in order that his guarantee may be fulfilled, he may do so only upon the written permission of the Engineer.

27. Preliminary Tests and Cleaning.

The Contractor shall make a thorough test of the plant to ascertain whether there are any leaks in the heater, piping, etc., after completion. He shall also arrange to remove all sediment, rust and dirt out of the system. In order to do this, the heater is to be operated for a period of not less than twenty-four (24) hours, and during this operation all condensation from the heater is to be discharged directly into the sewer.

28. Tests.

Upon notification from the Contractor, the Company will, within two weeks, make a test of the complete system, and it will be accepted only after test is satisfactory to the Company, all leaks and defects have been repaired, and all conditions of these specifications fully and satisfactorily complied with. The Contractor shall furnish a complete set of written instructions, neatly framed and glazed, covering the operation of the plant, for reference purposes.

29. Completion.

At the completion of the installation and its acceptance by the Company, the Contractor must give instructions as to the operation of the plant, showing in detail all points that require attention, and turn same over to the Company. He shall also furnish for the Company's file one complete set of tracing or Van Dyke negatives, on cloth, showing in detail the complete installation.

30. Cleaning.

At the completion of the work, the Contractor shall remove all construction equipment, scaffolding, staging, erection platforms and all surplus material from the premises, leaving the building in a clean and acceptable condition. If any equipment, material or debris is not removed with sufficient promptness, the Company may remove it at the expense of the Contractor.

31. 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 Section 1 of this specification, shall be considered to apply with equal force to this section of the specification.

SPECIFICATIONS FOR RAILWAY BUILDINGS

SECTION 20

Electric Light Wiring

1. General.

The Contractor shall furnish all labor, material, tools and equipment necessary to entirely complete and install any and all kinds of electric light wiring and appurtenances as herein specified, or as shown or implied on the drawings.

2. City Ordinances and State Laws.

All electrical work shall be done in accordance with the National Board of Underwriters' Rules and Regulations, except where local or state laws conflict, in which case said laws shall govern.

3. Scope of Specifications.

These specifications are intended to cover the installations of all electric light wiring and appurtenances from a point of supply to outlets for fixtures and apparatus.

4. Material.

The Contractor shall submit with his proposal the manufacturer's name, type, catalog and identification numbers of all electrical devices and material to be used, also complete wiring diagrams in triplicate showing the size of all wires and grades of covering. Devices and material of equal grade may be substituted on approval of the Engineer, but no inferior material or obsolete devices will be accepted.

5. Conduits.

Wiring shall be installed in approved rigid or flexible conduit, which shall be properly secured in place. Conduit shall be cut with a hack saw and ends thoroughly reamed. Conduits shall be free from sharp bends and of sufficient size to allow wires to be drawn without undue strain. During construction, ends of conduits shall be plugged at all outlets to keep the conduit dry and free from foreign matter.

Exposed conduit shall be run along beams, ceilings or walls, and not across open spaces unless properly supported by approved hangers, and shall be painted to match the finished color of background or completely masked by a molding, unless otherwise called for on drawings.

Conduit which is to be imbedded in masonry must be placed during construction. The cutting of chases will not be permitted.

Conduits shall not be installed in close proximity to heating pipes or hot air ducts.

6. Wires.

Except for fixtures and pendant cords, the minimum size of wire shall be No. 14 A.W.G. All circuit wires shall be of such size as not to produce a drop in potential of more than 2 per cent. and the entire system shall be calculated so as not to produce a drop in potential of more than 4 per cent.

Wire of No. 8 size A.W.G. and larger shall be stranded and may be single or double braid, according to local requirements.

Wires must have a distinct marking throughout their entire length, so that they can be easily identified. Coils must be plainly marked and tagged to show the name of manufacturer, date manufactured and the maximum voltage for which the insulation is designed.

7. Joints.

Unless joints are made with an approved electrically efficient and rigid splicing device, they must be made mechanically and electrically secure without solder, then soldered and covered with insulation equal to that of the conductors.

8. Outlet Boxes.

The Contractor shall provide and set metal outlet boxes of approved design and construction, suited to the requirements, at every light outlet and at every local switch outlet. Boxes must admit of being readily set or firmly joined to conduits. Conduit openings not in use shall be plugged or capped.

Boxes for all local switch outlets not at panel boards shall be of similar design to light outlet boxes. Gang boxes shall be used where switches are grouped.

Metal pull boxes shall be designed to allow of easy withdrawal and easy insertion of main and branch wires and shall be of approved type and design.

9. Service Switches and Cabinets.

Service switches shall conform to local or Underwriters' Rules, and shall be essentially of the Safety First type, installed separately and easily accessible.

Circuit cabinets shall provide for one more circuit than indicated on drawings, and shall be provided with cylinder lock and a set of three keys.

10. Local Switches.

The local switches shall be of not less than 10 amperes capacity, and shall be the style and type as indicated or directed. Where two or more switches come together, they are to be set in a gang box with one cover plate unless otherwise specified, finish of box to match adjacent hardware

11. Fuses.

Main and feeder circuits shall be provided with fuses of the enclosed type, which shall indicate plainly the amperes and volts for which they are rated. Branch lighting circuits shall be provided with .... screw plug cutouts and where lights are to be controlled from cabinet, approved detachable push or toggle switches with insulated dead front covering, or equal, shall be installed.

12. Wiring Systems.

Unless otherwise specified, wiring for lighting shall be a multiple wire system of 110 to 220 volts. Feeders and branch feeders shall consist of three wires, and the neutral wire shall in all cases have the same current carrying capacity as the outside wires. Branch circuits shall be two-wire. No branch circuit shall carry more than 660 watts except where especially approved.

13. Outside Work.

Exact locations to which the service company will bring service wires shall be ascertained by the Contractor, and he shall carry his work to the source of supply as a part of this contract.

14. Outside Wiring.

Wires shall be brought in overhead only when so specified.

The Contractor shall furnish necessary meter loops of suitable approved fused safety service switches as hereinbefore specified, and extend the service wires through the exterior walls of building for ready connection with service company's supply wires.

Wire supported on the exterior walls of buildings shall be carried on approved racks or brackets not more than 10 ft. apart, and parallel wires shall be spaced not less than 6 in. apart.

Any wiring outside the building, either underground or overhead, that is to be installed by the Contractor shall conform to the requirements of the American Railway Association for line construction.

15. General Conditions and Guarantee.

The Contractor must guarantee all workmanship and materials to be first-class and shall, at his own expense, replace or repair promptly upon receipt of written notice, any defects in material or workmanship which may develop within one year of acceptance of the work by the railroad company.

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 Section 1 of this specification shall be considered to apply with equal force to this section of the specification.

Appendix B

SPECIFICATIONS FOR RAILWAY PURPOSES

J. W. Orrock, Chairman, Sub-Committee

SECTION

Built-Up Roofing

Type "C1" (Class A)

Asphalt Impregnated Asbestos Felt and Asphalt Cement Over Wood

Roofing composed of one layer approximately 60-lb., two layers approximately 14-lb., asphalt impregnated asbestos felt (the latter lapped 17 inches), and a minimum of 85-lb. asphalt roofing cement, per 108 sq. ft.

1. Lay sheets of asphalt impregnated asbestos felt weighing approximately 60-lb. per 108 sq. ft. directly over the sheathing. Lap the joints 3 inches and seal them with asphalt cement. Nail these sheets along the lap with barbed nails driven through flat tin caps, spaced 6 inches apart, and in parallel lines approximately 10 inches apart and approximately 10 inches from the laps, these nails to be spaced 18 inches apart and staggered. This 60-lb. felt shall be laid parallel to pitch of roof and turned up 5 inches above level of roof on all vertical surfaces, but not cemented to vertical surfaces.

Over the 60-lb. felt, edging strips composed of the flashing material shall be applied at eaves and gable overhang, extending 4 inches on roof, cemented and nailed, and turned down over and secured to facia and projected ½ inch beyond to form a drip edge.

2. Mop the entire surface of the 60-lb. felt with the asphalt cement, heated to flow freely, and while the cement is hot, embed in it sheets of asphalt impregnated asbestos felt, weighing approximately 14-lb. per 108 sq. ft., in two-ply construction; this 14-lb. felt to be run at right angles to the 60-lb. felt, lapped 17 inches and turned up 5 inches above level of roof, on all vertical surfaces.

Start at low point of roof with a one-half width sheet of the 14-lb. felt, then a full width sheet of the same felt laid flush with and entirely covering the one-half width sheet. Then lay full width sheets, setting the first so as to overlap the one-half width, starting sheet 2 inches and then exposing 15 inches of each succeeding sheet to the weather.

Mop the entire surface between plies with the asphalt cement, heated to flow freely, and roll the felts closely behind the mop so that no missing of asphalt can possibly take place. Approximately 30 lb. of asphalt shall be used per square for each mopping.

Nail the back edge of each sheet with the barbed nails, driven through flat tin caps, spaced 9 inches apart; the center line of nail heads to be approximately ¾ inch below back edge of sheet.

3. Flashing-Walls and all other elevations above roof surface shall be carried vertically at least 12 inches to provide for proper flashing. Roofing material shall be carried up 5 inches above level of roof on all vertical surfaces.

All flashings, except those around ventilators, standpipes, exhausts, etc., shall be composed of base flashing of special asbestos flashing material, approximately 10½ inches wide, cemented and nailed to vertical surface. Such flashings shall be counter-flashed with approved fibrous mineral and applied with a reinforcement of impregnated asbestos felt.

4. When the roofing is otherwise complete, cover the entire surface with a mopping of the asphalt cement, to be applied hot, using approximately 25 lb. to the square.

TYPE "C1" (CLASS B)

Asphalt Impregnated Asbestos Felt and Asphalt Cement Over Wood

Roofing composed of one layer approximately 60-lb., two layers approximately 14 lb., asphalt impregnated asbestos felt (the latter lapped 3 inches), and a minimum of 55 lb. asphalt roofing cement, per 108 sq. ft.

1. Lay sheets of asphalt impregnated asbestos felt weighing approximately 60 lb. per 108 sq. ft., directly over the sheathing. Lap the joints 3 inches and seal them with asphalt cement. Nail these sheets along the lap with barbed nails driven through flat tin caps, spaced 6 inches apart, and in parallel lines approximately 10 inches apart and approximately 10 inches from the laps; these nails to be spaced 18 inches apart and staggered. This 60-lb. felt shall be laid parallel to pitch of roof and turned up 3 inches above level of roof on all vertical surfaces, but not cemented to vertical surfaces.

Over the 60-lb. felt, edging strips composed of the flashing material shall be applied at eaves, and gable overhang, extending 4 inches on roof, cemented and nailed and turned down over and secured to facia, and projected ½ inch beyond to form a drip edge.

2. Mop the entire surface of the 60-lb. felt with the asphalt cement, heated to flow freely, and while the cement is hot, imbed into it sheets of asphalt impregnated asbestos felt, weighing approximately 14 lb. per 108 sq. ft., in single ply construction; this 14-lb. felt to be run at right angles to the 60-lb. felt, lapped 3 inches and turned up 5 inches above level of roof on all vertical surfaces.

Start at low point of roof with a one-half width sheet of the 14-lb. felt, then a full width sheet of the same felt laid flush with and entirely covering the one-half width sheet. Then lay full width sheets, overlapping the preceding ones 3 inches, with balance exposed to the weather.

Mop the entire surface between plies with the asphalt cement, heated to flow freely, and roll the felts closely behind the mop so that no missing of asphalt can possibly take place. Approximately 30 lb. of asphalt shall be used per square for each mopping.

Nail the back edge of each sheet with the barbed nails, driven through flat tin caps spaced 9 inches apart; the center line of nail heads to be approximately ¾ inch below back edge of sheet.

3. Flashing walls and all other elevations above roof surface shall be carried vertically at least 12 inches to provide for proper flashing. Roofing material shall be carried up 5 inches above level of roof on vertical surfaces.

All flashings, except those around ventilators, standpipes, exhausts, etc., shall be composed of base flashing of special asbestos flashing material, approximately 10½ inches wide, cemented and nailed to vertical surface. Such flashings shall be counterflashed with approved fibrous mineral and bituminous cement and applied with a reinforcement of impregnated asbestos felt.

4. When the roofing is otherwise complete, cover the entire surface with a mopping of the asphalt cement, to be applied hot, using approximately 25 lb. to the square.

TYPE "C2" (CLASS A)

Asphalt Impregnated Asbestos Felt and Asphalt Cement Over Dry Concrete or Gypsum

Roofing composed of one coat asphalt primer, one coat asphalt cement over primer, one layer, approximately 60 lb., and two layers approximately 14 lb., asphalt impregnated asbestos felt (the latter lapped 17 inches), and a minimum of 85 lb. asphalt roofing cement per 108 sq. ft., not including primer or first coat over primer.

1. Coat the concrete or gypsum with cold asphalt primer, using approximately 1 gallon over concrete and 1 to 2 gallons over gypsum per 100 sq. ft. of roof surface to provide a proper bond between roof deck and asphalt. Allow the primer to dry.

2. Mop the entire surface thus primed with asphalt cement, heated to flow freely, and while the cement is hot embed into it sheets of asphalt impregnated asbestos felt, weighing approximately 60 lb. per 108 sq. ft. Lap the joints 3 inches and seal them with the hot asphalt cement. The 60-lb. felt shall be laid parallel to pitch of roof and turned up 5 inches above level of roof on all vertical surfaces.

Over the 60-lb. felt, edging strips composed of flashing material shall be applied at eaves and gable overhang, extending 4 inches on roof, cemented and turned down over and secured to facia and projected ½ inch beyond to form a drip edge.

3. Mop the entire surface of the 60-lb. felt with the hot asphalt cement, and while the cement is hot imbed into it sheets of asphalt impregnated asbestos felt, weighing approximately 14 lb. per 108 sq. ft. in two-ply construction; this 14 lb. felt to be run at right angles to the 60-lb. felt, lapped 17 inches and turned up 5 inches above level of roof on all vertical surfaces.

Start at low point of roof with a one-half width sheet of the 14-lb. felt, then a full width sheet of the same felt laid flush with and entirely covering the one-half width sheet. Then lay full width sheets, setting the first so as to overlap the one-half width, starting sheet 2 inches and then exposing 15 inches of each succeeding sheet to the weather.

Mop the entire surface between plies with asphalt cement, heated to flow freely, and roll the felts closely behind the mop so that no missing of asphalt can possibly take place.

4. On gypsum and other types of roof decks that permit of nailing, the back edges of all felts shall be securely nailed to roof slab with cut nails driven through flat tin caps in addition to mopping.

5. Flashing-Walls and all other elevations above roof surface shall be carried vertically at least 12 inches to provide for proper flashing.

Roofing material shall be carried up 5 inches above level of roof on vertical surfaces. All flashings except those around ventilators, standpipes, exhausts, etc., shall be composed of base flashing of special asbestos flashing material approximately 10½ inches wide, cemented and nailed to vertical surface. Such flashings shall be counterflashed with approved fibrous mineral and bituminous cement, and applied with a reinforcement of impregnated asbestos felt.

Note.—On concrete surfaces maximum pitch upon which this roofing may be applied without nailing is 3 inches to the foot, except on short runs, as in sawtooth construction. If wood nailing strips are inserted in concrete, the pitch may be increased.

Provision for expansion should be made in covering over expansion joints in concrete slab.

Type "C2" (Class B)

Asphalt Impregnated Asbestos Felt and Asphalt Cement Over Dry Concrete or Gypsum

Roofing composed of one coat of asphalt primer, one coat asphalt cement over primer, one layer approximately 60 lb., and two layers approximately 14 lb. asphalt impregnated asbestos felt (the latter lapped 3 inches) and a minimum of 55 lb. asphalt roofing cement per 108 sq. ft., not including primer or first coat over primer.

1. Coat the concrete or gypsum with cold asphalt primer, using approximately 1 gallon over concrete and 1 to 2 gallons over gypsum per 100 sq. ft. of roof surface to provide a proper bond between roof deck and asphalt. Allow the primer to dry.

2. Mop the entire surface thus primed with asphalt cement, heated to flow freely, and while the cement is hot, imbed into it sheets of asphalt impregnated asbestos felt, weighing approximately 60 lb. per 108 sq. ft. Lap the joints 3 inches and seal them with the hot asphalt cement. This 60 lb. felt shall be laid parallel to pitch of roof and turned up 5 inches above level of roof on all vertical surfaces, but not cemented to vertical surfaces.

Over the 60-lb. felt, edging strips composed of flashing material shall be applied at eaves and gable overhang, extending 4 inches on the roof, cemented and turned down over and secured to facia and projected ½ inch beyond, to form a drip edge.

3. Mop the entire surface of the 60-lb. felt with the hot asphalt cement, and while the cement is hot, imbed into it sheets of asphalt impregnated asbestos felt, weighing approximately 14 lb. per 108 sq. ft. in single-ply construction; this 14 lb. felt to be run at right angles to the 60-lb. felt, lapped 3 inches and turned up 5 inches above level of roof on all vertical surfaces.

Start at low point of roof with a one-half width sheet of the 14-lb. felt, then a full width sheet of the same felt laid flush with and entirely covering the one-half width sheet. Then lay full width sheets, overlapping the preceding ones 3 inches, with 29 inches exposed to the weather.

Mop the entire surface between plies with the asphalt cement, heated to flow freely, and roll the felts closely behind the mop so that no missing of asphalt can possibly take place. Approximately 30 lb. of asphalt shall be used per square for each mopping.

4. On gypsum and other types of roof decks that permit of nailing, the laps of the 60-lb. felt and the back edges of the 14-lb. felt, shall be securely nailed to roof slab with cut nails driven through flat tin caps in addition to mopping.

5. Flashings-Walls and all other elevations above roof surface shall be carried vertically at least 12 inches to provide for proper flashing. Roofing material shall be carried up 5 inches above level of roof on all vertical surfaces. All flashings except those around ventilators, standpipes, exhausts, etc., shall be composed of base flashing of special asbestos flashing material, approximately 10½ inches wide, cemented and nailed to vertical surface. Such flashings shall be counter-flashed with approved fibrous mineral and bituminous cement and applied with a reinforcement of impregnated asbestos felt.

When the roofing is otherwise complete, cover the entire surface with a mopping of the asphalt cement, to be applied hot, using approximately 25 lb. to the square.

NOTE.—On concrete surfaces maximum pitch upon which this roofing may be applied without nailing is 3 inches to the foot, except on short runs, as in sawtooth construction. If wood nailing strips are inserted in concrete, the pitch may be increased.

Provision for expansion should be made in covering over expansion joints in concrete slab.

REPORT OF COMMITTEE XXIV—CO-OPERATIVE RELATIONS WITH UNIVERSITIES

Robert H. Ford, *Chairman;*	Edwin B. Katte, *Vice-Chairman;*
R. N. Begien,	C. H. Mitchell,
W. C. Cushing,	C. A. Morse,
J. M. R. Fairbairn,	G. J. Ray,
W. D. Faucette,	Wm. G. Raymond,
F. W. Green,	Henry E. Riggs,
E. T. Howson,	H. R. Safford,
Milo S. Ketchum,	Geo. F. Swain,

Committee.

To the American Railway Engineering Association:

The scope of the activities of the Committee is as follows:

(1) A greater interest upon the part of railroad officers in assisting the universities to develop the best possible methods for the technical courses.

(2) A better means of bringing to the universities the results of our deliberations, where such can be made of value to them.

(3) A better means of bringing to the attention of the railroads the benefits of a technical education, thereby acquainting them with the qualifications of graduates of these courses for initial service in subordinate positions, and at the same time providing material from which men may be drawn for higher positions as they demonstrate their fitness.

(4) A means of stimulating a greater interest in the science of transportation among engineering students who may be inclined toward this branch of industry.

(5) A means whereby the facilities of the universities may be made more directly available for the research work of the Association by co-operative effort between their laboratories and the committees of the Association.

(6) A means whereby the universities may be better enabled to educate the students and the public regarding the value of transportation to the nation as a whole.

(7) A means of stimulating a greater interest among university officials in the study of transportation and economics and impressing them with the importance of experienced men for such teaching.

Action Recommended

No final action is recommended this year.

Recommendations for Future Work

Continue along the line of present activity.

Your Committee is able to report considerable progress in new contacts established during the year with organizations who are working in other branches of industry along lines more or less similar to the activities of this Committee. These contacts are beneficial in many ways, not the least of which has been to broaden the perspective on this somewhat complicated problem.

Bulletin 285, March, 1926

Railroading is the principal agency in the transportation industry. It has been decidedly affected by the marked advances which have been made of late years in the general science of transportation and there are unmistakable evidences that this fact is being increasingly reflected by a demand for qualified young men who have been properly trained in fundamentals as a necessary preliminary for advancement in this important industry.

Well-conceived practical co-operation between the universities and the railways will result in the institutions becoming more definite factors in the development of transportation. Improved reciprocal relations will secure a better understanding of the requirements of transportation as a national undertaking. The combined result will react in a better product of more highly trained young men who are thus drawn into the fascinating business of railroading.

While there is an evident desire on the part of both railways and educational institutions for effective co-operation, there is no doubt that this can be made more effective and correspondingly beneficial. This is caused to some extent by a lack of familiarity on the part of the colleges with the methods, personnel and organization of the railroads, and by a failure on the part of many railroads to appreciate the advantages which would accrue to them through a better familiarity with the great facilities offered by our institutions of higher learning and special training, which inclines the Committee to the belief:

1. That the result of the studies so far undertaken indicates that in few, if any, of the university or college faculties is there a clear conception of the kind of training required to fit young men for railway service.
2. That this is largely due to the fact that the college faculties have been unable to secure necessary information from responsible railway officials.

The railways are not interested in getting more men to the colleges or for getting jobs for college men. They are interested in what measures should be taken to convince railway officers that the employment of a sufficient number of properly trained college men, is to the advantage of the railroads, and the Committee suggests:

3. The railways should not take into their service more college-trained men than they can assimilate.

On the presumption that the best of these young men should ultimately be found among the leaders in the transportation industry, it is essential that the training in fundamentals should be such as to enable them to advance as rapidly as opportunity, environment and association will permit. While no doubt this applies to other major industries, it applies with equal force to transportation. With this in view, it is suggested:

4. That the engineering schools do not specialize beyond the three branches of engineering; viz., civil mechanical and electrical.

The ultimate effect on personnel resulting from the various methods of employment which are found among railroads and other principal industries, and the extent that specialization may be properly undertaken by the universities and colleges, together with other allied subjects, are also under investigation by your Committee.

Questionnaire

A tentative form of questionnaire is included in the report, in the hope that constructive criticism and suggestions may be obtained. This is somewhat similar to the form which is being used by several of the major industries.

Respectfully submitted,

THE COMMITTEE ON CO-OPERATIVE RELATIONS WITH UNIVERSITIES,
ROBERT H. FORD, *Chairman.*

Questionnaire on the Employment and Training of College Graduates in Railway Service

1. How many college-trained men are employed on your road?
    - (a) Transportation Department
    - (b) Engineering Department
    - (c) Mechanical Department
    - (d) Electrical Department
    - (e) Traffic Department
    - (f) Legal Department
    - (g) Accounting Department
    - (h) Other Departments
2. How many of these men are holding official positions of the rank of Division Engineer, trainmaster, master mechanic or equivalent rank and higher?
3. How many college graduates are you enrolling in your service annually and what is their approximate distribution between your major departments?
    - (a) Transportation Department
    - (b) Engineering Department
    - (c) Mechanical Department
    - (d) Electrical Department
    - (e) Traffic Department
    - (f) Legal Department
    - (g) Accounting Department
    - (h) Other Departments
4. Are you securing these men from those making application or are special efforts made to select picked men? If the latter, please give details.
5. What additional opportunity for progressive development do you offer these young men after they enter your service?
6. What advancement are these men making as indicated by the records of those now in your service?
    - (a) Approximate average starting salary
    - (b) Salary at end of 5 years' railroad service (average of men).
    - (c) Salary at end of 10 years' railroad service (average of men).
    - (d) Salary at end of 15 years' railroad service (average of men).
7. What percentage of the college graduates which you have employed do your records show as having left your service in the first five years?
8. What measures, if any, do you think the railways should take other than those which are now in effect to draw and hold more college-trained men in service?
9. What qualities do you consider requisite for a railway officer? (List in order of importance.) Industry Judgment Education Thoroughness Resourcefulness Executive ability Willingness to assume responsibility.
10. Wherein have you found college-trained men deficient?

.... Railroad Company

(Signed) ....

Title ....

Date ....

COMMITTEE XV—IRON AND STEEL STRUCTURES

SUPPLEMENTAL REPORT

February 8, 1926

To the American Railway Engineering Association:

The Committee on Iron and Steel Structures submits herewith report supplementing the annual report for 1925.

On February 4, 1926, the Committee made a thorough review of the work that it had done on Subject No. 4, Rules for Lighting Bridges, and a uniform Code of Regulations and Signals for Operating Draf Bridges. This subject has been on the Committee's outline of work about five years, during which time it was studied carefully by a special Sub-Committee. The Committee submits its findings on the subject in the following three conclusions adopted:

1. That the lack of uniformity in the rules for operating draw bridges does not affect the railways disadvantageously.
2. That the matter of lighting and operating draw bridges has been, to a very large extent, local in its application, and no material benefit would be derived from standardization.
3. That the full development of the subject might lead to the consideration of questions seriously affecting the cost of operation of railways.

Action Recommended

Your Committee recommends that this subject be withdrawn from the Committee's outline of work.

Respectfully submitted,

The Committee on Iron and Steel Structures,
O. F. Dalstrom, *Chairman.*

MONOGRAPHS

"THE AMERICAN RAILWAY ENGINEERING ASSOCIATION"

(Address delivered before the New England Railroad Club, November 10, 1925, by J. E. Armstrong. Reprinted from the Journal of the New England Railroad Club, by permission.)

President Bean:—I am sure the members of this Club and guests appreciate very much the visit paid to us this evening by our friends from Canada, and I have pleasure in presenting to you Mr. John E. Armstrong, Assistant Engineer of the Canadian Pacific Railway Company, who will address you on the subject, "The American Railway Engineering Association,"—Mr. Armstrong. (Applause—everyone rising.)

"THE AMERICAN RAILWAY ENGINEERING ASSOCIATION"

Address by J. E. Armstrong

Assistant Engineer, Canadian Pacific Railway Company

Mr. Chairman and Gentlemen:—It was to have been the privilege of Mr. J. M. R. Fairbairn, Chief Engineer of the Canadian Pacific Railway, to address you this evening on "The American Railway Engineering Association." As an indefatigable worker for many years in that Association and as its present President, he is most admirably fitted to present this subject in an interesting and authoritative manner. I regret that under his doctor's orders he is now in Southern France and, consequently, is unable to be present. I cannot regret that the mantle of his privilege has fallen upon my shoulders.

In order that you may visualize the American Railway Engineering Association, I should like to summarize briefly the reasons for its formation, the character of its membership, its method of working and the results it has accomplished.

The rapid expansion and development of railways on the North American Continent during the latter part of the Nineteenth Century carried them to a point where no one person could have a complete knowledge of any one of the various fields of railway work. The railways had developed individually and, quite naturally, had adopted different organizations and different practices. It became evident, therefore, that for the general benefit the several branches of the service required means of exchanging views, ideas and experience in regard to the work of their respective departments. With this end in view, men engaged in similar lines of work on different railways began forming associations of various kinds.

Prior to the beginning of the present Century the scientific practice of location, construction and maintenance of American Railways, in so far as it existed, was nebulous. On different railways, but under similar physical, climatic and traffic conditions, the organization of the Engineering and of the Maintenance of Way Departments varied widely, and the practices of these various organizations varied still more widely. It was only natural to suppose that these variations included both good and bad practices, and that by careful study and by the broader knowledge available in group consideration of matters of common concern the general average of conditions might be raised and even the best current practices improved.

In March, 1899, a number of officials connected with the Engineering and Maintenance of Way and Structures Departments of American Railways organized for this purpose "The American Railway Engineering and Maintenance of Way Association." This name was later shortened to "The American Railway Engineering Association." It may be that at some future time this present name will have to be still further shortened or altered, as the interest and the membership in this Association has spread beyond the limits of this Continent and has already become practically world-wide.

A member of the Association must be either a Civil Engineer, a Mechanical Engineer, an Electrical Engineer, or an Official of a railway corporation who has had not less than five years' experience in the location, construction, maintenance or operation of railways and who is engaged in railway service in responsible charge of work. A Professor of Engineering in a college of recognized standing may also become a member. A person not eligible as a member but whose pursuits, scientific acquirements or practical experience qualify him to co-operate with members in the advancement of professional knowledge, may become an Associate Member.

The Association started with some 280 charter members at the time of its first Annual Convention in 1900, some 80 of whom are still active members. The total membership has now increased to about 2,300 scattered over all parts of the world. While the Association was formed primarily for the consideration of problems peculiar to the Engineering and Maintenance of Way Departments, it has gradually broadened its scope. This may possibly best be indicated by the fact that of the present membership some 1500 are Engineering and Maintenance of Way officers, some 130 are Presidents, Vice-Presidents and other General Officers, and over 150 are Transportation, Maintenance of Equipment, Accounting, Traffic and Purchasing Officers. Some 60 College Professors and over 400 Consulting, Government, Municipal and other Engineers outside of railway service, have been admitted to membership of one class or another.

The object of this Association, as set forth in its original Constitution, has remained unaltered both in letter and in spirit. I quote directly: "Its object is the advancement of knowledge pertaining to the scientific and economic location, construction, operation and maintenance of railways." This is a very short statement but it covers a vast field.

The measure of success to which any organization tends to attain depends upon the breadth of vision of its founders, the clarity with which this vision is set forth, and the sincerity and effectiveness with which this vision is followed. In all of these respects the American Railway Engineering Association has been particularly fortunate.

It was the belief of its founders that the best results would be obtained through the formation, under a Board of Direction, of carefully selected Standing and Special Committees, in other words, permanent and temporary committees. Acting on this belief the entire field of railway engineering was in the first instance divided into fourteen parts and a separate Standing Committee was appointed to have charge of the Association's work in each one of these fields. Committee members were selected with due regard to their qualifications for dealing with subjects within the scope of the Committee to which they were assigned and to their intimate knowledge of diverse physical, climatic and traffic conditions to be met with in different parts of the North American Continent. The number of Standing Committees has since been increased to 23 and there are also at present three Special Committees handling special problems.

It was not the thought of the founders of the Association that any one of these Committees could cover the investigation of its entire field within any specified time. The Standing Committees were, therefore, made perpetual and change in their membership is brought about so gradually as not to interfere with the continuity of their work. Certain definite subjects for investigation are assigned to each Standing Committee within its own field. As one or more of these subjects is finally reported upon other subjects are assigned so that each Committee is gradually covering more and more of the ground allotted to it. At the present time the 23 Standing Committees have over 600 members who are actively engaged in handling some 180 different assignments. It was the thought of the founders that certain progress would be made each year by each Committee and that the net results of the Association's work would, at all times, represent mutually consistent progress in the various fields. This has since proven to be the case.

Committees are charged with the investigation of current practices and the collection of all facts in regard to an assigned subject, the analysis of its fundamentals and the presentation of conclusions as to what constitutes the best practice under various conditions. In their final reports the technical terms used are defined, when pertinent a brief historical outline is included, an analysis is made of the important elements of the matter under consideration, the disadvantages of other practices and the advantages of the practices outlined in the conclusions of the Committee are stated, and finally, conclusions are presented in concise form for consideration and adoption or otherwise by the Association.

The individual assignments to a Standing Committee are usually handled by Sub-Committees, the members of which are appointed by the Standing Committee from among its own membership, with a view to having the assignment handled by specialists on that particular subject. Sub-Committee meetings are held as required for performing the detailed work of preparing the Sub-Committee's report to the Standing Committee. Standing Committee meetings are held as required to review the work of the Sub-Committees both in progress and in final form and for handling such matters as come before the Committee as a whole. Thus before the report on an assignment is submitted to the Association it has been prepared by a competent Sub-Committee of specialists and their report has been critically analyzed and approved by a Standing Committee.

When the report has reached this stage it is issued in bulletin form to the entire membership of the Association in order that they may have an opportunity of becoming fully conversant with it before it is formally presented to the Association for disposition.

Committee membership has an undoubted educational value for the individual. In the work of both the Sub-Committees and the Standing Committees it affords an opportunity for keeping in touch with the development of technical details and for studying the mental processes and methods of approach of able men engaged in work similar to one's own. Not the least of its value is the opportunity of learning something of human nature and its reactions, as it is necessary for the member to act as a unit of the Sub-Committee and of the Standing Committee as well as to act as an individual.

The Association holds an annual meeting for the consideration of the reports of the Standing Committees and such other matters as may properly come before the Association in Convention assembled. This Annual Convention extends over three days and is held in Chicago commencing on the second or third Tuesday in March. It is participated in by men from all parts of the North American Continent and, to some extent, by men from other parts of the world. It is devoted to hard, conscientious work and no distractions are permitted to interfere with the program. The one social event is the annual dinner of the Association which is held on the evening of the second day of the Convention.

It is the aim of the Association in Convention assembled to intelligently consider both the pros and cons of the reports submitted to it and to bring out a thorough discussion of any controversial features. Each Standing Committee presents its own report and must satisfactorily meet and dispose of all written criticism of that report as issued in the Bulletin, as well as all oral criticism from the floor of the Convention. If for any reason this cannot be done or if any material doubt is cast upon the conclusions, the assignment in question is promptly referred back for further consideration. Thus after the careful preparation of a report by a Sub-Committee of specialists and its adoption by a Standing Committee it must still meet with the approval of the greater portion of the body of men who compose the Association and who are in a position to make use of the recommendations in their daily work, before the report is accepted and the conclusions adopted as Recommended Practice of the American Railway Engineering Association.

Although the American Railway Engineering Association is handling certain work of the Engineering Division of the American Railway Association, it has, nevertheless, also retained its identity as a separate Association. Its membership is composed of private individuals, not of appointed representatives of the various railways. Since membership is, therefore, entirely voluntary and those who join the Association do so on account of their interest in the work it is doing, the membership as a whole has proven remarkably active. Appointment to the various Standing Committees is earnestly sought, and after the appointment is secured the individual shows a lively personal interest in, and willingness, to contribute time and effort to, the Committee-work. Membership on a Committee is in no sense honorary.

It should be borne in mind that the conclusions adopted by the American Railway Engineering Association are issued merely as Recommended Practice. They are not called standards, nor has the Association any means of compelling their adoption by the individual railways. The members of the Association, as individuals, determine to the best of their combined knowledge the best practice in any given case, make a full statement of this best practice available to the railways, and there rest their case.

In addition to the monthly Bulletins, by means of which the reports of the various Standing Committees are issued to the entire membership of the Association prior to the Annual Convention, the annual volume of Proceedings is issued shortly after each Annual Convention. These Proceedings include not only the record of all matters which have been handled directly by the Association as such, but also a complete record of all reports of Standing and Special Committees presented at that Convention, a record of the discussions, both written and oral; relative to these reports, and a record of the action taken by the Convention in disposing of them.

In order to avoid the labor which would otherwise be involved in a search of the Association's Proceedings to determine its Recommended Practice on any given subject, the Association issues a Manual of its Recommended Practice. This Manual is, in effect, the net results of the Association's work summarized in brief form and includes references to the volume and page of the Proceedings where the details leading to these conclusions are reported. It is thus not only a summary of adopted conclusions but also an index to the material which has been summarized. It is revised and reissued every few years and in the interim is kept up to date through supplements, which are issued in Bulletin form after each Convention.

The present twenty-six volumes of the Proceedings aggregate well over forty thousand pages of detailed information in regard to the scientific and economic location, construction, operation and maintenance of American railways and the current Manual contains approximately one thousand pages of summarized conclusions, including over one hundred specifications for materials and methods in which Railway Engineers are concerned, as well as innumerable plans and statements of principles which are of inestimable value to these Engineers. A new Manual is to be issued in the near future which, including the revisions and additions which are now outstanding in supplement form, will probably contain somewhere in the neighborhood of fifteen hundred pages of summarized knowledge of the Railway Engineering profession.

It is, of course, impossible for me to attempt to outline at this time all of the Recommended Practice of the American Railway Engineering Association, but a few cases which may be regarded as indicative of the whole may be of interest to you. A study of the effect of moving loads on railway bridges has thrown much light on the previously vague knowledge of the important effect of impact in bridge design. The studies which have been conducted for many years in connection with the stresses to which rail is subjected in the track have developed extremely useful information. A series of rail sections, varying from 90 pounds to 150 pounds per yard by 10-pound increments, is recommended and are gradually being adopted by the railways to supersede the multiplicity of rail sections heretofore in use. Concurrent with the study of rail and of rail failures in the track there has been a reduction in the number of rail failures on the North American Continent from about 400 failures per 100 track miles in the first five years of the rail's service to about 125 such failures and the record is such as to indicate that this number will probably continue to decrease in the future. I shall not now take more of your time in giving examples of the Association's work or the very valuable effects that have resulted from it. Let me suggest that those of you who are interested examine at least the Manual. I can assure you that in it you will find much interesting and vital information.

During the earlier years of the Association's existence its activities were directed mainly to developing and perfecting the transportation plant and equipment. This field is, as yet, by no means finally covered but more recently the human factor has come to the fore and is receiving the consideration its importance merits. The Association, realizing that all other factors depend upon the loyal support and intelligent cooperation of the human factor, now has Standing Committees actively engaged in studying conditions of employment, maintenance of way labor in connection with seasonal supply and demand, and economic organization, education, discipline and equipment of forces for various kinds of work. Pertinent information in regard to these and allied subjects will, I have no doubt, appear more frequently and more extensively in the future Proceedings and Manuals of the Association.

The American Railway Engineering Association may, I believe, take pride in the results which it has achieved. Over a period of more than a quarter of a century it has worked, in its own field, toward uniformity of practice on the railways of this Continent and has endeavored consistently to make that uniform practice the best practice. The results secured, while possibly at times appearing to the overly enthusiastic to be slight, have been, I am sure, as rapid as can be expected considering the multiplicity of diverse practices which have been in vogue, and the inability of the railways to economically adopt many of the Recommended Practices until large renewals or new construction permit. Certainly the individual members have been stimulated and developed, and the railways have benefited in organization, materials and methods, particularly in those matters falling under their Engineering and Maintenance of Way Departments.

In conclusion, it may be asserted without fear of contradiction that so far in the Twentieth Century railway construction could not have progressed as it has, nor the railways have been as effectively operated and maintained as they have been had it not been for the organization and co-operation, shoulder to shoulder, individually and collectively, of the members of the American Railway Engineering Association.

Gentlemen—I thank you. [Applause, everyone rising.]

President Bean:—Mr. Armstrong, the members of this Club appreciate very much your kindness in coming here and giving us such a concise but complete picture of the aims, organization and functioning of the American Railway Engineering Association.

We are honored tonight by the presence of Mr. Grant Hall, Vice-President of the Canadian Pacific, and I am sure that all present will be very glad if Mr. Hall will be good enough to say something to us. [Applause.]

Mr. Grant Hall:—Mr. President and Gentlemen: It will of necessity be short, because, unfortunately, I do not always think of something to say, and then when I get on my feet I cannot say what I did think.

I think it is five years ago, 1920, that I had the pleasure of inaugurating, at the suggestion of some of your members, what has now got to be something of a feature at any rate for us who come down from Canada to visit you on this Canadian Night.

It is a matter of regret in a way that Mr. Fairbairn could not get here. He has been given the highest position in the gift of the A.R.E.A., in that this year he was elected President. Unfortunately his health not being of the best it was decided by his physicians that a complete rest was necessary and that he should cross the water. Speaking personally, if I may, I am very much pleased at the way the subject was handled by Mr. Armstrong and I am sure you are also from the way you received it.

It is always a pleasure for me to come here. I am sorry my throat is not in very good condition tonight. It is like some of the other throats I have heard on the radio lately, because of talking too much or shouting too much, but I wish to thank you all very much indeed and I sincerely trust that I will be where I can come again should you do me the honor to ask me. [Applause.]

President Bean:—Mr. Armstrong wishes to add a word to his remarks.

Mr. Armstrong:—I want to express my appreciation for being permitted to come down here and be with you this evening.

I have heard of the New England Railroad Club. I knew that Mr. Hall was very much interested in the New England Railroad Club, but I had no conception of what it really meant. It has been an eye-opener to me and an opportunity, and I want to express my very sincere appreciation for being able to be with you at your invitation. [Applause.]

President Bean:—Professor Allen, will you be good enough to say a few words?

Professor C. Frank Allen:—It is almost unsafe to ask me to say a work on Canadian Night. I have appreciated, I presume, more than most of the members the splendid paper of Mr. Armstrong. I was not one of the charter members of the American Railway Maintenance of Way Association, as it was first called, but I became a member very shortly afterwards. For many years I attended, as one of only two or three members in New England, the meetings of that Association, and in many ways I have been closely identified with their work. I am still a member of one of their committees, and I can supplement what Mr. Armstrong has said about the Association.

I belong to a number of organizations and I know of none that is so efficient in its work as the American Railway Engineering Association. I remember in the earlier years when the reports of the committees had not reached quite the state of—perfection is not quite the right word—that they afterwards reached, that the conventions were pretty lively in the discussion and dissection of committee reports, but it took but a very few years before the situation became such that in the convention itself it was pretty nearly hazardous to try and upset the recommendations of the committee. If one followed the earlier stages of the conventions that was a very noticeable effect.

In the work of the committees, not only are meetings held, not only are sub-committees appointed, but between the meetings there is a constant interchange by correspondence between all the members; monthly letters are sent to all the members on anything that one of the members sees fit to suggest or criticisms that he makes, so aside from the formal meetings there is a constant meeting going on of a very efficient sort.

I am not sure but what I have attended all of the Canadian meetings. I have a great deal of enthusiasm for our Canadian friends in one way or other. The Chairman of my committee for a number of years was the late Mr. McNab, of the Grand Trunk, who was, I think, the most effective member of the American Railway Engineering Association in keeping Canadians in close touch with conventions of the Association. When I say to you that in their conventions, as I think, I do not know of an exception where the event of the dinner has been other than the speech of a Canadian member. I do not know how they manage, either in that convention or here, to get such talent to bring before us as has been the case.

It is very hazardous to get me on my feet in connection with the Canadian meetings or in connection with the Canadians. My relations have been so extremely pleasant in every way that to me it is a greater pleasure than to almost any of you here to have a chance to say a word of enthusiasm for what our meetings have been.

I thank you very much for the opportunity to speak. [Applause.]

A MONOGRAPH

ON

TRANSLATING THE PHYSICAL CHARACTERISTICS OF A RAILWAY LINE INTO EQUIVALENT STRAIGHT AND LEVEL MILES AND TON-MILE COST IN THE ECONOMICS OF RAILWAY LOCATION AND OPERATION

By J. L. Campbell
Past-President, American Railway Engineering Association

SYNOPSIS

Rise and fall and curvature imposing, as they do, excess work in hauling a train between termini above that which would be required on the straight and level distance between the termini, and, the rate of rise or grade limiting, as it does, the weight of train, these physical characteristics impose upon a transportation plant limitation of capacity and excess cost of service which may be economically abated only as it is economically practicable to eliminate rise and fall and curvature or reduce grade rates.

The work necessary to overcome grade and curve resistance being reducible to equivalent straight and level track, as hereinafter shown, there can be, by such reduction, a restatement of the lengths of two or more railway lines in terms of straight and level miles and thereby be found the relative effects of rise and fall and curvature as between the lines so compared.

The formula or method herein described for translating the physical characteristics of a railway line into mileage and ton-mile cost is a modification of a method for the purpose devised by C. E. Day, Assistant Engineer, Southern Pacific Company.

TRANSLATION OF PHYSICAL CHARACTERISTICS

Application of the formula translates rolling train resistance, rise and fall of the train due to grades, and the resistance caused by curvature changing the direction of the train into equivalent straight and level track miles and ton-mile cost. It also includes the effect of limitation of train tonnage and multiplication of trains or use of helper engines due to grade rates.

THE COST ELEMENT

Ascending and descending grades increase wear and tear on track and equipment. Ascending grades increase but descending grades decrease fuel and water consumption. Because these two outstanding factors, wear and tear on track and equipment and fuel and water consumption, thus enter and affect the problem in differing ways and degrees, and since each gives a ratio of its own as between actual track miles and equivalent straight and level miles, as hereinafter appears in development of the formula, it is necessary to weight these ratios by applying to them unit ton-mile costs appropriate to the items of maintenance of way and equipment and fuel and water consumption as hereinafter shown in order that there may be derived as between actual mileage and equivalent straight and level mileage a single ratio in terms of ton-mile cost which shall include and reflect the effect of every element of the physical characteristics of the line or lines thus equated. The precise value of the unit costs, hereinafter shown, is immaterial because they apply comparatively and equally on both sides of all equations and to all lines included in the comparison. Any reasonable unit costs will do. Large variation in any one or all of the unit costs immaterially affects the ratio.

BASIS OF EQUATING MILEAGE

The ton-mile cost of moving tonnage trains over the entire line derived as the average of the ton-mile costs on all of the several engine districts composing the entire line is the basis of equating mileage and comparison between two or more lines. If the ton-mile cost on one line is represented by 1 and, on another, by 2, the ratio of equated mileage as between the lines is 2.

SIGNIFICANCE OF THE FORMULA

Application of the formula, the ratios derived thereby and the relation revealed between two or more lines reflect only the effect of the physical characteristics of distance, rolling resistance, rise and fall, grade rates and curvature. In the economics of railway location and operation, it is a measure of the absolute and relative effects of the characteristics named.

COMPOSITION OF THE FORMULA

The formula and its complete application are composed of two parts. The first consists of three equations, (a), (b) and (c), hereinafter given, whereby ratios between actual miles and their equivalent straight and level miles for wear and tear on track and equipment and fuel and water consumption are derived as shown. The second part or process consists in applying to the product of train tonnage by unit ton-mile costs the said ratios as multipliers, as hereinafter shown in illustrations (A), (B), (C) and (D).

The formula and its application will now be stated and illustrated in detail.

FORMULÆ

For translating rolling train resistance, rise and fall and curvature of railway track into equivalent track miles, rolling resistance on one mile of track being the equivalent of one track mile.

Let g^1 = grade of repose = rolling resistance in pounds per ton divided by 20.

l = total miles of track = $l_1 + l_2$.

l_1 = miles of track having grades not less than grade of repose.

l_2 = miles of track having grades less than grade of repose.

l_3 = miles of track on which locomotive works against rolling resistance in direction of movement.

p = rolling resistance in pounds per ton of train weight.

r = total rise or fall in feet both ways of all grade lines hereinafter defined.

r_1 = total rise in feet one way of all grade lines hereinafter defined.

r_2 = total fall in feet both ways of all profile grade lines having grades less than grade of repose.

r_3 = total fall in feet one way of all profile grade lines having grades less than grade of repose.

r_4 = curve resistance in feet vertical per degree of central angle.

v = total in feet both ways of all velocity heads hereinafter defined applying due to grade.

v_1 = total in feet one way of all velocity heads hereinafter defined applying due to grade.

x = that part of track mile which equals 1 foot of rise or fall.

Let $p = 6$ lb. $= g^1 = 0.3$ of a foot vertical per 100 feet horizontal = 15.84 feet vertical per 1 mile horizontal.

$r_4 = .04$ of a foot vertical $= .0025$ of a mile horizontal.

Then $g' = 0.3$ per cent grade; $r_4 = .0025$ of a track mile; and $x = .0631$ of a track mile.

(a) And $x(r - v) + l$ = track miles of work one way or both ways due to grade and rolling resistance.

(b) $\frac{x(r - r_2 - v) + l_1}{2} l_2$ = track miles of fuel and water both ways due to grade and rolling resistance.

(c) $x(r_1 - r_3 - v_1 + g^1 l_3)$ = track miles of fuel and water one way due to grade and rolling resistance.

NOTE.—In the three equations (a), (b) and (c), the word grade means rise and fall.

Use of Equations

Equation (a) covers a train one way or both ways and is the measure of wear and tear on track and equipment. Equation (b) covers a train both ways and is the measure of fuel and water consumption both ways. Equation (c) covers a train one way only and is the measure of fuel and water consumption one way only.

Basis of Equations

The equations rest on the relation existing between rolling train resistance and rise and fall when all are stated in terms of feet vertical and on the fact that (all factors except grade and gravity aside) the foot pounds of work delivering a train down a grade line equals the foot pounds of work pulling it up the line, and on the theory that the effect upon track and equipment of moving trains on the track is proportional to the work done in moving the trains.

Grade and Rolling Resistance

Gravity resistance against pulling a train up a 1.0 per cent grade is 20 lb. per ton of train weight. If rolling resistance equals 6 lb. per ton, it equals the resistance of a grade whose rate is 6 divided by 20 or a 0.3 per cent grade rising 15.84 feet per mile, from which (taking rolling resistance on one mile of track as the equivalent of one track mile) one foot of rise is equivalent to .0631 of a mile of track.

Work Done

Up grade, the locomotive delivers work through the driving wheels, and, down grade, through the brakes. Up grade, there is added to, and down grade, substracted from, the work due to grade done by the locomotive, the work of overcoming rolling resistance. Also from the work up grade and down grade there is subtracted from each the work stored as potential energy in the allowable velocity head accruing on grade due to grade. All work and velocity-heads are stated in the terms of feet vertical and the algebraic sum thereof multiplied by the numerical value of x gives the equated mileage.

Grade of Repose $g^1 = \mathrm{p} =$ Rolling Resistance

On a value of 6 lb. per ton for rolling resistance, the grade of repose is 0.3 of a foot vertical per 100 feet horizontal or 15.84 feet per mile. That value is taken to be a mean for freight train equipment and speed. On the grade of repose, grade resistance equals rolling resistance and either is the measure of fuel and water consumption. On grades less than the grade of repose, rolling resistance (constant for all grade rates) is the measure of it. On grades greater than grade of repose, grade resistance (variable with rate of grade) is the measure of it.

Grade Lines

As here defined, a grade line for translating rise and fall into mileage may be a single straight line. It may be a composite line over which, down grade, a train can be moved within speed restriction by gravity against grade resistance only. Such a grade line may contain any number of level sections or adverse sections no one of which rises in feet against gravity movement of train more than the attainable and allowable gravity velocity-head at the lower end of the rise. Each such grade line should include as much of the profile (not included in any other such line) as will fall within the limitations for a composite line above specified.

Total Rise or Fall r

The total rise or fall, r, is the sum of rise or fall of all grade lines above defined. It does not include rise or fall of adverse sections of composite grade lines. The rise or fall of a composite line is the difference in elevations of its ends.

Total Rise r_1

The rise, r_1, is the total rise of all grade lines above defined which rise in one and the same direction. It has two values (one for each direction) and the sum of the two equals r. In the Tabulation of Data table below, there are two columns for r_1. The left-hand column may be used for northerly or easterly directions and the right-hand column for southerly or westerly directions.

Total Fall r_2

The fall, r_2, is the total fall in both directions of all those parts of the profile grade line (l_2) which fall at a rate less than the grade rate of the grade of repose.

Total Fall r_3

The fall, r_3, is the total fall in one and the same direction of all those parts of the profile grade line which fall at a rate less than the grade rate of the grade of repose. It has two values (one for each direction) and the sum of the two equals r_2. In the Tabulation of Data table below, there are two columns for r_3 as above described for r_1.

Velocity-Head Total v and v_1

The velocity-head of a grade line equals the fall of the line provided the fall does not exceed the allowable head. For greater fall, the head equals the maximum, which, for freight trains, is here taken to be 20 feet. The sum of the heads of all grade lines equals v. The velocity-head of a grade line does not include velocity-heads which overcome grade resistance of adverse sections thereof. For any grade line, there is one velocity-head. This head is additional to a velocity-head on the summit of a grade line which summit of velocity is here taken to be 3.5 feet for freight trains. If the total velocity-head on the summit is not less than 23.5 feet, no accrual of velocity on grade is admissible and no velocity-head is subtracted. v_1 one way plus v_1 the other way equals v.

MILES OF l

l equals total miles of track or l_1 plus l_2.

MILES OF l_1

l_1 includes all track having grade rates not less than grade of repose. On such grades, the locomotive works against rolling resistance one way (upgrade) only.

MILES *of* l_2

l_2 includes all track having grade rates less than grade of repose. On such grades, the locomotive works against rolling resistance both ways.

MILES OF l_3

l_3 includes all track except those sections which fall in the direction of train movement at a rate not less than the grade rate of the grade of repose. It has two values (one in each direction).

In the Tabulation of Data table below, there are two columns for l_3. The left-hand column may be used for northerly or easterly directions and the right-hand column for southerly or westerly directions.

Tabulation of Data

In tabulating data from the profile, enter l to l_3, inclusive, in stations of 100 feet and reduce totals to miles as shown below. If preferred, totals for l_3 need not be so reduced but may be multiplied by 0.3 for equivalent feet vertical.

Stations	l	l_1	l_2	l_3		Elevations	v	v_1		v_2	v_3		v	v_1	
13344	....	....	....	East	West	4331.	....	East	West	....	East	West	....	E.	W.
13709	365	257	108	108	365	4576.	245	0	245	13	13	0	20	0	20
13835	126	112	14	126	14	4501.	75	75	0	0	0	0	20	20	0
14309	474	402	72	72	474	4835.	334	0	334	12	12	0	20	0	20
14365	56	34	22	56	22	4799.	36	36	0	3	0	3	20	20	0
14424	59	35	24	24	59	4834.	35	0	35	4	4	0	20	0	20
Totals	1080	840	240	386	934		725	111	614	32	29	3	100	40	60
Miles	20.45	15.91	4.54	7.31	17.69										

$$\text{Equation (a) } x\,(r - v) + l$$
$$= .0631\,(725 - 100) + 20.45 \qquad = 59.89 \text{ miles}$$

$$\text{Equation (b) } \frac{x\,(r - r_2 - v) + l_1}{2} + l_2$$
$$= \frac{.0631\,(725 - 32 - 100) + 15.91 + 4.54}{2} \qquad = 31.21 \text{ miles}$$

$$\text{(East) Equation (c) } x\,(r_1 - r_3 - v_1 + g^1 l_3)$$
$$= .0631\,(111 - 29 - .40 + 7.31 \times 15.84) \qquad = 9.97 \text{ miles}$$

$$\text{(West) Equation (c) } x\,(r_1 - r_3 - v_1 + g^1 l_3)$$
$$= .0631\,(614 - 3 - 60 + 17.69 \times 15.84) \qquad = 52.44 \text{ miles}$$

$$\frac{\text{Equation (c) East} + \text{Equation (c) West}}{2} =$$
$$= \frac{(b) = 9.97 + 52.44}{2} = 31.21 \text{ miles}$$

Equation (a) gives equated mileages for wear and tear on track and equipment

Equation (b) gives equated mileage for fuel and water consumption both ways.

Equation (c) (East) gives equated mileage for fuel and water consumption in that direction.

Equation (c) (West) gives equated mileage for fuel and water consumption in that direction.

$$\frac{\text{Equation (c) East} + \text{Equation (c) West}}{2} = \text{Equation (b)} = 31.21 \text{ miles}$$

in example above.

Ratios of Equated to Actual Mileage

In the foregoing example, the equated mileages divided by the actual mileage give the following ratios:

Equation (a)	59.89 ÷ 20.45 = 2.928
Equation (b)	31.21 ÷ 20.45 = 1.526
Equation (c) (East)	9.97 ÷ 20.45 = 0.487
Equation (c) (West)	52.44 ÷ 20.45 = 2.564

These ratios represent the mileage of straight and level track which, as to track miles of work or fuel and water, is the equivalent of one of the actual 20.45 track miles. For example, under equation (a), operation of trains on one actual mile is equivalent to operating them on 2.928 miles of straight and level track. These ratios are determined as hereinbefore shown for each engine district or helper district. They are then used as multipliers of ton-mile costs for straight and level track as hereinafter shown.

Curvature, r_4

To the foregoing equated mileages due to rolling train resistance and rise and fall, there is added the equated mileage due to curvature which is .0025 multiplied by number of degrees of curvature. If on the 20.45 actual miles above, there are 400 degrees, there is added under equation (a) $.0025 \times 400 = 1.00$ mile, and the total equated mileage is then $59.89 + 1.00 = 60.89$ and the ratio is $60.89 \div 20.45 = 2.977$.

This equated mileage due to curvature is likewise added to equated mileage of fuel and water except that the curvature on grade rates not less than the sum of grade compensation for curvature plus the grade of repose is excluded as to down grade train movement thereon, and, of the curvature on grade rates less than the sum named, only that percentage shown in the table next below is included. For example, referring to the table, all curvature of a 5 degree curve on a 0.5 grade is excluded down grade; but, of a 10 degree curve on this grade, 50 per cent of the curvature is included, grade compensation for curvature being at the rate of .04 per degree of curve rate and grade of repose being 0.3, from which the sum of curve compensation on a 5 degree curve plus grade of repose is 0.5, and, the actual grade, 0.5, not being less than this, all of the curvature is excluded. But, on the 10° curve, the sum named is 0.7 or a grade rate which measures the combined rolling and curve resistance on the 10 degree curve. Since the actual grade rate is 0.5, there is a resistance equal to that of a 0.2 grade which is not liquidated by gravity acting on the actual 0.5 down grade. Since all of rolling resistance is already covered in equations (a) to (c) inclusive, this unbalanced resistance equal to that of a 0.2 grade is curve resistance. On the 10 degree curve, total curve resistance is equal to that of a 0.4 grade, from which, it follows, in this case, that the percentage of total curvature unbalanced by the 0.5 grade is $0.2 \div 0.4 = 50$ per cent, which must be overcome by consumption of fuel and water. In this manner, the table is constructed as follows:

PERCENTAGE OF CURVATURE TAKEN DOWN GRADE

Curve	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°	11°	12°	13°	14°	15°	16°	Curve
Grade																	Grade
.3	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	.3
.4	.....	0	17	38	50	58	64	69	72	75	77	79	81	82	83	84	.4
.5	.....	.....	.....	.....	0	17	29	38	44	50	55	58	61	64	67	69	.5
.6	.....	.....	.....	.....	.....	.....	0	6	17	25	32	38	42	46	50	53	.6
.7	.....	.....	.....	.....	.....	.....	.....	.....	.....	0	9	17	23	29	33	38	.7
.8	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0	4	11	17	22	.8
.9	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0	6	.9
1.0	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0	1.0

Up grade or on the level, all curvature is, of course, taken.

Ton-Mile Unit Costs

Ton-mile unit costs for straight and level track are required as follows:

1. Maintenance of way account of engines.
2. Maintenance of way account of cars.
3. Maintenance of engines.
4. Maintenance of cars.
5. Fuel and water.

Also train and engine mile costs of

1. Train wages.
2. Engine wages.

Unit costs for straight and level track are found by dividing actual costs by the ratio which equated mileage bears to actual mileage. For this purpose, a typical district or districts giving a fair average ratio for all districts should be used. As already indicated in the paragraph on the cost element, great refinement in determining unit ton-mile costs is unnecessary for the purpose of ascertaining relative operating economies as between two or more lines.

For illustrations hereinafter given, unit costs are taken as follows:

1.	Maintenance of way account of engines..	$0.000192	per ton-mile.
2.	Maintenance of way account of cars.....	0.000096	per ton-mile.
3.	Maintenance of engines................	0.000100	per ton-mile.
4.	Maintenance of cars..................	0.000122	per ton-mile.
5.	Fuel and water.......................	0.000204	per ton-mile.
6.	Train wages..........................	0.165000	per train mile.
7.	Engine wages.........................	0.142500	per engine mile.

These unit costs include only items affected by use of the property. Such items may be found by the method of the American Railway Engineering Association or the Interstate Commerce Commission.

Engine and Helper Districts

Preparatory to equating the physical characteristics of a railway line to equivalent straight and level track, a condensed profile of the line is necessary whereon are shown the several engine districts, helper districts, if any, and ruling grades, from which, based on an engine of given weight and tractive effort, train tonnage and helper service can be found.

In the illustration below of train-mile and ton-mile costs on an engine district, the ruling grade is 0.5 East and 1.26 West. A 230 ton engine delivering a tractive effort of 50,000 lb., a combined efficiency of 90 per cent for the road engine and helper engine working together, and 6 lb. per ton for rolling resistance are assumed. All helper engine tonnage, including returning light, is charged to the direction in which the helper works in assisting the road engine.

In the illustration, the ratios which the equated miles bear to the actual miles, found, including curvature, as hereinbefore shown, are as follows:

For equation (a)	1.950
For equation (b)	1.128
For equation (c), East	0.647
For equation (c), West	1.607

Four illustrations are given, as follows:

(A) Equating both ways in one operation for balanced tonnage.

(B) Equating one way, eastbound, for balanced tonnage.

(C) Equating one way, westbound, for balanced tonnage.

(D) Equating for unbalanced tonnage in ratio of 10 tons East to 7.5 tons West.

(A) Both Ways for Balanced Tonnage

Train-mile cost from E to F, 26.3 miles.

Direction, both ways.
Ruling grade, 0.5% East and 1.26% West.
Weight of one engine, 230 tons.
Engine weight on 0.5 grade 230 tons
Trailing load on 0.5 grade 2900 tons
Total 3130 tons
Trailing load on 1.26 grade 2900 tons
*Engine weight on 1.26 grade 540 tons
Total 3440 tons

Maintenance of way account engines	540 tons @ \$0.000192 × 1.950 =	\$0.2022
Maintenance of way account cars	2900 tons @ 0.000096 × 1.950 =	0.5429
Maintenance of engines	3440 tons @ 0.000100 × 1.950 =	0.6708
Maintenance of cars	2900 tons @ 0.000122 × 1.950 =	0.6899
Fuel and water	3440 tons @ 0.000204 × 1.128 =	0.7916
Train wages		0.1650
†Engine wages = \$0.1425 × 540 ÷ 230		0.3349
Total train mile cost		3.3973
Ton-mile cost of trailing load		0.00117
Cost per ton, entire distance		0.0308

(B) Eastbound for Balanced Tonnage

Train mile cost from F to E, 26.3 miles.

Direction, Eastbound.
Ruling grade, 0.5 per cent.
Weight of one engine, 230 tons.
Trailing load on 0.5 grade, 2900 tons.
Engine weight on 0.5 grade, 230 tons.
Total 3130 tons.

Maintenance of way account engines	230 tons @ \$0.000192 × 1.950 =	\$0.0861
Maintenance of way account cars	2900 tons @ 0.000096 × 1.950 =	0.5429
Maintenance of engines	3130 tons @ 0.000100 × 1.950 =	0.6104
Maintenance of cars	2900 tons @ 0.000122 × 1.950 =	0.6899
Fuel and water	3130 tons @ 0.000204 × 0.647 =	0.4131
Train wages		0.1650
Engine wages		0.1425
Total train mile cost		2.6499
Ton-mile cost of trailing load		0.0009
Cost per ton, entire distance		0.0237

---

*Number of engines on helper grade $= \frac{2900 \times 31.2}{0.9\ (50000 - 230 \times 31.2}$

†Engine mile wages cost assumed proportional to engine tonnage.

(C) Westbound for Balanced Tonnage

Train mile cost from E to F, 26.3 miles.
Direction, Westbound.
Ruling grade, 1.26%.
Weight of one engine, 230 tons.
Trailing load on 1.26 grade, 2900 tons.
Engine weight 540 tons.
Total 3440 tons.

Maintenance of way account engines	850 tons @ $0.000192 × 1.950 =	$0.3182
Maintenance of way account cars	2900 tons @ 0.000096 × 1.950 =	0.5429
Maintenance of engines	3750 tons @ 0.000100 × 1.950 =	0.7313
Maintenance of cars	2900 tons @ 0.000122 × 1.950 =	0.6899
Fuel and water (West)	3440 tons @ 0.000204 × 1.607 =	1.1277
*Fuel and water (East)	310 tons @ 0.000204 × 0.647 =	0.0409
Train wages		0.1650
Engine wages	= $0.1425 × 850 ÷ 230	0.5266
Total train mile cost		4.1425
Ton-mile cost of trailing olad		0.00143
Cost per ton, entire distance		0.0376

Note.—For balanced tonnage, ton-mile cost East plus ton-mile cost West divided by 2 equals ton-mile cost both ways as shown herein in illustrations (A), (B) and (C) which is as it should be. For unbalanced tonnage, the line is necessarily equated in each direction separately.

(D) Unbalanced Tonnage, 10 Tons East, 7.5 Tons West

(a) Eastbound, F to E, 26.3 miles.
Same as (B) above for balanced tonnage.
(b) Westbound, E to F, 26.3 miles.
Trailing load = 2900 × 7.5 ÷ 10 = 2175 tons
Engine weight = 405 tons
Total 2580 tons

Maintenance of way account engines	580 tons @ $0.000192 × 1.950 =	$0.2172
Maintenance of way account cars	2175 tons @ 0.000096 × 1.950 =	0.4072
Maintenance of engines	2580 tons @ 0.000100 × 1.950 =	0.5031
Maintenance of cars	2175 tons @ 0.000122 × 1.950 =	0.5174
Fuel and water (West)	2580 tons @ 0.000204 × 1.607 =	0.8458
Fuel and water (East)	175 tons @ 0.000204 × 0.647 =	0.0231
Train wages		0.1650
Engine wages	= $0.1425 × 580 ÷ 230	0.3593
Total train mile cost		3.0381
Ton-mile cost of trailing load		0.0014
Cost per ton, entire distance		0.0368

Ton-Mile Cost, Entire Line

The sum of the costs per ton (last item of illustration above) of all of the engine districts of a railway line divided by the total length in miles of the line gives the average ton-mile cost for the entire line

---

*Fuel and water for return of helper engine (310 tons) east is chargable to westbound movement at ratio (0.647) east.

resulting from the physical characteristics of distance, rolling resistance, rise and fall, grade rates, and curvature.

Economic Comparisons

With the ton-mile cost for each of two or more lines determined as described the basis is laid for comparison of relative economy of railway location and operation as between the lines as affected by their physical characteristics. If this ton-mile cost on one line is divided by this ton-mile cost on another line, a ratio between them is found, and, if the actual mileage of the one line is taken as unity, the actual mileage of the other line multiplied by the ratio gives the equivalent mileage of the other line, from which with a given tonnage, the comparable costs of operation of the lines as determined by their physical characteristics may be found.

On first reading of the foregoing discussion of this method of translating physical characteristics, the process may appear complicated and cumbersome, but familiarity with it, easily acquired, will reveal that it is simple and may be applied with ease and expedition.

SHRINKAGE OF EARTH, SWELL OF ROCK AND SHRINKAGE OF BALLAST

By H. E. Hale

Engineer Eastern Group, Presidents' Conference Committee

There has recently been assembled by the authority of the Presidents' Conference Committee, a large amount of data, showing by actual measurement the shrinkage of earth and swell of rock. This yardage was measured in the cut and compared with the yardage of the same material measured in its compacted condition in railroad fills.

It can be readily seen any ordinary measurement of yardage of railroad cuts and fills would be of little value in determining the shrinkage or swell of the grading material, for two reasons:

> (1) The construction records do not usually show the exact location in fills of grading materials taken from certain cuts, which would permit measuring the same material in the cut and later in its compacted condition in the fill.
>
> (2) On an operating railroad, the yardage of cuts and fills is materially affected by the ditching and bank widening and wastage of material on fills.

Practically the first reliable data on this subject which the Sub-Committee was able to obtain was from the Vermont Central, on the Providence Extension of the Grand Trunk. The grading was never completed and therefore the grading for certain fills came from adjacent cuts only and no other material could have been used in these fills.

As the line had not been put in operation, the yardage was not affected by ditching nor bank widening and care was used to select fills where there was no subsidence which might affect the measurements.

Total yardage finally assembled, on which reliable data on shrinkage and swell was determined, equaled about 12,000,000 cu. yd. This yardage came from twenty different states and is, therefore, representative of the whole country and this quantity can be considered a very large yardage for the purpose of this study.

The Sub-Committee assigned to this investigation was composed of Messrs. D. J. Brumley, Chairman; H. E. Hale and Charles Silliman. Their first report was issued January 22, 1920, and a supplement was issued July 23, 1921. In the report, all projects were tabulated and full information was given for each project, such as name of railroad, location, kind of material, percentage of rock, loose rock and earth, the total yardage in excavation, and the total yardage in embankment of the identical material, etc.

The following diagram gives graphically the result of the study.

Shrinkage of Ballast

By the term "shrinkage of ballast" is meant the decrease in volume of the ballast as loaded at the pit and measured in cubic yards dumped loosely in the car, compared with the number of cubic yards measured in track after the same ballast has been tamped and compressed by the passage of trains.

Particular attention is called to the fact that "pay quantities" for ballast almost invariably consists of yardage of ballast dumped loosely in the car at the pit.

It is frequently assumed that ballast material, such as gravel, chatts, etc., will not shrink as much as earth. This assumption, however, fails to take into consideration the fact that the shrinkage of earth is measured by comparing the yardage as compacted under natural conditions in a cut, with the yardage of the same material compacted in a railroad fill, whereas the shrinkage of ballast is measured by comparing the yardage dumped loosely in cars at the pit, where it is paid for, with the yardage of the same material tamped and compacted in track under the passage of trains.

The difficulty of measuring with reasonable accuracy the shrinkage of ballast is due to the usual practice of ballasting a road piecemeal and to the general practice of keeping no record of the location of ballast bought under various contracts from various pits.

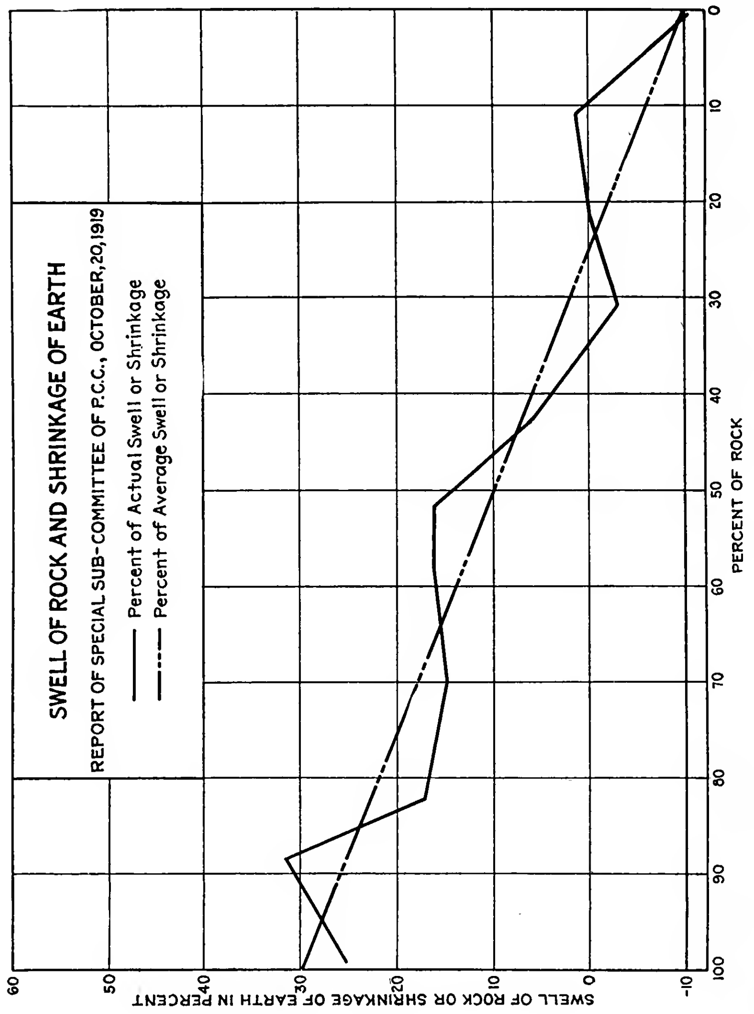
The following table gives some interesting results of actual measurements showing the shrinkage from the pay quantities to the yardage as measured compressed in the track:

Shrinkage for Various Kinds of Ballast.

Kind of Ballast	Number of Projects	Yards of Material		Per Cent of Shrinkage
		Purchased	Measured in Track	
Crushed Stone	8	2.113,117	1,812,020	16.62
Chatts	2	222,936	205,450	8.51
Gravel	3	381,586	313,295	21.80
Sand	1	74,910	65,484	14.39
Slag	1	195,159	157,234	24.12
Cinder	1	"Altoona	Test"	27.00

The quantities of ballast in this table are not large, compared with the total ballast in the railroads of the United States. However, if we consider the difficulties of comparing the yardage of ballast measured, compressed in track, with the same material measured dumped loosely at the pit, we may consider ourselves fortunate to have this amount carefully measured.

The shrinkage of ballast has sometimes been referred to as a loss of ballast and in some cases the additional ballast added to overcome this shrinkage has been charged to operation because it is said to be a replacement.


SWELL OF ROCK AND SHRINKAGE OF EARTH
REPORT OF SPECIAL SUB-COMMITTEE OF P.C.C., OCTOBER, 20, 1919
Percent of Actual Swell or Shrinkage
Percent of Average Swell or Shrinkage
PERCENT OF ROCK
0
10
20
30
40
50
60
70
80
90
100
SWELL OF ROCK OR SHRINKAGE OF EARTH IN PERCENT
60
50
40
30
20
10
0
-10

There is, however, no more reason to assume that ballast is lost due to shrinkage than there is to assume that cotton is lost due to the shrinkage of a bale of cotton in passing through a compress.

From this information, it is evident that in ordering ballast to produce a given ballast section, an allowance must be made for shrinkage in the same way that an allowance is made for "cutting and wastage" of lumber for buildings.

WATER SOFTENING DEVELOPMENTS ON THE ROCK ISLAND LINES

By P. M. LaBach
Engineer, Water Service, Chicago, Rock Island & Pacific Railway

A year ago there appeared in the columns of Railway Engineering and Maintenance a resumé of a report on results obtained by the use of sodium aluminate solution at certain water softening plants on the Chicago, Rock Island & Pacific. Since that time the use of this material by the Rock Island has been extended considerably and many laboratory and operating tests made to determine its behavior under varying conditions, and the proper means for its application to obtain the best results. The following is a summary of results obtained at Council Bluffs and Estherville, Iowa.

The Council Bluffs plant consists of a 26 ft. by 52 ft. settling tank with an 8 ft. diam. downtake equipped with double mechanical agitators. Chemical feeding is accomplished by means of a 10 in. by 12 in. duplex Roberts water motor. The water is obtained from the municipal supply of Council Bluffs which is drawn from the Missouri River and passed through the city's filtration plant. The use of sodium aluminate solution as an adjunct to soda ash and lime was introduced in the company's water treating during January of this year. It was added directly to the lime-soda ash mixture, a practice which had been found in other installations to be equally as effective as introducing it subsequent to the lime and soda ash. By using about 1.5 lb. of the solution per 1 m gals. in this manner the condition of the treated water was much improved. Typical tests are shown in Table No. 1.

Table No. 1—Water Conditions at Council Bluffs, Iowa.
Tests on Treated Water—Grains per Gallon.

Date	Soap Hardness	Total Alkalinity	Alkalinity to Phenolpthalein
Feb. 14	3.0	4.6	2.6
Feb. 15	3.3	4.2	2.2
Feb. 16	4.0	4.3	2.2
Feb. 17	3.5	3.7	2.0
Feb. 18	3.0	4.0	2.3
Feb. 19	3.2	4.0	2.4
Feb. 23	3.3	4.3	2.5
Feb. 24	3.2	4.0	2.7
Feb. 25	3.5	4.2	2.8
*Feb. 26	5.2	5.2	3.0
*Feb. 27	6.0	6.8	4.2

*Amount of sodium aluminate reduced due to temporary shortage of supply.

To determine the feasibility of reducing the amount of the solution used, a series of tests was made, the results being quoted below. These tests were conducted on 500 cc samples. Hydrated lime from the plant supply was weighted out for each test. In making these weighings it was convenient to make use of the relation that, with a 500 cc sample, 60 mg. is equivalent to one lb. per 100 gal. Soda ash was added by making up a solution containing 30 mg. per cc so that 2 cc of this solution was equivalent to one lb. soda ash per 1,000 gal. Sodium aluminate was added by first making up 10 cc of the solution as received (gravity 1.37) to 100 cc. In this solution 0.437 cc equals one lb. per 1,000 gals. of the concentrated solution. This relation will be clear when it is considered that one cc of the 10 per cent solution contains 137 mg. of the concentrated solution. The soda ash solution and the diluted sodium solution were measured with a one cc pipette graduated to .01 cc. Mixing was accomplished by inverting the container, and the samples were agitated by giving a whirling motion to the container, this being continued for 75 seconds where only one addition of chemicals was made, and being divided into two periods of 45 and 30 seconds where the sodium aluminate was added separate from the lime and soda ash. The temperature of the samples was approximately 48 deg. Fahr. and was maintained as near as possible at that point during the one hour's settling time allowed. These conditions have been fully specified as it is believed that too much stress cannot be placed upon the importance of exactly duplicating all conditions in order to obtain comparative results from tests of this kind.

The following series consists of six tests. No sodium aluminate was used on the first test and on tests Nos. 4, 5 and 6 there was used respectively 1/3, 2/3 and 1 lb. per 1,000 gals. In these three tests the sodium aluminate was introduced subsequent to the lime and soda ash. In tests No. 2 and 3 the sodium aluminate was added to the lime and soda ash mixture. Deductions in soda ash were made at the rate of 1/3 lb. soda ash per lb. of sodium aluminate used, the effort being to maintain all conditions constant except the alumina value and the method of application. The six tests are presented in Table No. 2.

TABLE NO. 2—RESULTS OF TESTS WITH SODIUM ALUMINATE

Test No.	Lb. Treatment Per M Gals.			Tests on Treated Water. Grains Per Gallon			Sodium Aluminate added together or separate
	Hydrated Lime	Soda Ash	Sodium Aluminate Solution	H	A	C	
1	1.40	.92	0	6.1	6.9	4.7	
2	1.40	.70	.67	4.0	4.4	2.6	Together
3	1.40	.59	1.00	3.4	4.2	2.4	Together
4	1.40	.81	.33	4.4	4.9	2.9	Separate
5	1.40	.70	.67	2.9	3.5	2.1	Separate
6	1.40	.59	1.00	2.0	3.3	2.0	Separate
	Raw water	......	....	13.3	9.1	.0	

No deductions in soap solution were made although the soap solution used was standardized at 12 grains to allow for the "lather" factor. It will be observed from the above that much better results were obtained on this water by using the sodium aluminate separate from the lime and soda ash, which confirmed a previous experience with Missouri River water at the Rock Island plant at Armourdale, Kan.

·To effect the separate introduction of the sodium aluminate solution, use was made of an 11/16 in. by 3 in. plunger pump, which was mounted on the water end of the Roberts motor as illustrated. Actual pumpage was found to be 5.6 gal. per hr. The supply to this pump was provided from a 50 gal. iron drum set so as to gravitate to the pump. In the suction line there was placed a ¾ in. separator of the type ordinarily used on air lines. The feeding was controlled by varying the dilution in the drum which held about a 10 hr. supply. The attendant makes up the solution in the drum on the basis of a specified number of pounds of aluminate per inch of total diluted mixture. The discharge from the pump was carried to the top of the softener and thence to a point two-thirds the depth of downtake. It was found of vital importance to vent this line at the top of the softener, as otherwise the discharge check valve did not function properly.

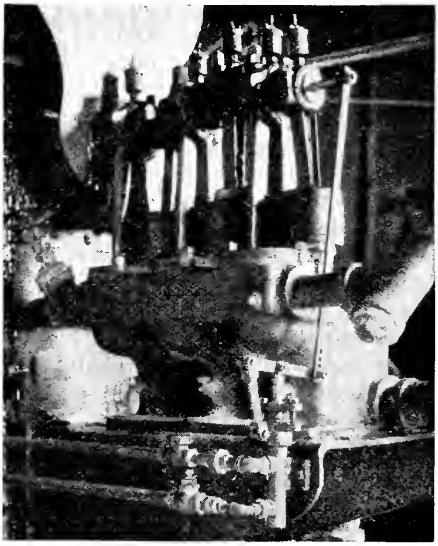


FIG. 1.—ARMOURDALE (KANS.) TREATING PLANT

When the installation as described above was completed and placed in satisfactory operation the aluminate was reduced to .64 lb. per 1,000 gals. but the results were not so satisfactory as previously secured when using 1.5 lb. per 1,000 gals. When the aluminate was raised to one lb. per 1,000 gals. the results checked closely with the previous figures from the softener as quoted above.

Upon completion of the tests and changes at Council Bluffs similar work was undertaken at the Rock Island softening plant at Estherville, Iowa, with similar results.

A further series was undertaken to determine the possibility of producing a low hardness under the conditions of these tests by resorting to a very considerable over-treatment. Settling time on this series was 20 minutes, results as follows:

Table No. 4

Test No.	Lb. Treatment Per M Gals.			Tests on Treated Water. Grains Per Gallon			Sodium Aluminate used separate or together
	Hydrated Lime	Soda Ash	Sodium Aluminate Solution	H	A	C	
15	1.85	3.11	0	7.5	17.5	9.6	
16	1.85	3.11	0	8.0	19.2	10.0	
17	1.85	2.50	1.84	2.0	12.9	6.4	Together
18	1.85	2.50	1.84	1.0	11.9	6.4	Separate

A duplicate of the pump used at Council Bluffs was installed at Estherville and connected as shown in Fig. 2, to the sprocket wheel driving chemical tank agitator. The drum used for aluminate feed is shown in the upper portion of the picture with vertical suction line and the horizontal air separator ahead of pump. The small line from discharge returns to top of aluminate drum so as to provide a ready means of checking discharge of pump and also to permit aluminate to circulate when the chemical agitator is run with water shut off. This installation proved satisfactory and it was found possible to duplicate with corresponding amounts of sodium aluminate the bottle tests above quoted, typical results from the softener with 1 lb. aluminate per M gals. being as follows:

H—3.3 A—4.6 C—2.6

Fig. 1 shows an installation of one of the smaller plunger pumps for pumping sodium aluminate solution at Armourdale, Kansas, plant of the Rock Island. This pump operates at 100 RPM. and has a stroke of one inch. The lower line is the discharge and this is provided with a special check valve with adjustable lift set so as to give an opening of 1/16-inch which results in positive operation of the check and consequent reliable functioning of the pump.

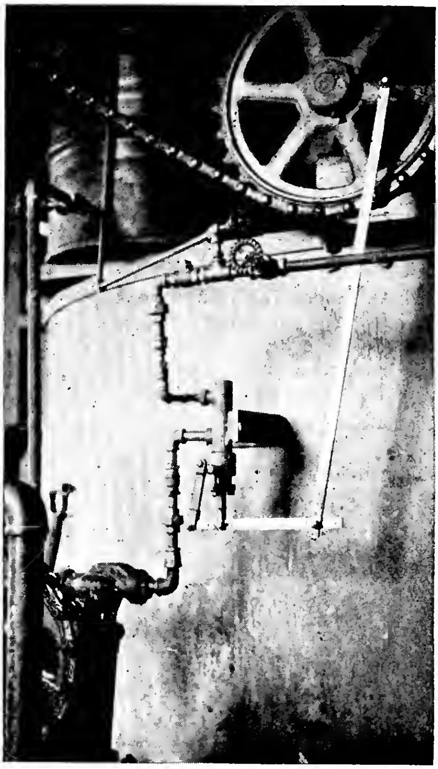


FIG. 2.—ESTHERVILLE (IA.) TREATING PLANT

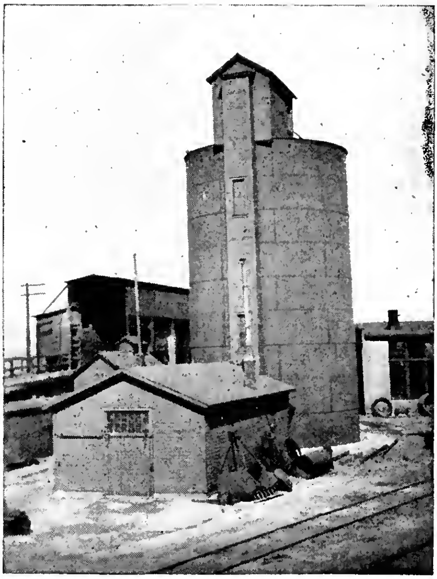


FIG. 3.—ESTHERVILLE (IA.) TREATING PLANT

Appendix I

The complete history of the Council Bluffs treating plant in this connection follows:

Table A—Weekly average tests of raw and treated water for period of three months previous to aluminate treatment. Lime and soda ash alone.

	Raw Water		Treated Water		
Week	H	A	H.	A.	C.
1	16.8	10.0	5.3	6.5	5.0
2	16.2	11.5	5.2	6.2	4.8
3	16.3	7.5	5.3	6.2	4.8
4	17.4	7.8	5.2	6.0	4.8
5	17.8	7.9	5.2	6.0	4.9
6	19.0	9.2	5.0	6.2	4.9
7	18.4	9.0	5.3	6.0	5.0
8	17.6	8.4	5.4	5.8	5.1
9	18.4	9.0	5.2	6.0	5.1
10	17.5	7.8	5.2	5.8	4.7
11	17.0	8.2	5.1	6.1	4.7
12	17.2	8.0	5.0	6.3	4.8

Table B—Weekly average tests of raw and treated water. Aluminate added at same time as lime and soda ash.

	Raw Water		Treated Water			Lbs. Aluminate
Week	H	A	H	A	C	per 1,000 gals.
1	15.7	7.7	4.4	5.5	3.6	1.85
2	15.8	7.5	4.4	5.2	3.4	1.85
3	15.5	7.5	4.2	5.7	3.8	1.85
4	14.5	7.5	4.3	6.0	3.5	1.85
5	15.0	7.3	4.6	6.5	3.6	1.85
6	13.4	7.0	3.7	5.0	3.8	1.85
7	12.8	6.5	4.0	4.5	3.6	1.85
8	12.5	6.4	3.2	4.0	3.2	1.85
9	12.2	7.0	3.3	4.0	2.9	1.85
10	12.2	7.2	3.0	4.0	3.0	1.85

Table C—Same. Adding aluminate separately after lime and soda ash.

	Raw Water		Treated Water			Lbs. Aluminate
Week	H	A	H	A	C	per 1,000 gals.
1	12.7	8.0	3.0	4.7	3.0	1.0
2	12.9	8.5	3.0	4.3	2.5	1.0
3	13.2	9.0	2.5	4.0	2.1	1.0
4	13.8	9.0	2.2	4.0	2.1	1.0
5	14.0	8.7	2.8	4.4	2.1	1.0

More recent tests show the following

	Raw Water		Treated Water			Lbs. Aluminate
Date	H	A	H	A	C	per 1,000 gals.
5/29	14.3	9.0	2.3	3.6	2.0	1.0
5/30	14.3	9.0	2.5	3.9	2.0	1.0
5/31	14.3	9.0	2.4	3.8	2.0	1.0
6/1	14.5	9.0	2.4	3.7	2.0	1.0
6/2	14.5	9.0	2.4	4.2	2.2	1.0
6/3	14.4	8.9	2.5	3.5	1.8	1.0

Appendix II

Estherville, Iowa, treating plant.

Water from Des Moines River. Temperature runs as low as 33 degrees Fahr.

Table D—Weekly averages of tests using lime and soda ash with aluminate added at same time.

Week	Raw Water H	Raw Water A	Treated Water H	Treated Water A	Treated Water C	Aluminate per 1,000 gallons
1	28.	21.0	4.9	7.2	5.4	0
2	27.	21.6	5.2	7.4	6.0	0
3	28.5	21.7	4.5	7.8	6.0	0
4	30.	22.0	5.0	7.0	5.1	0
5	25.	18.0	6.0	7.4	5.3	0
6	28.	18.5	4.8	7.3	4.9	0
7	27.	17.0	4.5	7.5	3.5	1.75
8	27.	16.0	4.6	7.0	3.7	1.75
9	27.5	14.5	4.5	6.8	3.9	1.75
10	26.0	17.0	4.7	6.5	3.9	1.75
11	24.0	16.5	4.8	6.4	4.0	1.75
12	25.0	16.0	4.5	6.3	4.0	1.75
		Same adding aluminate separately.				
1	22.	8.5	4.0	7.0	3.5	0.85
2	21.	9.5	3.2	5.2	3.0	0.85
3	22.	9.5	3.0	6.1	2.9	0.85
4	27.	11.2	3.1	5.8	3.0	0.85

THE RELATION BETWEEN THE SWAYING OF HOPPER CARS AND THE STAGGER OF RAIL JOINTS IN TRACK

By B. R. Leffler,

PRELIMINARY VIEW OF THE SUBJECT

1. It is well known that freight cars with high-center-of-gravity loads sway considerably, especially on tracks with low joints. It is the intention to show the relation between the stagger of rail joints and the swaying of cars.

2. The amplitude of swaying may be increased by a series of low joints, provided that the swaying of cars synchronizes with the impulses given by the joints. To produce synchronism, the time of swaying must have a definite relation to the speed of the train. The discussion will have two main parts. The first part will pertain to swaying; the second, to the proper stagger of rail joints to avoid cumulative swaying or increase of amplitude of swaying.

3. Excessive swaying causes unequal loading of the springs to a marked degree. This unequal loading may cause lifting of the wheels (momentarily) from the rail.

4. Excessive swaying causes great and unequal pressure on the side bearing; as a consequence, the trucks become momentarily locked, refusing to swivel on entering a curve or crossover.

5. It is the intention to use simple mathematics in the discussion. A concrete example will be taken. For this purpose, a loaded hopper car having the following characteristics is chosen:

(a) Capacity 140,000 lb.
(b) Distance center to center of trucks 30 ft. 8 in.
(c) Load supported by springs 180,000 lb. Call it W.
(d) Height of center of gravity of load (the 180,000 lb.) above the tops of the springs 5.9 ft. Call it h.
(e) Length of radius of gyration of the 180,000 lb. from tops of springs 6.3 ft. Call it k.
(f) Load below tops of springs 16,000 lb. Call it F.
(g) Distance (crosswise of track) center to center of springs 6.5 ft. Call it $2a$.
(h) The springs, on either side of the car, are compressed one inch under a load of 114,000 lb.; this being the specification requirement.

A CAR LIKE A PENDULUM

6. A swaying car is a pendulum. Its time of swaying and the moment causing the swaying can be calculated as precisely as for a simple ordinary pendulum.

7. The center of swaying (or rotation) is at the intersection of the vertical through the center of gravity of the vertical load and a horizontal line over the tops of the springs.

8. Fig. 1 is an outline of the end view of the car. Some of the characteristics mentioned in paragraph 5 are shown in the figure.

9. A swaying car is what is known as a compound pendulum, in contrast to a simple pendulum, which is a concentrated heavy weight (a ball of lead say) suspended by a thread.

10. The length of a simple pendulum is the distance from the point of suspension to the center of gravity (C.G.) of the weight. The length of a compound pendulum is the distance from its center of rotation to its center of percussion.

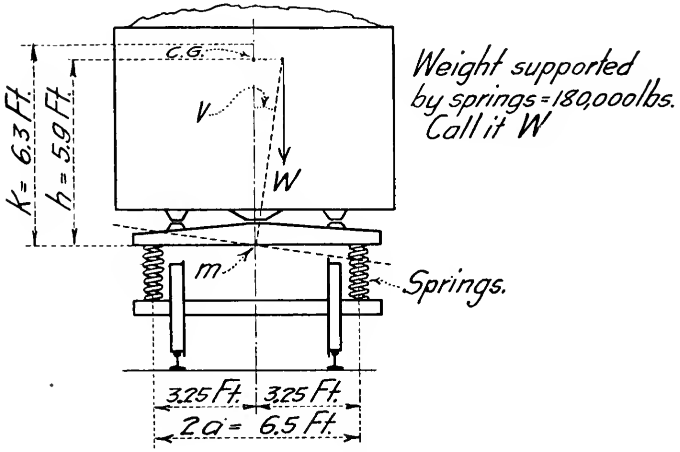


Fig. 1.

11. Both the swaying of a car and the vibration of a pendulum are particular cases of harmonic motion. A piston with a long connecting rod has harmonic motion. A violin string has harmonic motion, hence the name.

12. Fig. 1 shows the car in a vertical position. When the car sways, its load will have an angular motion about the point *m* which is the center of rotation as defined in paragraph 7. As the car sways, the load on opposite springs is alternately increased and diminished. It is this variation in the load on the springs that causes the car to continue swaying after it is once started. If a succession of impulses (such as are caused by a series of low joints) is not given, the swaying finally ceases because of friction.

TIME OF SWAYING

13. The time of swaying will now be calculated. For this purpose, the following symbols are used and defined:

Let v = the value of the angular deviation from the vertical.
W = the weight of the load on the springs, 180,000 lb.
k = the radius of gyration (6.3 ft.) about m.
h = the height of center of gravity (5.9 ft.) above m.
t = the time in seconds for the load to sway from its vertical position and return to its vertical position.
M = the moment, in foot-pounds, that causes the car to sway.
g = the acceleration of gravity equal to 32.2 ft. a second.

Then, $$t = 3.14\sqrt{\frac{Wk^2v}{Mg}} \qquad (1)$$

.14. In formula 1, the numerical values of the symbols under the radical sign, except v and M, are known. Symbols v and M are evaluated as follows: Let R_1 and R_2 be the respective loads on the left and right springs; the sum of these equals W. Let S equal the load which will compress the springs on one side of the car one inch; in paragraph 5 its numerical value was specified to be 114,000 lb. The increment of compression of the springs under R_2 is av. The following proportion now obtains:

$$R_2 - \frac{W}{2} : S = av : \frac{1}{12}, \quad \text{or } R_2 = \frac{W}{2} + 12\,Sav.$$

Also $R_1 = \frac{W}{2} - 12\ Sav.$

$$R_2 - R_1 = 24\,Sav.$$

Again, take moments about m:

$$(R_2 - R_1)\,a - Whv = M.$$

Whence $M = 24\,Sa^2v - Whv \qquad (2)$

By substituting the value of M, formula 1 becomes:

$$t = 3.14\sqrt{\frac{Wk^2}{(24\,Sa^2 - Wh)\,g}} \qquad (3)^*$$

Referring to Equation 2, M, the swaying moment, is a maximum when v is a maximum; that is, when the car has swayed to the extreme right and is just on the point of going back. When v is zero, M is zero; the center of gravity is then over the middle of the track and is moving at its greatest velocity, energy being stored to slam hard on the left-side bearing and left springs. When the left springs are fully compressed, M and v are again at their maximum, and the swaying is repeated. The

---

*See Low's Applied Mechanics, Article 259; also Gray & Gray's Dynamics, Article 231. The formula in its present shape was derived by the writer.

numerical values of the symbols in formula 3 under the radical sign are now all known. Using these values,

$$t = 3.14\sqrt{\frac{180000\text{x}(6.3)^2}{32.2\ [24\text{x}114000\text{x}(3.25)^2 - 180000\text{x}5.9]}}$$

$t = 0.28$ seconds.

EFFECTS OF EXCESSIVE SWAYING

15. Before considering in detail the staggering of rail joints as related to the swaying of hopper cars, it is well to investigate some of the effects of swaying. For this purpose, it is not necessary to know the cause of swaying.

16. Let Fig. 2 represent the trucks and springs of a car. Let R_1 be the pressure on the left springs, R_2 on the right springs. AB is a line across the top of the springs when $R_1 = R_2$. $A_1 B_1$ is the position of the line when the right springs are greatly compressed; this condition arises when the center of gravity of the load is far to the right.

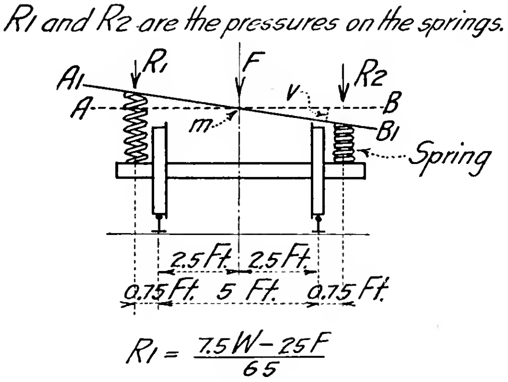


FIG. 2.

17. Now, what are the values of R_1 and R_2 that will cause the left wheels to lift from the rail? Remember now the symbols defined in paragraphs 5 and 13. Taking moments about the center of the right rail, the following equations are obtained:

$5.75\,R_1 + 2.5\,F = 0.75\,R_2$

$R_1 + R_2 = W$. From which

$$R_1 = \frac{7.5\,W - 25\,F}{65} \quad \text{.......................................} (4)$$

Equation 4 is very important in considering the stability of a swaying car. If the swaying causes a less value of R_1 than found by Equation 4, the left wheels will lift from the rail. For the car chosen for this discussion (see Fig. 1) F equals 16,000 lb. and W equals 180,000 lb. With these values R_1 becomes 14,600 lb.

18. Note that the left wheels are about to lift, even though there is a downward pressure of 14,600 lb., through the left springs, upon the left car journals. If the springs were between the wheels, as for a locomotive, R_1 might be zero before the left wheels are about to lift.

19. Again look at Equation 4. The larger F is, the smaller R_1 is. This means that for a larger F, a greater swaying is allowable before the wheels would lift. F is the weight of the trucks and all other parts not supported by the springs. The higher the center of gravity of the parts above the springs, the greater F should be. Were it practicable to make the parts below the springs of aluminum so as to reduce F to almost nothing, high-center-of-gravity cars would not stay on the track at all.

20. I wonder if car designers have considered the importance of F. The parts not carried by the springs should have more weight than is just necessary for strength.

21. Referring again to Fig. 2. How much must the right springs compress before R_1 equals 14,600 lb. and the left wheels are about to lift? When the car is not swaying R_1 equals R_2 and each is 90,000 lb. When R_1 is 14,600 lb., R_2 is 165,400. That is, R_2 has been increased 75,400 lb. The increase on the right springs causes the additional compression av. According to paragraph 5 the springs will compress one inch under 114,000 lb.; for 75,400 lb. av must equal ⅝-inch, a compression which is quite possible.

22. The values of R_1 and R_2 show that a wheel load can be greatly increased by excessive swaying. This means greater stresses in joints and increased cost of maintenance of track.

22a. To show that a high-center-of-gravity car is susceptible to more swaying than a low-center-of-gravity car, I will again use formula 3. The moment of the momentum is an indicator of susceptibility to swaying.

22b. The center of gravity moves through a distance $2kv$ in the time t. Its average velocity is $\frac{2kv}{t}$.

$$\frac{2kv}{t} = 2kv\sqrt{\frac{(24Sa^2 - Wh)g}{\pi^2 Wk^2}} = \frac{2v}{\pi}\sqrt{\frac{(24Sa^2 - Wh)g}{W}}.$$

The momentum equals the fraction multiplied by the mass $\frac{W}{g}$. Hence the momentum equals $\frac{2v}{\pi}\sqrt{\frac{W(24Sa^2 - Wh)}{g}}$.

The average moment of the momentum equals $\frac{2kv}{\pi}\sqrt{\frac{W(24Sa^2 - Wh)}{g}}$, which indicates the influence of k, the radius of gyration.

22c. The radius of gyration k for a car load is always somewhat greater than the height of the center of gravity h. In other words, the greater k, the greater is h, and the greater is the susceptibility to swaying.

CAUSES OF SWAYING

23. Momentary swaying may be caused by many unknown forces and moments. Increase of amplitude or cumulative swaying must be caused by forces and moments acting in a regular sequence. Before going further with this subject, it is necessary to show the use of the term phase.

PHASE OF SWAYING

24. Referring to Fig. 1, when the center of gravity is moving clockwise about m, the swaying is in right phase. The right springs are then being compressed. When the center of gravity is moving counter clockwise, the swaying is in left phase.

25. If a car is swaying in right phase and the right-hand wheels hit low joints the amplitude of swaying is increased. If the left-hand wheels hit low joints, the amplitude is decreased providing the center of gravity is not too far to the left. It is likewise for swaying in left phase.

26. If both trucks hit simultaneously two low joints in the same line of rail, the increase of amplitude will be greater than for one truck only hitting a joint. If the two joints are in opposite lines of rail, no increase of amplitude will occur if the joints are equally low and the car body has sufficient torsional strength.

27. A common length of rail is 33 ft. The joints are staggered midway. A car with trucks 30 ft. 8 in. center to center will hit simultaneously two joints in the same line of rail. When the car has moved 16.5 ft., it will hit simultaneously two joints in the opposite line of rail. The swaying will be augmented by the second pair of joints if the swaying is in a phase opposite to the phase of swaying at the time of hitting the first pair of joints. To produce this cumulative swaying, the speed of the car must be such as to bring the suitable phase for each joint.

28. This speed for a car with characteristics mentioned in paragraph 5 will now be calculated:

Let T = the speed of the train in miles per hour.
Let p = the number of phases between two successive joints.

$$\text{Then } T = \frac{16.5 \times 3600}{5280\, tp} = \frac{16.5 \times 3600}{5280 \times 0.28 \times p}$$

For $p = 1$, $T = 39$; for $p = 3$, $T = 13$. For these values of T, cumulative swaying will occur. In other words, there is synchronism between the speed of the car and its swaying. With long enough continued cumulative swaying, R_2 in Fig. 2 will become great enough to cause lifting of the left wheels.

BREAKING UP THE SYNCHRONISM

29. In paragraph 26, I have already forecast a principle that may be used to destroy cumulative swaying. I will now state it: *Principle.* The stagger of rail joints must be such that a car must hit, simultaneously, a pair of joints, the joints being in opposite lines of rails. This principle can not be applied in its entirety. It is simply an ideal. To illustrate this principle, I will assume ideal track and cars.

IDEAL TRACK AND CARS

30. For the application of the foregoing principle in its entirety the following characteristics of track and cars must be had:

(a) The rail length must be twice the distance center to center of trucks.
(b) The joints must be staggered midway.
(c) The joints must be equally low.
(d) The distance center to center of trucks must be the same for all cars.

For these ideal conditions, cumulative swaying would be destroyed for deep cars at any speed of train.

ANOTHER PRINCIPLE

31. A second principle is applicable. The stagger should be unequal in such a way that enough joints occur at suitable phases of swaying to neutralize the effeots of the other joints. Frictional resistance helps in this principle.

32. Now, track and cars are not built along ideal lines. The foregoing principles can only be partly applied.

ACTUAL CARS

33. Hopper cars of 100,000 lb. capacity, or somewhat more, have a distance center to center of trucks ranging from 20 ft. to 22 ft. about. For cars of 140,000 lb. capacity, the distance is about 30.5 ft. These truck distances cover about all of the hopper cars.

PROPOSED STAGGER OF JOINTS

34. Many railroads are using a rail length of 39 ft. A 33 ft. length is quite common. Why not use both rail lengths in the same track? In each line of rail, alternate the two lengths. Give the joints the following staggering in feet: 28-11-22-11, 28-11-22-11-28 and so on. The 28 ft. staggering will take care of the longer cars and the 22 ft. the shorter ones. Furthermore, the 11 ft. stagger will also tend to break up any synchronism. The proposed staggering contains both principles

set forth above. The joint spacing may be varied slightly, to allow suitable tie spacing.

35. If rails of one length only are to be used (the present practice), the stagger should be unequal. The short stagger should be from one-fourth to one-third of the rail length.

36. I do not regard one rail length as suitable as two. Two lengths allow the use of three kinds of stagger as against two with one length. Three lengths of stagger will surely break up all synchronism and consequent cumulative swaying.

SUPPLEMENT TO PARAGRAPH 22B.

37. While reading the galley proof, it appeared desirable to the writer to show the influence of the stiffness, S, of the springs. Let U denote the average moment of momentum. Then according to paragraph 22b $U = \frac{2\,kv}{\pi}\sqrt{\frac{W\,(24\,Sa^2 - Wh)}{g}}$. Now Wh is very small compared to 24 Sa^2; it is close enough to write

$$U = \frac{2\,kv}{\pi}\sqrt{\frac{24\,WSa^2}{g}} = \frac{2\,kav}{\pi}\sqrt{\frac{24\,WS}{g}}.$$

Referring to paragraph 14, call the particular value of $R_2 - R_1$ for which the left wheels are about to lift c. Then c $= 24\,Sav$, or $av = \frac{c}{24\,S}$.

Therefore $U = \frac{2\,kc}{\pi}\sqrt{\frac{W}{24\,Sg}}$, which shows that the spring stiffness, S, tends to counteract the effects of a high center of gyration.

38. The value of S has important practical aspects. Suppose that new cars show a tendency to sway considerably and thus lift off the rail. This tendency may be lessened by inserting stiffer springs. There may be objections, not here under consideration, which limit the value of S. Again for cars long in service, S may become smaller. Such cars need new springs.

A NOTE ON THE TIME OF SWAYING OF HOPPER CARS

By B. R. Leffler

1. This note is intended as an addition to my paper which appeared in Bulletin 279, and also appears in the same volume of the Proceedings with this note.

2. Paragraphs 13 and 14 of that article give formulas and calculations for the time of swaying. The formulas are for undamped, or free, harmonic motion. At the time these formulas were adopted, I assumed that damping was very small and hence could be neglected. Since then several experimenters have furnished results of tests. These results show that

damping of the springs is quite large and lengthens the time very much. Friction and side bearing clearance also act somewhat like damping.

3. Damped harmonic motion has the same time characteristics as free harmonic motion; namely, that the time of each phase or sway remains constant. Damping simply makes the time greater than for free motion; it also causes a dying out of the swaying. The successive sways have decreasing amplitude.

4. The neglecting of the damping factor in my article does not affect the fundamental principles set forth therein.

5. Formula 3 of my article should be modified to allow for damping as follows:

$$t = 3.14\sqrt{\frac{Wk^2}{(24Sa^2 - Wh - n)\ g}}$$

in which n is an allowance for damping.

6. It should not be necessary to show how n is inserted in formula 3. The reasoning is clearly set forth in works on theoretical mechanics. Art. 110 in Slocum's Mechanics is particularly clear on damped harmonic motion. My formula 3 with n inserted can be transformed into the formula accompanying Fig. 208 of that article.

7. For 140,000-lb. capacity cars, a tentative and rough value of n is 23,000,000, and for 100,000 capacity cars about 17,000,000. Accurate values of n can only be determined by careful experiments. The damping quality of a spring is a function of S.

8. The time of swaying for damped motion becomes 0.67 seconds. Now refer to Par. 28 of my article. For $t = 0.67$ and $p = 1$, T equals 17 miles an hour. This value of T is approximately in accord with test results. In Par. 28, I used several values of p to compute T values. On account of the large damping action, it is probable that p, for values greater than one, will not be causative of cumulative swaying.

THE EFFECT OF MINOR SAGS AND HUMPS ON THE OPERATION OF TRAINS

By Walter Loring Webb

A "minor" sag or hump, in what would otherwise be a uniform grade, is one which does not require any change in the operation of the locomotive. The depth of the sag below the uniform grade line is not great enough to increase the velocity so much as to require the use of brakes or changing the throttle. The height of the hump is not great enough to reduce the velocity below the safe minimum limit for operation.

A. M. Wellington claimed that dynamometer tests proved that the drawbar pull remains constant through such sags and humps. He also assumed that train resistance is constant at all velocities. These two assumptions would permit the application of the theory of virtual velocities, which greatly simplifies the solution of the problem of computing the effect of such a sag or hump on the operation of trains. But it is now well known that the drawbar pull is very materially reduced when the velocity is increased. The University of Illinois experiments (Bulletin 43) also demonstrated that car resistance varies somewhat with the velocity. Since these two essential assumptions have been shown to be at least inaccurate, the problem still remains to determine the effect on operation of such minor sags and humps.

The following demonstration utilizes the laborious but exact method developed in the A.R.E.A. Manual to compute the drawbar pull of a typical locomotive, drawing a train up a uniform grade of 0.4 per cent at the uniform velocity of 20 m.p.h. It is then assumed that there is a sag, followed immediately by a hump, all as shown in the figure.

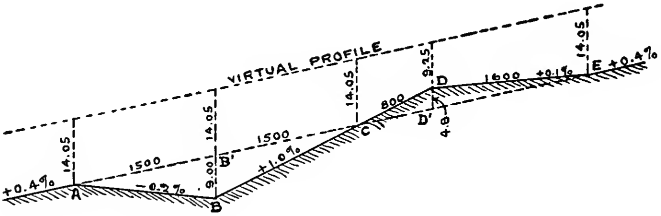


Fig. 1

The variation in drawbar pull and velocity along the line *ABCDE* is computed for each point, noting the variations from the corresponding figures for the uniform grade line *AB'CD'E*, and particularly at *E*, where the uniform grade is again resumed.

The assumed locomotive is a Mikado, having the following dimensions:

Cylinder ....diam. 22"
Cylinder ....stroke 28"
Driving wheel ....diam. 57"
Boiler pressure ....lb., 185
Firebox ....length, 102⅜"
Firebox ....width, 65⅞"
Grate area ....sq. ft., 46.8

Weight, driving wheels...153,200 lb.
  engine alone ....196,100 lb.
  engine and tender.......315,000 lb.
Heating surface, firebox
  and tubes ....2565 sq. ft.
  superheating surface ... 550 sq. ft.

From a table of virtual velocities, which shows the "velocity head" or the kinetic energy of trains moving at various velocities, allowing for the rotary kinetic energy of the wheels, it is possible to compute the velocity head, and then the velocity in miles per hour, for the several points on the profile. At *A*, the velocity head is 14.05, the velocity being 20 m.p.h. The drop *below the grade line* at *B* is 9.00 feet, making the velocity head 23.05, which corresponds to a velocity of 25.62 m.p.h. Similarly the velocity head at *D* is reduced to 9.25, which corresponds to a velocity of 16.24 m.p.h. Of course the velocity head at *C* and *E* are the same as at *A* (14.05), and the velocities would presumably be also 20.00 m.p.h.

In order to test the degree of approximation of the simple and convenient method of estimating the velocity at various points (the method of "virtual velocities") the problem will be recomputed according to the more laborious but more accurate method of the "Economics" section of the A.R.E.A. Manual. Since the object is to test the rigid application of the more precise method, all numerical calculations will be carried to a precision unrealizable in actual operation. *"M"* velocity is computed to be 7.885 m.p.h. The assumed velocity (20 m.p.h.) is therefore 2.536 *M*. The cylinder power for 2.536 *M* is found, by interpolation in Table 5 of the Economics section of the Manual, to be 49.47 per cent of that for *M* velocity, or 18372 lb. The engine resistance at this velocity is computed by Table 7 in the Manual to be 2182 lb., leaving a net drawbar pull of 16190. This is the drawbar pull on a level; on a grade the grade resistance, or assistance, of the locomotive must be deducted or added. On this 0.4 per cent grade it equals $20 \times 157.5 \times 0.4 = 1260$ lb., which makes the *net* effective drawbar pull $16190 - 1260 = 14930$ lb. Assume that the average weight of one freight car and load equals 60 tons. At 20 m.p.h. the resistance per ton will be about 4.1 lb.; see Fig. 11, University of Illinois Bulletin 43, Freight Train Resistance, by Prof. E. C. Schmidt. The grade resistance per ton is $20 \times 0.4 = 8$ lb.; the train of such freight cars which can be drawn at a uniform speed of 20 m.p.h. up the 0.4 per cent grade by that particular locomotive will weigh $14930 \div (8 + 4.1) = 1234$ tons. The whole train will weigh $1234 + 157.5 = 1391.5$ tons. So far, the problem has been worked backward, in order to compute the weight of train which will be hauled up that grade at the assumed uniform speed by the assumed locomotive.

The tractive resistances, in pound per ton for 60-ton cars, at various velocities, are obtained from Fig. 11, Bulletin 43, previously referred to, and are given in column 7 of the tabular form. The total car tractive resistance for 1234 tons of cars is given in column 8. The fact that 1234 is not an even multiple of 60 need not vitally affect the accuracy, provided the *average* resistance per ton is not appreciably affected.

Columns 1 to 8 show in convenient tabulated form the various figures for computing column 9, which is the force available for grade or acceleration *on a level track,* after mere tractive resistances have been allowed for. Any curve resistance is assumed to be provided for by grade compensation.

As the train runs down the — 0.2 per cent grade, its velocity increases which results in a diminution of the drawbar pull. On account of this diminution, the force available for acceleration will be diminished somewhat and the velocity at *B* will not be increased quite to 25.62 m.p.h., as computed by the simple theory of virtual velocities.

Following the A.R.E.A. method, the various net forces available for acceleration for the *mean* velocities between 20.00 m.p.h., 20.50, 22.08, 23.655 and 25.23 m.p.h. are computed to be 11.83, etc., pounds per ton, as given in column 13. The first three distances in which these increases in velocity will be developed are 120, 417 and 478, which total 1015 feet, leaving 485 feet distance to the bottom of the grade. By carrying the computations one stage further, we find that, if the same grade continued 548 feet further, the velocity would then equal 3.2 *M*. 485 ÷ 548 = .884. At this ratio of the interval between 3.0 *M* and 3.2 *M,* the velocity will increase from 23.655 m.p.h. to 25.047 m.p.h., the computed velocity at the bottom of the — 0.2 per cent grade. This velocity is somewhat less than the velocity (25.62) as interpolated from a table of "virtual velocities" for a velocity head of 23.05 feet.

At the point *B* the train has a velocity of 25.047 m.p.h. but the operating conditions are then changed. The grade becomes + 1.0 per cent, which makes a grade resistance for the whole train of $1391.5 \times 20 \times 1.0 = 27830$ lb., which is much more than the drawbar pull and the velocity is retarded up the entire grade. Subtracting 27830 (algebraically) from the drawbar pull (column 9) for that velocity, we have the *negative* retarding forces. The mean of each pair, divided by the total train tonnage, 1391.5, gives the retarding force per ton, column 19. As before, the velocity at the end of the 2300-foot grade is computed to be 15.34 m.p.h., which is less than 16.24, the approximate velocity for that point by the virtual velocity theory.

For the next 1600 feet, the grade is actually up 0.1 per cent although it is a down-grade relatively to the average 0.4 per cent grade. There is a grade resistance of 2783 lb., which must be subtracted from the available forces (column 9) on a level at the several velocities, but even these leave large accelerating forces. Computing as before, the final distance after attaining the velocity of 2.4 *M* is 424 feet, which is .599 of the interval and indicates a velocity of 19.866 m.p.h. when the point *E* is reached. This very nearly equals the velocity at *A,* and also the velocity computed for *E* by the virtual velocity method, 20.00 m.p.h. The net available force (on the basis of a level track) is slightly in excess (11205 rather than 11130) of

CHARACTERISTICS OF MIKADO LOCOMOTIVE—ON A LEVEL TRACK

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Velocity		Cylinder Tractive Power		Locom. Resist. (2082+ .25 V^2)	Drawbar Pull	Car Resistance	
Mult. of *M.*	M. p. h.	Per Cent of M.	Pounds			Pounds per Ton	Total Pounds
1.8 M	14.19	63.66	23 641	2132	21 509	3.7	4566
2.0	15.77	58.96	21 895	2146	19 757	3.8	4689
2.2	17.35	55.12	20 470	2157	18 313	3.9	4813
2.4	18.92	51.53	19 137	2171	16 966	4.0	4936
2.536	20.00	49.47	18 372	2182	16 190	4.1	5060
2.6	20.50	48.50	17 961	2187	15 774	4.15	5121
2.8	22.08	45.82	17 016	2204	14 812	4.2	5183
3.0	23.655	43.49	16 151	2222	13 929	4.3	5306
3.2	25.23	41.21	15 304	2241	13 063	4.45	5491

$M = 7.885$ m.p.h.

that at *A*. At *E*, after starting up the 0.4 per cent grade, there will be, at the start, the same slight excess of 75 lb. over the 14930 lb. of effective pull at *A*. If the 0.4 per cent up grade continued for a sufficient distance and operating forces and resistances continued absolutely in accordance with the above assumptions, this slight excess force would gradually increase the velocity from 19.866 to the full 20.00 m.p.h.

FORCES ON 1.0 PER CENT UP-GRADE, 2300 FEET LONG

(1)	(9)	(16)	(17)	(18)	(19)	(20)	(21)
Veloc. Mult. of *M.*	Force Avail. for Gr. or Acc. on *Level*	Grade Resistance, Whole Train	Net Retarding Force	Mean Retarding Force		Distance	
				Pounds	Per Ton	Point to Point	Total
1.8	16 943	27 830	10 887	11 824	8.50	390	....
2.0	15 068	27 830	12 762	13 546	9.73	376	2193
2.2	13 500	27 830	14 330	15 065	10.83	368	1817
2.4	12 030	27 830	15 800	16 250	11.68	252	1449
2.536	11 130	27 830	16 700	16 938	12.17	116	1197
2.6	10 653	27 830	17 177	17 689	12.71	370	1081
2.8	9 629	27 830	18 201	18 704	13.44	375	711
3.0	8 623	27 830	19 207	19 671	14.14	336	336
3.177	7 694	27 830	20 136				0

$$\begin{array}{r} 2300 \\ 2193 \\ \hline 107 \end{array} \qquad \frac{107}{390} = .274 \qquad \begin{array}{r} 15.77 \\ 14.19 \\ \hline 1.58 \times .274 = \end{array} \begin{array}{r} 15.77 \text{ m.p.h} \\ 0.43 \\ \hline 15.34 \text{ m p.h.} \\ = 1.945\ M \end{array} \qquad \begin{array}{r} 16943 \\ 15068 \\ \hline 1875 \times .274 = \end{array} \begin{array}{r} 15068 \\ 513 \\ \hline 15581 \end{array}$$

Forces on 0.2 Per Cent Down Grade, 1500 Feet Long

(1) Veloc. Mult. of *M*.	(9) Force Avail. for Gr. or Acc. on *Level*	(10) Grade Assistance, Whole Train	(11) Net Force Avail. for Accel.	(12) Mean Accelerating Force	(13)	(14) Distance	(15)
				Pounds	Per Ton	Point to Point	Total
2.536	11 130	5566	16 696	16 457	11.83	120	0
2.6	10 653	5566	16 219	15 707	11.29	417	120
2.8	9 629	5566	15 195	14 692	10.56	478	537
3.0	8 623	5566	14 189	13 663	9.82	548	1015
3.2	7 572	5566	13 138				....

1500
1015
485

$\frac{485}{548} = .884$

25.23
23.655
1.575×.884= 1.392

23.655 m.p.h.
1.392
25.047 m.p.h.
= 3.177 *M*.

8623
7572
1051×.884= 929

8623
929
7694
Grade resist., 1 per cent, —27830
—20136
—19207

Mean retarding force on first section of 1 per cent upgrade, —19671

Forces on 0.1 Per Cent Up-Grade, 1600 Feet Long

(1) Veloc. Mult. of *M*.	(9) Force Avail. for Gr. or Acc. on *Level*	(22) Grade Resistance, Whole Train	(23) Net Force Avail. for Accel.	(24) Mean Accelerating Force	(25)	(26) Distance	(27)
				Pounds	Per Ton	Point to Point	Total
1.945	15 581	2783	12 798	12 542	9.01	177	0
2.0	15 068	2783	12 285	11 501	8.26	443	1770
2.2	13 500	2783	10 717	9 982	7.17	556	620
2.4	12 030	2783	9 247	8 559	6.15	708	1176
2.6	10 653	2783	7 870				....

1600
1176
424

$\frac{424}{708} = .599$

20.50
18.92
1.58×.599= .946

18.92 m.p.h.
.946
19.866 m.p.h.

12030
10653
1377×.599= 825

12030
825
(Instead of 11130) 11205

The above solution is theoretically inaccurate since the vertical curves which would be introduced at the sag (B) and the summit (D) reduce the depth and height of those points, as shown on the profile by the intersection points of the grades. On a uniform grade the center of gravity of the whole train is at a distance above the rails equal to the average weighted height of the several centers of gravity for each car. On a vertical curve, the mean center of gravity is somewhere within the arc formed by the several centers of gravity of the individual cars and is not at the same distance above the rails as it is on a uniform grade. On a summit vertical curve, the center of gravity of the whole train does not rise to the normal average height of the center of gravity of the cars above the rails. Similarly, in a sag, the center of gravity of the whole train does not sink as low. For a very long train this difference is very considerable and it practically means that the vertical movement of the center of gravity of the whole train, when passing through sags or over humps, is not as great as the profile of the rails would indicate, and is still less than the difference of elevation of the grade intersections, such as B and D in the figure. But since the vertical curves are merely the elimination of very small humps, or sags, while the above general demonstration shows that even very considerable humps and sags make very little difference in the final velocity, the effect of these refinements on the accuracy of the general demonstration is evidently negligible.

The above calculations may be utilized for an analysis of the effect of a simple sag, such as ABC, assuming that the grade again became $+ 0.4$ per cent beyond C. It may be readily computed that at C the velocity has dropped to 18.70 m.p.h., instead of 20.00, but on the other hand the drawbar pull at this lower velocity is 1104 lb. more than that normally required on the $+ 0.4$ per cent grade. This excess force would gradually increase the velocity to the normal of 20.00 m.p.h. but it would require nearly 9000 feet and the grade conditions might change within that distance.

The reduction in tractive power at the higher velocities in the sag is responsible for the velocity reduction from 20.00 to 18.70 m.p.h. at the point C. On the other hand, the effect of the hump is to increase the velocity from 18.70 to 19.866 m.p.h., due to the increase in tractive power at the lower velocities.

Although not worked out in the tabular form, the time in seconds for each stage is readily computed. Such computations show that the sag ABC will be passed in 93 seconds, rather than 103 seconds, the time required for a uniform speed of 20 m.p.h. On the other hand the hump will require over 105 seconds, rather than only 81 seconds, and the net loss of time for both sag and hump is about 14 seconds.

As a final summation: (a) when a simple sag is located in an otherwise uniform grade, a train which would operate on a uniform grade at a uniform velocity will go through the sag at a somewhat higher average velocity and therefore in somewhat less time, but its velocity at the end of the sag will be somewhat less than at the beginning, and the tractive force somewhat higher; (b) on the other hand, a hump will lower the average velocity and increase the time required, but the velocity at the end of the hump will be greater than at the beginning; (c) several sags and humps, on what would otherwise be a uniform grade, tend to neutralize each other as to their effect on velocity, tractive power and the time required to run the total distance.

The tests of Prof. Schmidt, as well as others, have shown that, even when great precautions are taken to insure uniformity, tests of car resistance give a wide variation in results, even when all conditions are nominally uniform. Presumably the same wide variation would be found in any attempts to verify the above computed results experimentally. Probably Wellington also found the same wide variation in results, out of which he was able to pick enough figures which agreed with his theory so that he could claim that tests verified his theory.

As before stated, the computations were carried out with a precision (e. g., to the nearest pound of drawbar pull) absolutely unrealizable in operation. This was purposely done so that definite results could be obtained on the basis of operating conditions which were assumed to be perfectly definite and exact. On this basis, we may know that any experimental variation from the above results will be caused entirely by the unavoidable variations in track resistance, quality of coal, uniformity of firing, etc., which can never be exactly controlled or predicted. We can therefore draw definite conclusions as to the normal effect of sags and humps, even though we know that the final operating results may vary widely, both plus and minus.

THE DESIGN OF TREADS FOR THE SUPPORTING AND SEGMENTAL GIRDERS OF ROLLING LIFT BRIDGES

By Otis E. Hovey

Assistant Chief Engineer, American Bridge Company

1. General

Rolling-lift bridges have several advantages, particularly when the spans are not too long and the resulting rolling loads are not too great. Except for the rolling segmental girders, the superstructure is of simple construction, and has no mechanical joints or trunnions. The rolling friction is small and the operating machinery is simple. They require less power than trunnion bascules, and the machinery is correspondingly lighter and more economical.

The treads on the horizontal supporting girders and the rolling segmental girders of many rolling lift bridges have been made too thin and too weak to distribute the concentrated rolling loads to the girders. The result has been that the tread plates have been stressed far beyond the elastic limit of the material and have elongated, widened, and bent away from the central planes of contact. Rivets and bolts attaching them to the girders have been sheared and girder flanges and stiffeners wrecked by the intensity of the undistributed rolling loads. These failures have been so serious that extensive repairs have been made on a number of bridges.

For many years, the author has strongly advocated the use of much thicker tread plates, and engineers who have devised methods of making repairs have increased their depth and strength as much as was feasible under the limiting conditions imposed by other details of the designs. The author believes that the weakness of the tread plates, in the older designs, is the principal reason why the rolling lift type of bridge has not been more favorably considered during recent years. One difficulty has been the inadequate knowledge of the laws of the distribution of heavy loads on the line contact between the rolling segment and the horizontal track on which it rolls.

An elaborate series of tests to determine these laws is being made by Professor W. M. Wilson for the Engineering Experiment Station of the University of Illinois.[1] These tests have not been completed, but Professor Wilson has drawn the conclusion that the stress relation at the line of contact has been only a minor cause of the many failures that have occurred, and the author fully agrees with this conclusion. The major fault has been the weakness of the treads on the rolling segments and the track girders. The treads not only must be thick and strong enough to resist local distortions beyond the elastic limit of the material, but their strength

---

[1] Professor Wilson is working in consultation with a special committee of the American Railway Engineering Association, of which the author is a member. The results of the tests will be published in a forthcoming Bulletin of the Engineering Experiment Station of the University of Illinois.

and stiffness must be great enough to distribute the local concentrated load from the line of rolling contact to the girders to which they are attached.

2. Unit Stress on Line Contacts

The Engineering Experiment Station has kindly furnished the author with the results of the tests already made, and his analysis of some of them, made on a medium steel castings, indicates that the smallest load per inch of line contact which produces permanent set in thick tread plates from three to four inches wide on the line of contact, may be expressed by

$$P = 900 \sqrt[4]{D^3} \quad \ldots\ldots (1)$$

In this expression:

P = the load per inch of line contact that produces set, in pounds, and
D = the diameter of the rolling segment, in inches.

Some of the tests, in which the specimens were rolled when under load, seem to indicate little, if any, additional effect due to movement.

Probably no danger to the surfaces would be caused if the loads were limited to three-fourths of the minimum static load that produces permanent set, or

$$P = 675 \sqrt[4]{D^3} \quad \ldots\ldots (2)$$

These expressions must be considered as only tentative, pending the completion of the tests and their analysis, but will serve as a basis for a study of the design of the treads to distribute the rolling loads to the girders and segments to which they are attached, which the author conceives to be the major problem.

3. Design of the Treads

When a rolling-lift bridge is relatively long and heavy, the radius of the rolling segment must be made proportionately large, which results in a supporting girder of considerable length. In such a track girder, the load concentrated at the rolling line contact must be distributed so that by means of the direct support of the tread by the girder web, and the rivets attaching the vertical parts of the flange to the web, all of the stress is delivered to the girder within a reasonable distance along its length. In the case of a bridge of ordinary span, the treads usually become too long to be made as a single piece, and joints are necessary. When the rolling load is near a joint, or near the end of the tread, the tread must act practically as a cantilever on the side of the load adjacent to the joint, or the end of the tread. The ideal distribution would be one in which the reciprocal pressures between the girder and the treads were constant per unit of the length through which the distribution of pressure was made.

The supporting girder will deflect downward as a simple supported beam when the bridge rolls along it. The cantilever end of the tread, near a joint or end, will tend to deflect upward as a cantilever uniformly loaded along its bottom. The laws of these two deflections are mutually incompatible, and no arrangement will give a perfectly uniform distribution, but an approximation within reasonable limits may be found.

The object of the following discussion is to propose a method of proportioning the treads that is founded on a rational theory that takes into account the elastic action of the supporting girder and the treads; and which enables the designer to make his calculations from data normally developed during the design of the supporting girder.

4. Radii of Curvature of Deflected Beams

Let Fig. 1 represent a supporting girder of a rolling-lift bridge, carrying a concentrated load, *W*, assumed to be uniformly distributed along a length, *b*, by means of a thick stiff tread resting on the girder.

In order that the load on the tread be uniformly distributed along the length, *b*, of the supporting girder, *A B*, the radii of curvature of the deflected girder and the tread must be the same. This is not attainable. If the radii are made the same at a point *e*, one-fourth of *b* from the point of application of *W*, a close approximation to the ideal condition will be made. The tread will have full contact at *W*, but, theoretically, will be slightly above the girder at other points in the length *b*/2. However, the load, *W*, causes compressions within the portion of the tread, *f g*, so that instead of the cantilever end of the tread separating from the girder, the reciprocal pressures between the tread and the girder will become variable along the length *f g*.

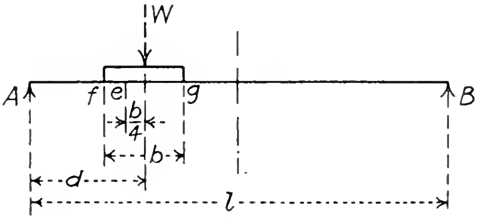


FIG. 1

The radii of curvature of the girder at various points along its length are different and also vary when the load is moved along it. The stiffness of the tread cannot be made variable without serious complications and unwarranted expense, but should bear some relation to the stiffness of the girder. It is well known that the radius of curvature of any deflected beam, when the stresses are within the elastic limit, is closely expressed by,

$$\frac{1}{R} = \frac{d^2y}{dx^2} = \frac{M}{EI}, \text{ or } R = \frac{EI}{M} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Let:

W = the rolling load in pounds,
l = the length of the girder in inches,
b = the length of the portion of the tread necessary to distribute the rolling load to the web of the girder,
d = the distance of the rolling load from the end of the girder,
I_g = the moment of inertia of the girder, and
I_t = the moment of inertia of the tread.

Consider the load, W, to be placed at various points along the girder. At each of these points calculate the moments for point e, both in the girder and the tread, considering the girder as a simple span and the tread as a cantilever of length $b/2$. Substitute the results in equation (3) equate the expressions and solve them for the values of I_t. The values thus found for I_t are shown in Table I.

TABLE I

VALUES OF I_t

Position of W on the girder. Distance d	Values of I_t in terms of l, b, and I_g
$\frac{b}{2}$	$\frac{I_g\, l}{7l - 4b}$
$\frac{l}{4}$	$\frac{I_g b}{6l - 7b}$
$\frac{l}{3}$	$\frac{9\, I_g\, b}{64l - 57b}$
$\frac{l}{2}$	$\frac{I_g\, b}{8l - 5b}$

It will be noted that I_t is very large when $d = b/2$, and diminishes rapidly to $d = l/4$, and reaches its minimum at $d = l/2$. Assume that the tread is proportioned for the value of I_t when $d = l/2$. Having designed the tread for this value of I_t, it can be tested for the variation in the unit pressures between its bottom and the top of the girder. When W is placed at $d = b/2$ from the extreme end of the girder, the difference between the radius of deflected curvature of the girder and that of the tread, considered as a cantilever, is a maximum. If the inequalities in the reciprocal unit pressures are not too great, the tread will still be in contact with the girder.

The expressions in the table show that I_t is a direct function of I_g and l or b, and an inverse function of multiplies of l and b, hence a short and stiff supporting girder will require a deeper and stiffer tread than a long and shallow one.

The tread on the rolling segment may safely be made of the same section as for that on the supporting girder.

5. Example

Assume a double track rolling-lift bridge weighing 3,000,000 pounds. Let the radius of the rolling segment be 28 feet and the angle of opening be 85 degrees. The length of the track along which the bridge rolls becomes, $\frac{56\pi}{4} \times \frac{85}{90} = 41.5$ feet. Assume that the treads are ordinary steel castings, with carbon of about 0.40 per cent. Let the permissible rolling line contact load be as given by equation (2), or

$P = 675\sqrt[4]{D^3}$, then

$P = 675\sqrt[4]{(672)^3}, = 675 \times 132 = 89{,}100$ pounds per linear inch.

Assume an impact of 20 per cent., then

$$\frac{1{,}500{,}000 \times 1.2}{89{,}100} = 20.2$$ linear inches required for line contact across the width of the tread. Assume the weight of the supporting girder to be 100,000 pounds, then:

	Shears	*Moments*
The girder, dead	50,000 lb.	518,750 ft.-lb.
Rolling loads, live	1,500,000 lb.	15,562,500 ft.-lb.
Impact	300,000 lb.	3,112,500 ft.-lb.
Totals	1,850,000 lb.	19,193,750 ft.-lb.

The web area required is $1{,}850{,}000 \div 10{,}000 = 185$ sq. in.

This can be made up as follows:

2 web plates 108 in. × ⅞ in. 189 sq. in.

The girder may be made up as follows:

2 webs 108″ × ⅞″	189 sq. in.
8 side plates 16″ × ⅞″	112 sq. in.
4 side plates 8″ × ⅞″	28 sq. in.
4 angles 8″ × 6″ × ⅞″	46 sq. in.
4 cover plates 30″ × ⅞″	105 sq. in.
Total area	480 sq. in.

This section has a gross moment of inertia of 930,987 in.^{4}, or a net moment of inertia of 805,665 in.^{4}.

The extreme fiber stress on net area is

$$\frac{19{,}193{,}750 \times 12 \times 55.75}{805{,}665} = 15{,}940 \text{ lb. per sq. in.}$$

The load which must be distributed to the girder web from the tread is $1{,}500{,}000 \times 1.20 = 1{,}800{,}000$ pounds. Refer to Fig. 2, and assume one-inch rivets.

Direct bearing on one
web in 22½ inches $= 22\frac{1}{2}'' \times \frac{7}{8}'' \times 24{,}000 = 472{,}500$ lb.
21 rivets 1″ in diam., in double shear at $18{,}850 = 395{,}850$ "

Available in 22½ in. on one web $= 868{,}350$ "
Available on two webs, 1,736,700 "

Length required for distribution, $22.5 \times \frac{1{,}800{,}000}{1{,}736{,}700} = 23.32$ in.

Let the rolling load be assumed as placed at $d = 1/2$ from the end of the girder, then, using the gross moment of inertia,

$$I_t = \frac{I_g\, b}{8\,l - 5\,b} = \frac{980{,}987 \times 23.32}{8 \times 498 - 5 \times 23.32} = 5{,}613 \text{ in.}^4 \text{ reqd.}$$

The tread section shown in Fig. 3 gives $I_t = 5{,}612$ in.^{4}.

Now place the load, W, so that the distance d, Fig. 1, is $\frac{23.32}{2} = 11.66$ inches from the end support of the girder.

Load W will not act at a point, but will be distributed somewhat by the elastic distortions of the two treads at their line of contact. W is assumed as concentrated on a line on account of simplicity in the analysis. The calculated deflections will be a little too large but will be on the safe side.

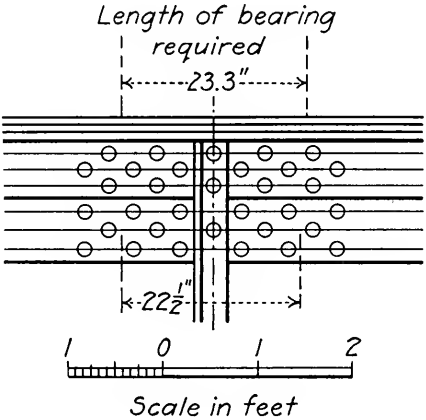


Fig. 2

Calculate the deflections of the girder downward from the end and of the cantilever end of the tread upward from a tangent to the deflection curve of the girder at point d, 11.66 inches from the end. Combine the results and find the theoretical distances between the points on the deflected girder and the corresponding points on the tread. Table II gives these distances.

Table II

Distance of points from the end of the girder in inches.	Theoretical distances between the top of the girder and the bottom of the tread in inches.
0	0.000,974
2.915	0.000,600
5.830	0.000,253
8.745	0.000,028
11.660	0.0

Fig. 4 illustrates the theoretical condition, the vertical distances having been greatly exaggerated.

Now conceive the girder to be incompressible and that the tread is brought into contact with it by elastic compression of the tread by the superposed load, which will now be assumed as uniformly distributed along the portion of the tread that is required to distribute the load to the web of the girder. Under this assumption, it is found that about 137,300 pounds on 11.66 inches of tread is required to cause contact at point *O*. There then remains 900,000 — 137,300 = 762,700 pounds to be taken uniformly by the two webs of the tread, the section of which is shown in Fig. 3. This corresponds to 762,700 ÷ 104.94 = 7,268 pounds per sq. in. in the webs. Had the distribution been uniform, the unit compression in the webs of the tread would have been, 900,000 ÷ 104.94 = 8,576 pounds per sq. in. Table III shows the various unit stresses and their combinations.

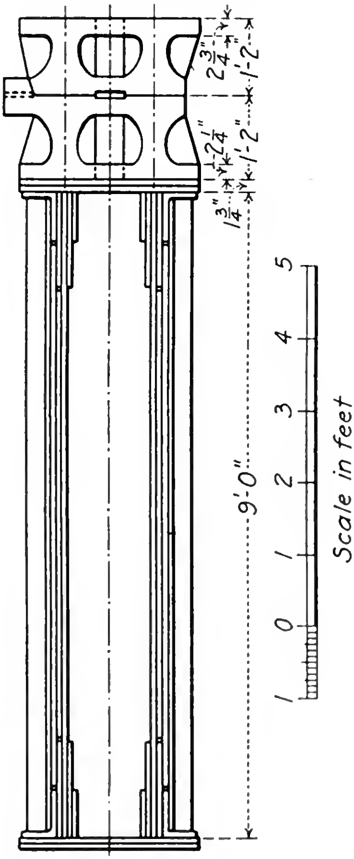


FIG. 3

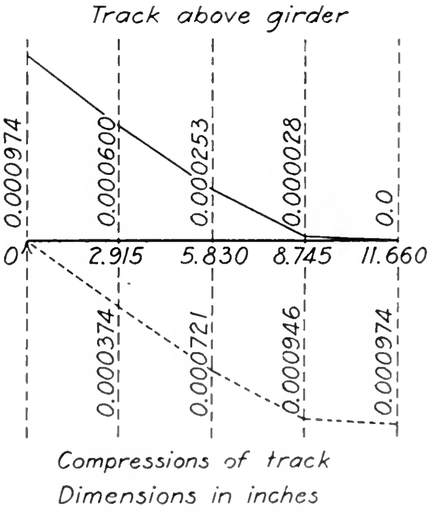


FIG. 4

TABLE III

Distance from end of girder in inches	Unit stress if uniformly distributed, lb. per sq. in.	Unit stress to cause contact at P, lb. per sq. in.	Total unit stress, lb. per sq. in.	Per cent of 8,576 lb. per sq. in.
0	7,268	0	7,268	84.7
2.915	7,268	775	8,042	93.8
5.830	7,268	1,494	8,762	102.2
8.745	7,268	1,960	9,228	107.6
11.660	7,268	2,018	9,286	108.3

The maximum unit stress is only 8.3 per cent more than for a uniform distribution.

It is recognized that this approximate method does not give the actual variations in the unit pressures between the tread and the girder; but the results are close enough to indicate that a tread designed in this manner will be satisfactory in service.

Table IV gives a comparison of tread plates to carry a load of 1,800,000 pounds, including 20 per cent impact, in accordance with several methods that have been proposed for their design.

TABLE IV

Designation	Theory	Type of construction	Depth of tread, inches	Sectional area of tread, sq. in.	Per cent
1	Elastic stress directly under load W at bottom of tread. No adequate provision for distributing the load to the girder......................	Solid with attachment flanges.	6.6	163	66
2	A. R. E. A. Spec. Pressure of 13,000 lb. per sq. in. at bottom of tread. Distribution 45 deg. each side of vertical through load W...........	Solid with attachment flanges.	7.9	221	89
3	J. E. Greiner's Spec. for Movable Bridges..........................	Ribbed castings.	22.6	325	131
4	The author's theory as developed in this article.......................	Ribbed castings.	14.0	248	100

DISCUSSIONS

DISCUSSION ON RULES AND ORGANIZATION

(For Report, see pp. 65-79.)

Mr. W. C. Barrett (Lehigh Valley—Chairman):—You will find the report in Bulletin 280, beginning on page 65. The Board of Direction assigned to this Committee for report this year but two subjects, the first, "Revision of the Manual." Because of the fact that last year's report of this Committee was not printed until September, although Sub-Committee No. I, having this subject in charge, of which Mr. Harsh was Chairman, did a great deal of work and collaborated with practically all of the other Standing Committees and had a report practically completed to be submitted to this convention, the Committee thought, as we have mentioned in the report, that it would be better to defer any revisions of the Manual until next year, to give the members of the Association an opportunity to go over last year's report, which was really a resumé of the entire work of the Committee for the past number of years, and be prepared to submit criticisms to the Committee during this coming year which could be used in our next report.

Some of the other Standing Committees might perhaps wonder why we did not use in our report some of the matter which was agreed upon in collaboration, and I make this explanation in order that they will understand.

The principal work of revision of the Manual was given to "Rules for Inspection of Bridges, Trestles and Culverts," and in addition to the fact that the time was short, some of the interested committees asked us to defer our report until they could revise some of the rules on which they were then working, and that also is the reason why we made no report on Revision of the Manual this year.

Subject No. 2, "Manual of Rules for the Guidance of Employees of the Maintenance of Way Department," Mr. Barnhart, the Vice-Chairman of the Committee, was Chairman of the Sub-Committee having that subject under consideration and he will present the report.

Mr. E. H. Barnhart (Baltimore & Ohio):—You will find the report of Sub-Committee No. 2 in Appendix A on page 66 of Bulletin 280.

The first rules, 510 to 515 inclusive, under the subject "Water Service Repairmen," on page 66, were compiled by Committee XIII—Water Service in collaboration with this Committee. If there is no objection to these rules, they will be passed.

The President:—Is there any objection? If there is no discussion, we will consider these rules approved as submitted.

Mr. Barnhart:—On pages 67 and 68, rules 1661 to 1682, inclusive, were compiled by this Committee and approved by Committee VI—Buildings. If there is no objection to these, we will pass them.

The President:—It is open for discussion if there is any.

Mr. A. F. Blaess (Illinois Central):—It seems to me that comes under the scope of specifications instead of rules.

Mr. Barnhart:—This is a subject which has been under consideration by the Committee for a number of years. We usually take the decision of the Standing Committee as to whether they are specifications or rules. The Buildings Committee passed upon these as rules. This is as far as I can answer the question.

Mr. C. W. Baldridge (Atchison, Topeka & Santa Fe):—I hardly think that this matter belongs in the list of rules. If you will read them through, you will find that all but two, I believe, of these proposed rules are instructions as to how work shall be done, without any regard as to who is going to do it. My understanding of a rule would be instructions to an individual or a group of individuals as to their duties and how they are to be performed. It seems to me that this matter under consideration should have been presented by Committee VI—Buildings as specifications, and I move that it be referred back to Committee VI for inclusion as specifications.

Mr. Barrett:—As Mr. Barnhart has already said, this Committee has found it very difficult all through the years of our work to absolutely draw a line as to what are instructions and what are rules, and in the form in which we have submitted our "Manual of Rules for the Guidance of Employees of the Maintenance of Way Department," these particular rules are under what we designate "Conduct of Work," and, as has already been stated, these rules were gone over very carefully by the Committee on Buildings and approved by them for use by this Committee as rules. They really are not specifications, and in view of the fact that all of the rules we could submit would be general and we could not specify just exactly who was going to carry them out, I hardly see how we could make any specific rules for any specific individual.

Mr. O. E. Selby (Big Four):—I agree with the two speakers who have spoken from the floor that the rules on buildings are not a proper subject for inclusion in the Manual in this place, under this Committee. The rules presented are not rules for guidance of employees; they are specifications, and to my mind incomplete specifications. The rules cover in less than two pages the whole realm of building construction. Naturally there cannot be put in that small space anything like a complete manual for the doing of building work. Some of the specifications already are in the Manual and in the reports of other committees; I see no good reason for repeating them here.

In the two pages of these rules there are covered the subjects of concrete, brickwork, sand, framing, carpenter work, roofing, sheet metal work and plastering. It seems to me absurd to put in such a small amount of matter on all of those subjects with manifestly no attempt to cover the whole subject. My notion is it would be better to leave them all out and insert under "Buildings" merely rules for the employees and not attempt to cover specifications for building work.

Mr. Barrett:—I think a close study of these rules will indicate to anyone that they are absolutely not specifications. They give no sizes or dimensions —nothing of that sort. A man could not take these rules and call them specifications and put up a building from them. The idea that the Committee had in mind, and we thought that covered in our instructions, was to take all of the material we could find in collaboration with the Committee on Buildings and boil down into a few simple rules the fundamental things which a builder should do under the proper specifications when he is putting up a building. That is the reason why there are so few rules.

Of course, everyone understands this "Manual of Rules for the Guidance of Employees of the Maintenance of Way Department" would never be complete. New things will come up from year to year and new rules will be added. This is the first start on presenting rules covering instructions on maintenance of buildings. These rules were never intended as and are not specifications.

Mr. W. H. Woodbury (Duluth & Iron Range):—I would like to second Mr. Baldridge's motion to refer back.

The President:—You have heard the motion. It is moved and seconded that this section on rules for buildings be referred back to Committee VI—Buildings. Is there any further discussion?

Mr. W. C. Cushing (Pennsylvania Railroad System):—If I may, I would like to present some general remarks on this subject which place a different point of view on this matter. The Maintenance of Way Department is a part of the Operating Department of the railroad. The book of rules of the Operating Department is the general statement of rules of conduct and the duties of the employees who for the most part hold positions as heads of departments.

There should be no duplication of those rules or instructions in any other books that are issued by the various departments. There should be one place to look for the instructions concerning the duties of employees, and that is in the book of rules of operation. The book of rules for the Maintenance of Way Department should be a supplementary book to it and should not contain the same substance in it.

I have noticed in the different reports of this Committee from time to time there is a great deal of that repetition. It is entirely uncalled for. It takes up space and requires reference to more than one place for ascertaining the duties of employees.

This book of instructions to the Maintenance of Way Department should contain no reference to the duties of employees except in so far as they have not been covered by the book of rules of operation, such as some of the sub-employees.

The work of the Committee should be put in the form of specifications for work, and specifications for the guidance of the Maintenance of Way Department consist mostly of the usual duties of the trackmen and the carpenters, and so forth.

To enlarge on that somewhat, the main way of conveying information for doing work to the employees is by specifications or plans, and the preparation of those specifications or plans should be complete each one in itself and prepared by the committee dealing with that particular subject.

There should not be different places for conveying that information, but each plan or specification should be made as complete as possible in itself. That leaves only the ordinary permanent way matters, such as the maintenance of roadbed and track, policing and so forth, for the general specification of rules for the guidance of Maintenance of Way employees, and they should be informed as to how to do the work and not what should be done by each particular employee, because that is well-known already from the book of rules of operation, which prescribes those duties. My own personal view would be to recommend a back track on the part of this Committee to correct its plan of work in that respect.

You will find an immense amount of repetition. They all begin with an outline of duties for each individual in charge of a gang, which are the same for almost every one of them, and you will find that in the various rules in the Manual already published those things are repeated over and over again, whereas they are already in the Book of Rules of the railway Transportation Department. My suggestion would be that the Committee should work on that line instead of the present line that it is pursuing.

Mr. Barrett:—In answer to Mr. Cushing's suggestion, I might just state that so far as we have been able to determine, the Committee has worked directly along the lines laid down for us by the Board of Direction of the Association, so that if we are on the wrong track it is because we have been directed wrongly, and as Chairman of the Committee I rather believe we have been directed properly.

I just want to make this comment on the motion. I think it has already been said, and I wish the members of the Association to know it definitely, that these rules were submitted to the Committee on Buildings before they were printed in the Bulletin by the Committee on Rules and Organization, and this Committee hardly sees where we can get any further along by having them referred back to the Committee on Buildings, because they have already approved them.

Mr. L. P. Kimball (Baltimore & Ohio):—As I understand the purpose of the Association in assigning such a subject to the Committee, it is to result in the eventual completion of an independent book of rules for the Maintenance of Way Department, independent in the sense of being published perhaps separately from the Manual, at least when complete, and as such I think it is entirely proper to include material of this nature in that book of rules, even though it is a repetition and a duplication in some instances of material which has been prepared and published in the specifications by the Buildings Committee.

Mr. J. P. Hanley (Illinois Central):—It appears to me that these are rules on the conduct of work. I believe we may have rules on the conduct of work the same as on the conduct of individuals; or procedure in case of accident; or how to handle explosives, and things of that nature. I believe the Committee did a great deal of work, and it would be a good idea to let these rules stand as recommended good practice. Those roads who do not care to use them do not have to use them, and I cannot see that they will do any particular harm.

Mr. J. L. Campbell (Southern Pacific):—It seems to me that the point at issue is brought out by comparison of the rules which have been submitted for the guidance of the water service department on page 66 with the specifications which appear on pages 67 and 68. It has been my view that the rules which would be submitted by the Committee should have reference only to the organization that would do certain work.

It seems to me that these rules on page 66 refer to that, the organization, not the actual conduct of work under the organization, but rules for the guidance of the employees of that organization. I think that they are proper and should be recommended as rules for the guidance of the employees of the organization, but when we come over to page 67, we find that we have, I believe, nothing but specifications for doing the work, referring to the details of the execution of the work, and I believe that has nothing in particular to do with the organization itself and the guidance of the employees.

It seems to me that if these specifications on pages 67 and 68 go into the Manual, they should go in under the Committee's recommendation on buildings, and certainly there should be no duplication.

Mr. Hunter McDonald (Nashville, Chattanooga & St. Louis):—I want to endorse what Mr. Cushing and Mr. Campbell have said with respect to this report. I myself had noticed that the rules for water service repairmen had dealt only with the conduct of the individual, while I think the specifications for buildings encroach upon the field of the Designing Engineer or Architect and should be taken care of as specifications.

As illustrating the difference between these two reports, I will call attention to Rule 1676, "Flashing must be properly placed to insure roof from leaking." That, of course, is a principle that is already so thoroughly settled that there is no need to give it a number, but under the head of Water Service Repairmen there is nothing to show that tanks must be built so that they will not leak, and I cannot see why the two principles are so divergently treated in this report. I believe that the rules prepared by this Committee should be confined to outlining the duties of the Maintenance of Way employees charged with maintenance of track and structures in order that they may be in proper shape for the service of the public.

That is the most important feature, it seems to me, and I do not believe it is necessary to go into all the detail as has been done in this report.

Mr. Barrett:—I would like to call the attention of the members to Bulletin 279, Supplement to the Manual, containing the report of this Committee for last year, particularly to the fact that the report is divided into two distinct parts. The first is the "Duties of the Various Divisional Officers and Employees," and the second is "Conduct of Work." The real reason for the very great difference between the rules on page 66 and the rules beginning on page 67 is because the rules on page 66 are rules for employees, water service repairmen, instructions to the individual; while the rules beginning on page 67 under Buildings are rules for conduct of work, that is, brief statements as to what this Committee considered, and the Buildings Committee also approved, were fundamental things which should be done when constructing or maintaining buildings. So there is really no connection whatever between the rules for employees and the rules for conduct of work. These must necessarily be entirely different, and while the Committee does not want to enter into a discussion as to what are specifications and what are rules, we do not think these are specifications at all. We consider them rules.

The President:—Any further discussion?

(The motion was carried.)

The President:—That section of the report will be referred back to the Committee on Buildings.

Mr. Barnhart:—On page 68, Rule 1717, under the general subject "Painting"—Conduct of Work, this rule was prepared by the Telegraph and Telephone Section of the American Railway Association in collaboration with this Committee. It has to do particularly with insulated wires. I move its approval.

The President:—If there is no objection, it will stand approved.

Mr. Barnhart:—On pages 68, 69 and 70, Rules 3000 to 3055, inclusive, were prepared by this Committee and approved by Col. B. W. Dunn, Chief Inspector of the Bureau of Explosives. They are offered for printing in the Manual.

Mr. Hanley:—It appears to me these are rules on the conduct of work and they should be rejected also.

The President:—Do you make that as a motion, Mr. Hanley?

Mr. Hanley:—Yes, sir.

The President:—Mr. Hanley, what does your motion cover, the reference of these back to this Committee? There is no other committee in collaboration on this particular section.

Mr. Hanley:—It appears to me that all of these rules are very good things to be published somewhere, that is, the rules on handling explosives; what to do in case of accident; first aid to the injured, and so on, but they are rules on the conduct of work and if we object to the rules on the conduct of building work, the same objection should cover all the others.

Mr. Barrett:—I think perhaps the speaker has rather misunderstood the situation. There is no question, as I understand it, about these rules covering handling of explosives, scrap and refuse material being specifications. It is my understanding that the real reason why the rules on buildings were referred back was because the majority of the members thought they were more in the nature of specifications than rules. For that reason we should like very much to have these rules on the handling of explosives, scrap and refuse material approved, because, as has already been said, Col. Dunn went over these rules very carefully and made some few corrections, and the rules are printed exactly as he approved them. As I understand it, he is the last word on that subject. So if they were referred back to us, we would not know what to do with them.

Mr. W. C. Cushing:—With reference to that particular point, I would like to ask if these are the same as those already issued in great detail by the American Railway Association, Col. Dunn being the one who has had the supervision of their preparation. The railroads generally are supposed to be making use of those instructions concerning the handling of explosives, and I do know that the Pennsylvania Railroad has a document of that kind issued by the Transportation Department, just like it issues the Book of Rules that I have been speaking of, which is approved by the American Railway Association. This is another case of duplication.

Mr. Barrett:—The only answer I can make to that is that the Committee has been trying to do what it was instructed to do. Unless everything, so far as possible, referring to the duties and work of employees in the Maintenance of Way Department is included in this Manual, something will be missing, perhaps, and it is our thought that that is what the Association wanted us to do—to take the time, which the individual does not have, to go over all the voluminous reports of the various Standing Committees and get all the information we could from every source and bring it before the Association in concrete form in the fewest possible rules so that it would be workable. That is what we tried to do.

Mr. Hanley:—I am in favor of the Committee's report, and I believe that there is a distinction between rules for employees and rules for the conduct of work. I believe both have a place in the report, but we should be consistent. If we cut out the rules on building work, we should be consistent and cut out the rules on the handling of explosives. I would, however, like to see the entire report stand. I do not wish Mr. Barrett to have a wrong impression of my attitude.

Mr. McDonald:—I differ with Mr. Cushing in his remarks regarding the paragraph on explosives. I do not think we can repeat the instructions regarding the care and handling of explosives too often, and if the rules are issued by the Operating Department in accordance with the American Railway Association, they will probably be in one volume with other rules of conduct and may never come to the hands of the maintenance of way foremen. I think every foreman should be instructed with regard to the matter of handling explosives. Those rules as drawn relate to the conduct of the men and not as to the quality of the workmanship.

Mr. Cushing:—There is some confusion. There are two things regarding explosives. One of them is the handling of explosives for transportation purposes and the other is the handling of them in work of construction. Those are two distinct and different subjects, and the one in which the first reference was made was a set of rules prepared by the American Railway Association for handling them in transportation. In addition to that there are rules for the handling of explosives when using them in construction work, which is a different matter and for supervision by the maintenance people. Our plan for handling that is to issue them in the form of specifications which are transmitted to all the members of the department interested in or concerned with their use.

That to which I call particular attention is the necessity for making use of the information in regard to transportation by the American Railway Association, which is authoritative, and which can be easily referred to for our own full information and explanation in the preparation of such additional rules as may be necessary in the case of the use of explosives.

It is entirely proper to put that in the form of specifications.

Mr. Campbell:—It seems to me that these rules as presented here are entirely appropriate for being included as a part of the work of this Committee. We want to have a complete Manual of this Association, and I believe it is necessary to put this sort of thing in the Manual in order to have it complete. Of course, in all matter that goes into the Manual that covers ground that is covered by other departments of the Operating Department, there should be no conflict, and on the supposition that these instructions as here presented do not conflict with the instructions of any higher authority, I am in favor of their being accepted.

Mr. W. G. Arn (Illinois Central):—Mr. Campbell has brought out one of the points I had in mind, that the rules, or specifications, whichever you call them, on page 67, are covered in specifications which this Association has put out.

These rules on handling explosives, scrap and refuse material, as I understand it, are not covered anywhere else in what the Association has done, and, therefore, we should have something of that kind.

It seems to me, however, that the handling of explosives should not be included with scrap and refuse material, but that they should be separated into two separate and distinct matters because the handling of scrap and refuse material is pretty general and the handling of explosives is limited to very few in the department of the railroads in which this Association is directly concerned.

Mr. Barrett:—I might explain with reference to including all of these that it will be noted there are different subheads and the rules are numbered. Those numbers fit in the Manual as already approved, so that when they are actually printed with the other rules already approved for printing in the Manual they will be inserted in their proper places and the rules for handling of scrap and refuse will not be confused with the rules with reference to explosives.

The President:—Is there any further discussion? It has been moved and seconded that this section should also be referred back to this Committee. All in favor please say "aye"; contrary "no." The motion is lost.

Mr. McDonald:—Do we understand that that approves this heading, and scrap and refuse will not be separated from the explosives?

Mr. Barrett:—No, sir, they will be printed in the proper place in the Manual.

The President:—As it now stands, the only part that is referred back is the portion referring to buildings.

Mr. F. D. Batchellor (Baltimore & Ohio):—I would like to call attention to Rule 3055 on page 70, which requires, "In case of wrecks involving tank cars of inflammable oils the Section Foreman should be specially careful," to do certain things. It seems to me he should only do these things until the arrival of a higher supervising officer who should then relieve him of those duties.

The President:—Mr. Batchellor, I believe that can not be altered now. It has already been approved.

Mr. Barnhart:—Rules for procedure in case of accident are given on pages 70 to 72. The Committee, since the Bulletin was issued, has received two or three criticisms which were acted upon last night and we desire to make two changes in these rules: In Rule 3126, on page 71, the last phrase, reading, "and the case put in his exclusive control," to be eliminated, ending the sentence at the word "charge." At the top of page 72, in rule 3155, the last part of the rule, we have changed the phraseology, placing the words "should be stated" at the end of the sentence instead of where it is shown in the Bulletin.

I move that these sections and changes be adopted.

The President:—It is moved that this section with the changes be adopted. If there is no objection, it is approved.

Mr. Barnhart:—Rules for First Aid to the Injured are covered in Rules 3150 to 3248, on pages 72 to 77. I move they be adopted.

The President:—You have heard the motion. If there is no objection, the rules will be considered adopted.

Mr. Barrett:—I thought it might be interesting to mention at this time that these rules just approved have been reprinted by the American and Chinese Association of Engineers. The Committee felt highly honored that someone else thought these were good rules.

Mr. Barnhart:—Appendix B, starting at page 77, and continuing through to and including page 79, is offered as information. The Committee desires to make one correction. After Rule 2, under the general heading "General Supervisor of Work Equipment," at the bottom of page 77, we desire to add the words, "Ballast cleaners, electric and pneumatic tools, and such other equipment as may be specified." These rules are shown under the several headings of General Supervisor of Work Equipment, Inspectors of Work Equipment, Supervisors of Work Equipment, Work Equipment Repairmen and Work Equipment Operators, and are offered as information.

The President:—Is there any discussion on these last rules? They are offered as information only, and unless there is objection, they will be so received. The Committee is relieved, with the thanks of the Association. The Chair also desires to congratulate them on the fact that their rules have been reprinted by the American and Chinese Engineering Association. (Applause.)

DISCUSSION ON BALLAST

(For Report, see pp. 81-88.)

Mr. F. J. Stimson (Pennsylvania Railroad System—Chairman) :—The Committee on Ballast were given several subjects to report on. Out of the various subjects that were assigned they have reported on four. Of these one is the Revision of Manual. It is very brief. A revision of specifications for washed gravel ballast is the only part of the report that involves any particular action on the part of the convention.

In the absence of Mr. Winchester, who was Chairman of the Sub-Committee on Revision of Manual, I will present what there is of that. It will be recalled that last year, owing to the manufacturers having brought out the fact that the fifteen-tine ballast fork which had been adopted by the Association as a recommended standard could not be commercially produced, the Ballast Committee recommended and the Association approved the withdrawal of the plan with the idea that a new fifteen-tine fork would be designed.

It developed in the discussion of this matter that fifteen-tine forks such as had been designed really had no particular office. The fork was designed particularly with the view of having it narrow so it could be used in the crib between the ties in removing ballast for cleaning, and it is quite evident that a shovel is better for that purpose, as it will remove the dirt which you want to get out from between the ties much more satisfactorily than the ballast fork. For that reason it is recommended that no design for the fifteen-tine ballast fork be provided for inclusion in the Manual.

The question of handles for forks, shovels, and so forth, was brought up and it was decided by the Committee that in view of the modern practice and developments in designs of handles, the following note should be added to the designs shown in the Supplement to the Manual of 1921: "Dee handles of the built-up type may be substituted if designs meeting the approval of the . . . . . Engineer are submitted."

I move that the two recommendations of the Committee be adopted.

Mr. W. H. Kirkbride (Southern Pacific) :—I think we should have a standard ballast fork. We have succeeded in getting manufacturers to produce a fork for the Southern Pacific; as I recollect, it is a fourteen-tine fork and the spacing between the tines is approximately half an inch. I think that is what the Committee endeavored to get by the original specification. We would be pleased to furnish blueprints of this fork to the Committee. I think we should have a standard fork, not so much for cleaning the ballast out between the ties, but for forking over the ballast to remove the dirt, those particles of rock which are smaller in size than five-eighths of an inch.

Mr. Stimson :—I think the last speaker has overlooked the true situation. The specification for ballast fork that was originally adopted carried two designs, a fourteen-tine fork and a fifteen-tine fork, the fourteen-tine fork being the general conventional ballast fork such as is used by a great many railroads. We found that many railroads were actually getting ballast forks made in accordance with the plans or specifications for the fourteen-tine fork, but the fifteen-tine fork was, as I have said, designed for the specific purpose of removing ballast from the space between the ties. While having one more tine than the other, its width overall was less, resulting in a spacing between tines (I am not sure I am right) of only three-eighths of an inch. It is that fork that we are proposing to withdraw from the Manual and not substitute any design, because of the fact that, first, the manufacturers say it is impossible to commercially produce a fork with tines so close together as our design required and, second, because we feel that a fork for working between the ties is not an essential tool for track-work.

Mr. Kirkbride:—I think it is a fact that the manufacturers refused and said they could not manufacture a fork with the tines close together; what I mean by close together is less than half an inch. I was under the impression that this was under discussion last year and that one of the controlling reasons for reconsidering the fork was the fact that you could not get the manufacturers to make the fork that you want. The ordinary ballast fork that I have seen has tines possibly an inch or an inch and a quarter apart. They are too far apart for ballast. If we can get a fork with the tines approximately half an inch apart, a little bit less than that would be desirable, we certainly should adopt it. I cannot see the difference between the fork of fifteen tines and the one of fourteen tines; that does not appear to be the controlling feature in connection with the design of a fork. I do believe that we need a fork, the tines close together, that will enable us to fork fine material out of ballast when it has become foul with dirt.

The President:—Any further discussion? You have heard the motion.

(The motion was carried.)

Mr. Stimson:—Mr. Dare, Chairman of Sub-Committee on the Revision of Specification for Washed Gravel Ballast, has asked me to present the report of the Sub-Committee on account of his hoarseness. The main features of these revisions are the changes in the proportioning of the aggregates. The Committee has found from its investigation that washed gravel ballast containing a material percentage of crushed gravel is a good ballast without the same content of fine material that is necessary where the gravel contains little or no crushed material. They, therefore, have provided a specification which provides three different mixtures, the variations depending upon the amount of crushed gravel that is contained in the output. I might add in this connection that the Committee recognizes the specification is not complete, and that, as stated in the report, the gravel may be well washed, well screened and well graded, and yet be practically worthless as ballast because of its lack of resistance to disintegration and wear. The Committee has not been able to develop any specification and tests for checking that quality in the ballast but proposes to carry on its investigations along that line.

The specifications as proposed change the first paragraph providing that the material shall be of such size that it will pass in any position through a one and one-half inch ring. The old specification provided a two and one-half inch ring. The old specification also provided twenty per cent as a maximum and fifteen per cent as a minimum of sand. The new specification provides, as I have stated, varying proportions of the aggregate, depending upon the percentage of broken stone in the product.

I move the adoption of this portion of the specification, having to do with the size and proportioning of the material.

The President:—Unless there is some objection, it will stand approved.

Mr. Stimson:—The next paragraph is on Test No. 1, Dust, Dirt and Loam. There is no particular change in this specification, being merely redrawn to cover the same matter in a somewhat different language. I move the adoption of this paragraph.

The President:—If there is no discussion on this section, it will stand approved.

Mr. Stimson:—Test No. 2, Large Aggregate: The only change in this is in the matter of size, which by virtue of the first part of the specification has been made one and one-half inches in place of two and three-quarters inches. I move the adoption of this paragraph.

The President:—If there is no discussion on this paragraph it will stand approved.

Mr. Stimson:—The next paragraph, Test No. 3, Sand: The only change in this is in connection with the amount of sand which will be accepted. Under the general provision of the first paragraph, there is supposed to be no material which will pass a No. 10 screen permitted in the product. The commercial practice in producing washed gravel makes it impossible to live up to that specification literally and the tolerance of three per cent which is given in this specification for Test No. 3 sand is merely to take care of that small amount of sand which naturally adheres to the wet stone and so passes into the product, but practice has shown that this can be kept as low as or below three per cent.

I move the adoption of this paragraph.

Mr. J. P. Hanley (Illinois Central):—I would like to ask what the No. 10 screen signifies, that is, what size in inches or parts of an inch.

Mr. Stimson:—The No. 10 screen referred to is a commercial testing screen that has ten meshes to the inch. The openings are slightly less than one-tenth of an inch, due to the fact that the wire of which it is made is taken out of the opening.

The President:—Any further discussion? If not, the section stands approved.

Mr. Stimson:—There is no change in the section on Inspection, nor in the section on Measurements.

After the report was printed, our attention was called to the fact that nothing was provided in the specification covering uniformity in the mixture of the aggregates. That is considered a very important part of the production of washed gravel ballast and if proper provisions are not made, it will be found that the coarse aggregate will be segregated in one part of the car and the fine aggregate in another part of the car, or if a material is first put in the bins, it is quite probable that a full carload will be very largely of large material and another carload very largely of fine material.

The Committee wish to add this paragraph, headed "Uniformity":

"The finished product when loaded in cars must have the various sizes of aggregates uniformly distributed throughout the whole. Any segregation of the aggregate which, in the judgment of the Engineer, will lessen the value of the product as ballast, will be cause for rejection."

I move the inclusion of the paragraph which I just read as a part of the specification.

The President:—Any discussion on that? The section just read by Mr. Stimson not having been printed in the report, it should have the unanimous consent of the convention to its being considered; otherwise it will have to lay over for one year. If there is no objection, it will stand approved as read. It stands approved.

Mr. H. M. Stout (Northern Pacific):—I want to call the attention of the Committee to one paragraph which in this report is designated as not changed, namely, "Measurements" on page 85. They have provided there in the previous specification, which is continued in this report, a measurement by the ton. I think that that specification or that way of measuring ballast should be discouraged as much as possible. The usual engineering rule for measuring ballast is the cubic yard, and I think it is against the interest of the business to confuse this point by producing or maintaining numerous units.

During the Federal valuation of the railroads, all the ballast reported, probably, was included on the basis of cubic yards, and provisions of the Bureau of Valuation under their Order No. 3, specify that "the unit designations, the quantities and descriptions recorded in the completion reports and in the record of property changes shall be stated, so far as possible, in the terms of the inventory taken by this Commission." The inventory for ballast was taken in the unit of cubic yards. To comply with the requirements of the Interstate Commerce Commission, it appears advisable to recommend that ballast be purchased by the cubic yard. For record purposes the weight of ballast material should be ascertained and verified from time to time, as this information is needed in compiling freight charges. Analysis of cost is referenced to the common unit of cubic yard for all ballast material, also the cost of unloading and the cost of applying.

Mr. Stimson:—In answer to the last speaker, I would call attention to the fact that the paragraph on Measurements does not limit it to measuring the ballast by the ton. It provides for measuring it by ton if that is the unit of measure under which the ballast is purchased, and while the matter in the paragraph itself is just as self-evident to any Engineer as anything can be and does not need to be in here—I do not think there is a man in railroad service who does not know how he can find out how many yards there are by weighing his material or how many tons there are by measuring his material—but to make the specification complete, this formula, if you are pleased to call it that, for reducing tons to yards or yards to tons was included. No thought was in the minds of the Ballast Committee that they were fostering the method of buying ballast by the ton or fostering the method of buying ballast by the yard.

It is a matter of record and common practice that ballast is very generally bought by the ton, as that is the easy way to make a ready measurement.

The weights are obtained for transportation purposes and are easily applied in ascertaining the amounts to be covered by the invoices. While I have no question at all in my mind that the yard is the unit which will be used in the records to which reference has been made, I can see no inconsistency in the rule as given here in this specification which, as I have said before, merely recites what everybody knows—how to reduce tons to yards and yards to tons.

Mr. C. C. Westfall (Illinois Central):—Concrete Engineers have brought out a point in the last few years on the bulking of wet sand which is thrown loosely into a pile. It seems to me that this would affect to a considerable extent the measurement of sand or ballast. There is a probability that there would be some difference in the quantity of wet sand measured, if you measured it at the pit or after it had been hauled over the railroad. The same thing would hold if you pay for that sand by measurement; you would be paying for some of the water. Wet sand, when thrown loosely into a pile, has some adhesive qualities and will bulk as high as forty per cent, depending upon the amount of moisture.

I believe in buying sand it might be well to make a study of that and possibly arrive at the methods of measurements based on price.

Mr. Stimson:—I might say in reply to the point just made that the new specification is set up with a view that all sand will be removed, and that the only sand that is tolerated in the specification is that which has been demonstrated from the operation of pits it is impossible to get rid of in a reasonable commercial way.

As a matter of fact, the test for the sand requires that the material be dried and that the sand that is found shall be measured in that way, and the limit is set at three per cent as being the maximum that will be permitted. I think that any variations that might be due to wetness or dryness of the sand can be entirely ignored.

The President:—Mr. Stout, do you have a change to suggest in the two paragraphs under the caption of "Measurements"? These have not been suggested this year, but are the former approved portion of the specifications. It will be necessary to move that some change be made, or that it be referred to the Committee for reconsideration.

Mr. Stout:—I have no change formulated. My thought was to bring the matter before the Committee. My understanding is that this specification is presented at the present time with the expectation of its being acted upon a year from now. It was my thought that if the matter were brought to the Committee's attention they might be willing to make a change between now and the adoption of the report. The whole point is the discouragement of the use of the ton in favor of the use of the cubic yard.

The President:—I think you are correct, Mr. Stout. They are only asking for the approval of this as a tentative specification.

Mr. Stout:—That was my understanding.

Mr. J. L. Campbell (Southern Pacific):—I want to direct the attention of the Committee with regard to the word "receptacle" in the eighth line of the last specification under "Dust, Dirt or Loam." I would like to know if the Committee intended to use the word "water" instead of the word "receptacle."

The President:—The Committee will consider that, Mr. Campbell. Unless there is further discussion, this will stand accepted as a tentative specification to be dealt with further next year.

Mr. Stimson:—The balance of the report, given in Appendix C and Appendix D, are merely submitted as information.

The President:—Unless there is some discussion on the remainder of the report, it will be accepted as information.

That concludes the report of the Committee on Ballast, and they are dismissed with the thanks of the Association. (Applause.)

DISCUSSION ON IRON AND STEEL STRUCTURES

(For Report, see pp. 89-113.)

(The report was presented by Mr. B. R. Leffler, Vice-Chairman, in the absence of the Chairman, Mr. O. F. Dalstrom.)

Mr. B. R. Leffler (New York Central):—The report of Committee XV is to be found in Bulletin 280, beginning at page 89. Following the list of subjects contained in the report, is the action recommended on the report.

The first recommendation is to the effect that the matter relating to Bearing Pressures on Large Rollers be received as information. This is an important subject and has been under experimental investigation at the University of Illinois for a period of four years, and it is hoped in another year to show some very valuable and interesting results. This subject has an important bearing or influence on the design of large bascule rolling lift bridges.

The President:—If there is no objection, this section will be received as information.

Mr. Leffler:—The work covered under the subject of "Punched Work" and "Reamed Work" has been done by a special Sub-Committee, but the main Committee has not yet digested the results of the investigation. This is also offered as information.

The President:—If there is no discussion, it will be so received.

Mr. Leffler:—We wish to defer action on revision of the Manual until other matters in the report have been disposed of.

Appendix B covers Specifications for Steel Highway Bridges. This work is in excellent stages of progress. Two organizations are co-operating in this matter effectively, namely, the American Association of State Highway Officials, a national body, and this Association. Collaborating with these bodies is the American Institute of Steel Construction, acting in an advisory capacity. It is hoped in another year to make a final recommendation.

Appendix C covers "Instructions for Maintenance Inspection of Superstructures of Steel Bridges." This material is offered for approval and insertion in the Manual.

Mr. W. C. Barrett (Lehigh Valley):—As Chairman of the Committee on Rules and Organization, I do not wish to be understood as offering any criticism of these rules or instructions as they are printed, but I just want to mention this fact: During the past year, our Committee has been working in very close co-operation with this Committee on revision of the rules now appearing in the Manual for inspection of bridges, trestles and culverts, that is, including all sorts of bridges and trestles and culverts, whether steel, wood or masonry, and we had a report practically completed, but as I explained on the platform, we were asked to defer that until this Committee on Iron and Steel Structures had revised their rules.

These rules, I understand, are that revision, but inasmuch as the Committee on Rules and Organization had no opportunity to co-operate with or collaborate with this Committee, I just want to raise the question as to whether or not it were proper to put rules for inspection of steel structures in the Manual when we already had rules for inspection of all sorts of bridges.

Mr. Leffler:—I will ask Mr. Stuart to explain a little bit on that matter.

Mr. H. B. Stuart (Canadian National):—I believe the two committees should get together and agree on these rules. By referring to Bulletin 280, page 65, Committee XII have for future work rules for inspection of "Bridges, Trestles and Culverts" as Subject No. 1 under revision of the Manual. Some months ago the rules now before the convention were forwarded to the Chairman of Committee XII and later were included in their entirety by that Committee in tentative rules for inspection of "Bridges, Trestles and Culverts," draft copy of which was forwarded by Mr. Barrett. It was therefore inferred that these rules now before the convention for inclusion in the Manual have been considered and passed upon by Committee XII. The location of these rules in the Manual is a matter for the Committee that is revising the Manual and bringing it up to date.

Mr. Leffler:—Do I understand that it is the wish of the Chairman of the Committee on Rules and Organization that these instructions be not put into the Manual until they have been passed upon by the Committee on Rules and Organization?

Mr. Barrett:—That is the thought I had, not because we wanted to take from your Committee any of its authority, but because otherwise there will be duplication and our Committee thought if we had all of the rules for inspection of bridges in one place, for the reason that the same man inspects the steel bridge and the wooden bridge and the masonry bridge, it would be better, for the rules then would be assembled in one place in the Manual.

Mr. Leffler:—Is it the intention to change the substance of these rules or just the location in the Manual?

Mr. Barrett:—Our report included bodily, except just what minor changes in English were necessary to make them fit in with the other rules, the rules that your Committee had already printed in the Bulletin for information, and it would be our intention, if this matter were deferred for another year, to work as we did during this last year very closely in co-operation with this Committee to have one set of rules by both Committees.

I move you that the instructions for inspection of steel structures be referred back to the Committee for collaboration with the Committee on Rules and Organization during the ensuing year.

(The motion was carried.)

Mr. Leffler:—Appendix D gives the report of the Committee on Column Tests.

A special committee of the American Society of Civil Engineers, of which Dean Turneaure is Chairman, has been at work during the past two years collecting and studying existing data on column tests. That committee will outline a program of tests based on the findings from the study of former tests, and of certain preliminary tests made recently for its guidance in outlining such a program.

The Committee on Iron and Steel Structures, through Dean Turneaure, who is also a member of this Committee, has maintained contact with the special committee of the American Society of Civil Engineers in its work to the present time. When a program of tests is completed, it is intended to arrange for co-operation between the two committees in making the tests.

The President:—Unless there is some discussion, Appendix D will be accepted as information.

Mr. Leffler:—Appendix E covers "Specifications for Waterproofing and Drainage of Solid-Floor Railway Bridges." This is the first time that a specification, I believe, has been presented to the Association for this kind of work, and it is presented as information, hoping that wide discussion will follow. Written discussions in particular are desired. It is presented for information and tryout in actual service.

The President:—Unless there is some discussion, this section will be received as information. In the meantime the Chair suggests that the membership give it full consideration during the year and assist the Committee by written discussion of the subject.

Mr. Meyer Hirschthal (Delaware, Lackawanna & Western):—Paragraph 2, section 11, under Appendix E, Design of Bridges, reads, "Where contraflexure would injure the waterproofing special details shall be provided." Is it meant that where the structure is subject to reversal of stress, special details shall be designed for waterproofing?

Mr. Leffler:—I would interpret it to mean that where there is a reversal of stress; the usual reversal of stress occurs under reverse bending.

Mr. Hirschthal:—I think this is not entirely clear.

Mr. Leffler:—The Committee will be glad to note that criticism and make a revision to take care of it.

The President:—Unless there is further discussion, Appendix E will be accepted as information.

Mr. Meyer Hirschthal (Delaware, Lackawanna & Western—by letter): —I desire to call attention to some points in connection with the "Specifications for Waterproofing and Drainage of Solid Floor Railway Bridges." In the first place from examination of various structures, I do not believe that felt has proven a good agent for waterproofing purposes on bridge work and would criticize its use for that purpose. In regard to the use of coal tar pitch for waterproofing of bridges, I personally feel that coal tar pitch should not be used on any but sub-surface work, for when exposed to the air any length of time, coal tar pitch loses its life and becomes an inert material.

Under Elastic Cement on page 103, the specification calls for a penetration of 300 at 115° Fahr. This I believe is too high and I doubt whether an asphalt could be refined to give a penetration of less than 15 at 32° Fahr. and yet give so high a penetration at 115° Fahr.

In paragraph 20, page 104, under sub-division (C) the thread count is 18 to 36. I believe that 36 is too close a weave to conform to the term of open mesh and when saturated with asphalt is practically without openings. I would suggest the reduction of this upper figure to 30. Paragraph 27 on the same page specifies that the fabric be wound on 2-inch square mandrels. An improvement in this winding has been made by the use of other than the square mandrels which makes easier rolling at the end without the waste of the end pieces of cloth; would suggest that this point be not specified. Paragraph 61, page 109, calls for the placing of waterproof paper on concrete if bond between the surface of the concrete and the membrane is not desired. In my opinion, this paper would be burnt and punctured, despite the weight of paper specified by the application of the hot asphalt.

In paragraph 68, the size of coarse aggregate specified for the concrete protection is ¾-inch with the reinforcement in the center of a 1½-inch slab. This size is too large for the condition and I would suggest limiting the size to ½-inch. In paragraph 69, it is provided that 7 days after the placing of this protection coat, trains will be permitted over this surface. I believe this time too short for the application of the full load. Under paragraph 75, under Proportions for Poured-in-Place Mastic Portland cement is called for. In my experience with this mixture I have found that limestone dust makes more acceptable a vehicle than Portland cement, because of the fact that no water is used in the mixture. I believe this is a good reason for substituting the limestone dust or slate dust for cement, or at least permitting the Engineer the choice of the two. In paragraph 77, page 111, "Wooden Strips" are specified for gaging the thickness of layers of the asphalt mastic. On our East Orange improvement work it was found that these wooden strips would warp and char so that steel bars or strips were substituted with much more satisfactory results.

Mr. Leffler:—The last appendix of the report, Appendix F, covers "Copper-Bearing Steel for Structural Purposes." This is a subject which has been recently assigned to the Committee and some valuable investigations have been made. The Committee has nothing at this time to offer for final recommendation.

A supplementary report of Committee XV is found in Bulletin 285, page 1209. For several years the Committee has had a Sub-Committee on "Rules for Lighting Bridges and a Uniform Code of Regulations and Signals for Operating Drawbridges." The Committee submits its findings on the subject in the following three conclusions.

(Mr. Leffler read the three rules on page 1209, Bulletin 285.)

Mr. Leffler:—The Committee recommends that by reason of the three foregoing conclusions this subject be withdrawn from the Committee's outline of work. I move that the recommendation be adopted.

The President:—You have heard the motion. Is there any discussion? It will be so ordered.

Mr. Leffler:—The Committee recommends the outline for future work shown on page 90 of Bulletin 280, the reassignment of the following subjects in the form given.

The President:—Unless there is some suggestion in connection with this recommendation for future work, it will be transmitted to the Outline of Work Committee of the Board of Direction for action.

The Chair thinks we are to be congratulated on the work that has been done by the Committee on Iron and Steel Structures. They have had a busy year and have performed a large amount of excellent work, and are to be complimented. The Committee is relieved, with the thanks of the Association. (Applause.)

DISCUSSION ON ELECTRICITY

(For Report, see pp. 113-170.)

Mr. Edwin B. Katte (New York Central—Chairman) :—This year twelve subjects were assigned to the Committee on Electricity. Eight of these are reported merely as progress. Four subjects were completed and will be submitted to you by the Chairmen of the Sub-Committees which worked them up for your consideration and approval. The Committee recommends that the Representatives in the various States be continued.

The first report is that on revision of the Manual, and will be presented by Mr. A. E. Owen, in the absence of the Chairman of that Sub-Committee.

Mr. A. E. Owen (Central of New Jersey) :—The Sub-Committee on Revision of the Manual recommends for approval the printing in the Manual of the following specifications:

(a) Specifications for maintenance of overhead electric supply lines.

(b) Specifications for the joint use of poles for power communication and signal circuits.

(c) Specifications for friction tape.

(d) Specifications for porcelain insulators for railroad supply lines.

It is suggested, however, that action on these recommendations be deferred until the Sub-Committees, in charge of the preparation of the various specifications present their reports.

This Sub-Committee also recommends the approval and printing in the Manual of the Clearance Table for Third Rail and Overhead Working Conductors. This table is presented every two years and is compiled to show the practice of various carriers.

The Sub-Committee withdraws recommendation (F). In view of the fact that certain changes in the Tungsten Lamp Schedule have recently been suggested by the manufacturers, the Sub-Committee wishes to take this matter again under advisement and asks that this subject be continued for another year.

The President:—Unless there is objection to that course, it will be so ordered.

Mr. Katte:—The report of the Sub-Committee on Inductive Co-ordination will be presented by Mr. Davidson.

Mr. J. C. Davidson (Norfolk & Western) :—During the past year the activities of your Committee have been confined entirely to representation on the American Committee on Inductive Co-ordination. I believe full information as to the makeup of this Committee was given in last year's report. The American Committee on Inductive Co-ordination has issued a questionnaire to its constituent bodies, and it is understood the replies to this questionnaire are now in course of tabulation. It was expected that a general meeting of the American Committee would be held prior to the date of this convention, but so far no such meeting has been held.

It is recommended that the subject be continued, and the activity of your Committee for the present be confined to representation on the American Committee on Inductive Co-ordination.

The President:—Unless there is some objection to that, it is so ordered.

Mr. Katte:—The next Sub-Committee report is on "Water Power," and will be presented to you by the Chairman, Mr. R. J. Needham.

Mr. R. J. Needham (Canadian National):—The work of the Sub-Committee on Water Power for the past year was in the nature of a review of what this Sub-Committee has done since its inception in 1916, enlarged upon and brought up-to-date. You will notice the statement on page 119, "Developed Water Power in the United States," by sections, has been revised up to the end of 1923. The statement on the same page, "Potential Water Power Resources of the United States," has been revised and brought up-to-date.

Similar data is to be found on page 122 for Canada. This is data not previously reported on.

Page 123 is a statement of the electrified steam railroads. This has been revised and brought up-to-date. You will note in this particular instance that the amount of power generated by steam as compared with water is about four to one.

The end of the report is a recapitulation of the total water power in the world. It is surprising to note here that only about five per cent of all the water power in the world has been developed. This is to a considerable extent due to the very insignificant amount of water power that has been developed in Africa, which is .41 per cent. In Europe 21.58 per cent has been developed; in North America, about 20.8 per cent. This report is submitted as information, and it is suggested the subject be continued.

The President:—Unless there is some discussion, Appendix C will be received as information.

Mr. Katte:—Appendix D is report on Electrolysis. In the absence of the Chairman of the Sub-Committee, Mr. W. M. Vandersluis will present the report.

Mr. W. M. Vandersluis (Illinois Central):—The Committee has confined its activities to the work of the Sub-Committee on Research of the American Committee on Electrolysis. So far the American Committee has not received the Research Sub-Committee's report. We, therefore, recommend that the report on Electrolysis, Appendix D, be accepted as information, the subject to be continued, with representation on the American Committee on Electrolysis without commitment as to subscriptions or dues.

The President:—This report will be received as information unless there is some discussion on the subject.

Mr. Katte:—Appendix E, Co-operation with the United States Bureau of Standards in the matter of revision of the National Electrical Safety Code, will be presented by the Chairman of the Sub-Committee, Mr. W. L. Morse.

Mr. W. L. Morse (New York Central):—The Committee has continued co-operation with the United States Bureau of Standards throughout the year. A number of meetings have been held and a number of parts have been formulated, some of which have been duly analyzed and found satisfactory and some of which have not as yet been received from the printer.

Part I, "Rules for the Installation and Maintenance of Electrical Supply Stations," has been found acceptable to the railroads.

Part II, "Rules for the Installation and Maintenance of Overhead and Underground Electric Supply and Signal Lines," which comprises those parts which will ultimately cover the specifications for power line crossings, is still with the printer. I understand it will be received in about ten days. It is in such shape, however, that undoubtedly the railroad representatives will need to take exceptions and file a minority report.

Part III, "Rules for the Installation and Maintenance of Electrical Utilization Equipment," has been pretty much ironed out and will probably be satisfactory to the railroads.

Part IV, "Rules to be observed in the Operation of Electrical Equipment and Lines," will undoubtedly be found acceptable to the railroads.

Part V, "Rules for Radio Installations," has been found satisfactory to the railroads.

It is recommended that the work be continued in co-operation with the United States Bureau of Standards for the coming year.

The President:—Unless there is some objection, the Committee will be so instructed.

Mr. Katte:—Appendix F, Overhead Transmission Line Construction, the Committee submits this year two completed specifications. In the absence of the Chairman, Mr. Wells, the report will be presented by Mr. G. I. Wright.

Mr. G. I. Wright (Illinois Central):—Your Sub-Committee has completed its work on two specifications this year, both of which are addenda to the "Specifications for the Construction of Overhead Electric Supply Lines for Railroad Use on Railroad Property." The first of these specifications is for the maintenance of overhead electric supply lines. I will read the headings of the section: (1) Scope; (2) Maintenance Forces; (3) Inspection, Examination, Replacements; (4) General Maintenance Requirements; (5) Steel Towers; (6) Wood Poles; (7) Guys; (8) Crossarms; (9) Pole Fittings; (10) Conductors and Ties; (11) Clearances and Separations, and (12) Trees, Foliage, Brush, etc.

Mr. Katte:—I move that the vote now be taken on the adoption of this specification as a recommended standard and to be printed in the Manual.

The President:—You have heard the motion. Is there any discussion? If not, the motion will be considered approved, unless there is objection.

Mr. Wright:—The second is a "Specification for the Joint Use of Poles for Power, Communication and Signal Circuits." The Table of Contents is given on page 131 of Bulletin 280.

Mr. Katte:—I move that this specification be approved as recommended practice and printed in the Manual.

The President:—You have heard the motion. If there is no discussion, this specification will be considered approved for insertion in the Manual.

Mr. Katte:—Appendix G, Collaboration with Committee XVI—Economics of Railway Location, will be presented by the Chairman, Mr. D. J. Brumley.

Mr. D. J. Brumley (Illinois Central):—This Sub-Committee has collaborated with a similar Sub-Committee of Committee XVI—Economics of Railway Location. That Committee has prepared a tentative outline report which will be submitted at the afternoon session.

The Committee recommends that this subject be continued and that further collaboration be had with a similar Sub-Committee of Committee XVI during the ensuing year.

The President:—Unless there is some objection, that recommendation will be accepted.

Mr. Katte:—Appendix H, Standardization of Adhesive and Rubber Tapes. In the absence of the Chairman, Mr. Warren, the subject will be presented by Mr. Vandersluis.

Mr. Vandersluis:—This Committee has in hand the preparation of specifications for rubber tape and adhesive tape. The Committee will present later a definite specification for rubber tape. The adhesive tape specification as presented is the result of the Joint Committees' work, representatives of the Telegraph and Telephone Section, the Signal Section, and your Committee participating. It was approved by the Signal Section at its annual meeting in Chicago yesterday.

Your Committee recommends that this revised specification for friction tape be accepted, approved as recommended practice and substituted for the specification now in the Manual.

Mr. Katte:—Mr. Vandersluis, will you read by title each of the sections in the specification for friction tape?

Mr. Vandersluis:—(1) Cotton Sheeting; (2) Frictioning Compound; (3) Impregnation of Fabric. Under Physical Properties and Tests: (4) Adhesive Test; (5) Tensile Strength; (6) Pin Holes; (7) Di-electric Strength Test; (8) Test Samples. Under Standard Weight, Dimensions and Variations: (9) Weights, Dimensions and Yardage. Under Packing and Marking: (10) Packing; (11) Marking; (12) Inspection.

Mr. Katte:—I move that this specification be accepted as recommended practice and printed in the Manual.

The President:—You have heard the motion. If there is no discussion or objection, it will be so ordered.

Mr. Katte:—Appendix I, Standardization of Insulators: This year the Committee has completed the Specifications for Porcelain Insulators which it has had under preparation for two or three years, and the report will be presented by the Chairman of that Sub-Committee, Mr. F. D. Hall.

Mr. F. D. Hall (Boston & Maine):—In 1924, an earlier form of these specifications was adopted as tentative recommended practice. In this revision, the Committee has sought to incorporate additional information derived from questionnaire and new data which has become available.

The specifications consist of the following topics: (1) Scope; (2) Design. Under Materials, Properties and Uses: (3) Porcelain; (4) Glaze; (5) Sanding; (6) Hardware; (7) Galvanizing. Under Inspection: (8) Factory Inspection. Under Preliminary Tests: (9) Testing the Individual Parts. Under Assembly: (10) Pin and Suspension Types. Under Testing Completed Units: (11) Pin Insulators; (12) Suspension Type Insulators. Under Definitions: (13) Pin Insulator; (14) Suspension Insulator; (15) Shell; (16) Insulator Unit; (17) String; (18) Sanded Surface; (19) Ultimate Mechanical Strength of Insulators; (20) Ultimate Combined Mechanical and Electrical Strength; (21) Dry Flashover Voltage; (22) Wet Flashover Voltage; (23) Puncture Voltage.

Appendix I:—Some Causes of Insulator Failures; Selection of Insulators for Railroad Use; Atmospheric and local conditions and the effects they produce. There follow examples of application of the rules set forth in the specifications for the selection of insulators.

The Committee believes that these specifications are now in proper form for your acceptance and inclusion in the Manual, and so recommends.

Mr. Katte:—I move that the Specifications for Porcelain Insulators be approved as recommended practice and printed in the Manual.

The President:—Unless there is some objection, the motion will be considered carried.

Mr. Katte:—Appendix J, Clearances for Third Rail and Overhead Working Conductors. In the absence of Mr. Bassett, the Chairman of the Sub-Committee, I will explain that these tables are brought up to date and are presented every two years. Inadvertently the report recommends that these tables be printed in the Manual, which, however, was not the intention. They are merely submitted as information and will be revised again two years hence. They are presented as information and for printing in the Proceedings, but not in the Manual.

The President:—Unless there is objection these tables will be accepted as information.

Mr. Katte:—Appendix K, Protection of Oil Sidings from Danger Due to Stray Currents, the report will be presented by the Chairman of the Sub-Committee, Mr. S. Withington.

Mr. S. Withington (New York, New Haven & Hartford):—During the last year there have been no new developments in connection with the proposed recommended rules for protection of oil sidings from danger due to stray currents. A good many railroads are engaged in following these rules, and so far as we know, no difficulties have been experienced.

The oil companies in general agree with the recommended practice, and what discussions there have been were merely discussions as to who was going to pay for the protection. Practically all the oil companies, with very few exceptions, are paying for the installations as they are made.

The Committee recommends that the subject be continued and that any new developments be noted and reported by the Sub-Committee.

The President:—Unless there is objection, Appendix K will be accepted as information.

Mr. Katte:—Appendix L, Specifications for Track and Third-Rail Bonds: During the past year the Committee has taken this up as a new subject, nothing heretofore having been presented to the convention. In the absence of Mr. Davis, the Chairman of the Sub-Committee, the report will be presented by Mr. J. V. B. Duer.

Mr. J. V. B. Duer (Pennsylvania Railroad System):—It will be noted that the track-rail bonding as well as third-rail bonding practice varies widely even where conditions that affect the selection of the bonds are similar. Reliable data covering relative merits and performance of the different types of bonds is lacking and it is felt that further experimenting and engineering study is necessary before it will be practicable to standardize modern practice to an appreciable extent.

The report is divided into several headings: First, track-rail bonding, which gives the classifications of mechanically applied bonds to web of rail and heat applied bonds to head of rail, as well as the third-rail bonding, and the conclusions, which are that the report be accepted as progress and the subject continued, with especial reference to development of standard basis for measurement of bond resistance, securing data on current carrying capacity of bonds, study of details of bond design and practice for the purpose of determining to what extent standardization is practicable without interfering with the progress of the art, with a view to developing specifications covering the different classes of bonds.

There are three typographical errors in the report to which I would like to call attention, the first of which is on page 162. That table carries the heading that it refers to Track Rail Bonds, Alternating Current Systems. That should be Track Rail Bonds, Direct Current System.

On page 163, there is a table which carries the heading, Track Rail Bonds, Direct Current System. That should be Third Rail Bonds, Alternating Current System.

On page 164, there is a table carrying the heading, Track Rail Bonds, Direct Current System, which should bear the heading Track Rail Bonds, Alternating Current System. That is simply a confusion in the titles to the alternating current and direct current and the third rail bonds.

The President:—Unless there is objection, Appendix L will be accepted as presented.

Mr. Katte:—Appendix M, Specifications for Incandescent Lamps: During the past year the Committee has revised the lamp schedule which now appears in the Manual, and a revised schedule is presented as the Schedule for 1925. However, since the preparation of this schedule, the manufacturers have completed a new line of standard lamps, of a considerably different type, the filament being more concentrated and the bulbs being frosted on the inside instead of the outside by a new process.

The Committee has reviewed this new lamp schedule but is not prepared to recommend it at the present time because of the relatively short time that these new lamps have been in actual service. Further, the Committee has not completed its co-operative work with other Divisions of the A.R.A., and could not, therefore, submit a 1926 schedule which would be acceptable to the other Divisions. Therefore, the Committee desires to change its recommendation and asks you to accept this report merely as information, and to continue the subject with the view of submitting a Tungsten Lamp Schedule next year.

The President:—Unless there is objection to this recommendation of the Committee, it will be so ordered.

Mr. Katte:—On page 167 you will find the list of State Representatives and Alternates who represent the Committee on Electricity in matters of wire and cable crossings over railways. These representatives are very helpful and are of great assistance to the Railroad Officials in the various States when the Local Commission having jurisdiction brings up the subject of wire crossings over railroad rights-of-way. Therefore your Committee wishes to recommend that these same representatives and alternates be asked to serve for another year.

The President:—Unless there is objection to this course, these same representatives will be asked to serve again.

Mr. Katte:—That completes the report of the Committee on Electricity, Mr. President, and I would move that the report as a whole be accepted.

The President:—We have put through a great deal of highly technical matter in the last half hour. The Chair thinks the Committee is to be congratulated very heartily on the amount of work they have presented this year. Inasmuch as this is an important subject, we would like to have a vote on that motion. All in favor please say "aye"; contrary, "no." It is carried unanimously.

The Committee is dismissed with the grateful thanks of the Association. (Applause.)

DISCUSSION ON ECONOMICS OF RAILWAY LOCATION

(For Report, see pp. 171-176.)

(First Vice-President C. F. W. Felt in the Chair.)

Prof. E. E. King (University of Illinois—Chairman):—The Committee on Economics of Railway Location during the past year has studied two topics of its assignment and presents reports on both subjects. Both reports are submitted as progress reports. The first of these, "The economics of railway location as affected by the introduction of electric locomotives, conferring with the Committee on Electricity," is given under Appendix A, on page 172.

The report is given under three topics, "Alinement and Profile," "Characteristics of Electric Locomotives," and "Availability of Motive Power"; the conclusions are printed on page 173.

I should like to call the attention of the convention to the Minority Report on page 174, submitted by Mr. Fred Lavis, a member of this Committee.

I would like to move, Mr. President, that this report be accepted as a progress report.

Chairman Felt:—Are there any comments to be made on this report? This is a very important question, and we would like to have some discussion on it. I am sure that some of you gentlemen could assist the good cause by doing so.

Mr. Maurice Coburn (Pennsylvania Railroad):—I have read this report and it seems to me that the Minority Report is worthy of careful consideration. The whole problem could be stated more clearly and definitely. I am afraid the novice would be a little bit mixed up when he reads this report and attempts to understand the subject.

Prof. King:—This is a progress report that simply outlines the field for future study. The Committee was assisted in the preparation of this report by a similar Sub-Committee of the Committee on Electricity. We should like to have any discussion on it that the members might see fit to offer. The conclusions are:

1. The introduction of the electric locomotives may affect the economics of railway location with respect to:

(a) The ruling grade,

(b) Total curvature,

(c) Length of tunnels,

(d) Location of repair, inspection, and terminal facilities.

2. Each proposed railway must be studied and a separate determination made as to whether electrification is economically justified.

3. This subject should be continued and data collected which could be used for the economic study referred to in Conclusion 2.

4. The performance of self-contained power plant locomotives should be followed as affecting further reports on this subject.

Chairman Felt:—Is there any discussion? The Chairman's motion was seconded that this be received as a progress report. If there are no objections, it will be received as such.

Prof. King:—The other report, the relative merits of a 0.4 per cent ruling grade as compared with a 0.3 per cent grade, is given in Appendix B on page 175 of this Bulletin.

In the absence of Prof. Walter Loring Webb, who is Chairman of this Sub-Committee, I have asked Mr. Layng to present the report.

Mr. F. R. Layng (Bessemer & Lake Erie):—The report is divided into seven paragraphs and consists of these seven general conclusions: Paragraph 1, the general proposition—the lighter the grade, the better; paragraph 2, the primary advantage of the lighter gradients, which brings out very clearly the increasing returns as related to resistance that accrue from the lighter grade lines; paragraph 3 deals with the advantages of these lighter grade lines as related to uniform speed; paragraph 4 comments on starting resistance and brings out the fact that the booster and other refinements in the locomotive have changed to some extent our ideas in regard to starting resistance. Paragraph 5 calls attention to certain data in the Manual from which it is possible to calculate the resistance for any given locomotive on any grade; paragraph 6 calls attention to the fact that a number of prominent railroads are using lighter than four-tenths per cent grade lines; paragraph 7 is comment on the length of grade, calling attention to the fact that with the further refinements of locomotives, especially as to the stoker, it is possible to use longer maximum grades than we did formerly.

Mr. Chairman, I wish to recommend that this report be received as information.

Prof. King:—This is a new topic for this Committee, and the Sub-Committee would like very much to have some discussion on this question at this time.

Mr. J. B. Jenkins (Baltimore & Ohio):—I think this Committee could very well go further and show the relation between the tonnage, the amount of money that could be expended, and the advantage that would accrue from the expenditure of that money. There is a necessary relation between the three, and I think the Committee should cover that point.

Mr. Layng:—Mr. Jenkins, the Committee is in correspondence with a number of other roads that are using these lighter grade lines and we are collecting that data.

Mr. Robert H. Ford (Chicago, Rock Island & Pacific):—I am glad that the Committee is progressing along the lines indicated by the report because there is no doubt that scientific grade revision when planned in connection with comprehensive studies of past performance and future possibilities of development, will ultimately revolutionize many transportation practices. This, in turn, will eventually react for downward revisions of carrying rates and weaken the effect of other forms of competing agencies, such as waterways and auto trucks, because of the increased ability of railways to transport more economically and advantageously than before.

The Committee has also reflected the advancing tendencies among roads for a lighter grade than 0.4. So far as I have been able to ascertain, the operating results secured by roads who have made reductions of this character on their heavy traffic lines have shown that cuts or fills of 70, or even 100 feet, are in reality of little significance when compared with the ability to earn good returns on the investment as a result of the altered grade, meanwhile permitting the Traffic Department to take a more aggressive stand as a result of better service with corresponding increase in the opportunity to attract added tonnage.

There is a fine opportunity for this Committee to work along the lines which have been mentioned and I think all are in agreement with the Committee that it is a subject which should be given much thought and consideration.

The outline which the Committee has prepared opens new avenues for future work. The problem of railway rates and the economics of railway operation are centered very largely around work of this character and I bespeak for the Committee the earnest, helpful assistance of the Association.

Mr. J. L. Campbell (Southern Pacific):—I had not intended to discuss this report of the Committee at this time. I would not want to undertake it unless I had made special preparation, which I have not done, but in this connection I do want to read into the record a correction in connection with a subject that comes directly within the work of this Committee. It is in Bulletin 285; beginning on page 1221 there is a monograph on the effect of the physical characteristics of a railway line. If any of the members have Bulletin 285 with them now, they can take their pencils and make these corrections. It may save you a little confusion if you get around to reading this monograph.

On page 1223 equation "b" is not correctly written, inasmuch as the plus sign should be placed before l_2. Then on page 1226 there is a substitution of the letter "v" for the letter "r" in the heading of four of the right-hand columns of the tabulation of data which appears on that page.

Following the column having the elevations, the letter "r" should be substituted for the letter "v." Then in the next column the letter "r_1" should be substituted for the letter "v_1."

In the next column "r_2" should be substituted for "v_2." In the next column the letter "r_3" should be substituted for the letter "v_3." Otherwise the table is all right and this correction has not affected the integrity of the figures which appear in the monograph, then on this page 1226, remove the letter 2 from the numerator of the left-hand side of the equation (c) East and West, making it read

$$\frac{9.97 + 52.44}{2} = 31.21 \text{ miles.}$$

Mr. J. M. Metcalf (Missouri-Kansas-Texas):—There is one other factor in this problem that has not been touched on in this report which

I would suggest should be treated in this connection. That is, the character of traffic, which may fit the possible train length limit, and number of trains necessary to be run, and so will affect the economy of the lighter grade.

Mr. Maurice Coburn (Pennsylvania Railroad System):—It seems to me that this is a very important report and that we should hope the Committee can carry it further and give more exact data as to some of the points that are mentioned. There have been many grade changes made on many railroads where they have made the mistake of not remembering that the increased trainload is going to slow up the movement. I would have placed a little more emphasis on the fact that you do not get the theoretical saving for various reasons. If we could have more data as to those points, it would be of value.

Chairman Felt:—Is there any further discussion? If not, this will be considered as accepted and the Committee will be dismissed with the thanks of the Association. (Applause.)

DISCUSSION ON WATER SERVICE

(For Report, see pp. 177-243.)

(First Vice-President C. F. W. Felt in the Chair.)

Mr. C. R. Knowles (Illinois Central—Chairman):—The report of the Water Service Committee appears on pages 177 to 243, Bulletin 281.

The first report is given on page 179, which is that of the Sub-Committee on revision of the Manual. This report consists of the preparation of rules governing water service repairmen, which were submitted to the Committee on Rules and Organization and appears under Appendix A, page 66, Bulletin No. 280; and a list of 172 definitions which appear under Appendix A, page 179, Bulletin 281. Of the definitions submitted, forty-nine are taken from the Manual and have already been approved by this Association. Fifteen are revisions of definitions now in the Manual, and 108 are additions to the Manual. Let me say in this connection that the Committee has received several suggestions as to changes in wording of the definitions as submitted. These suggestions will all be given consideration. It is not permissible to discuss definitions on the floor of the convention, but all suggestions that are submitted to the Committee will receive due consideration.

I make a motion to the effect that these definitions be adopted and included in the Manual.

Mr. R. A. Tanner (Northern Pacific):—I want to call attention to some of these definitions.

Page 180, third definition: "Boiler, return tubular." The description given applies to any tubular boiler, and the characteristics of a return tubular boiler are omitted.

Page 182, fifth definition: "Head friction." "The increased head," should read, "The increase in the head."

Page 182, tenth definition: "Hydraulic ram." I would recommend the following definition: "A machine in which the momentum of water supplied through a pipe line under a given head is utilized to force a smaller quantity of water against a greater head."

Page 186, twelfth definition: "Priming." Should be, "Priming, boilers." Should not priming of pumps also be mentioned?

Page 188, sixth definition: I believe the Nye pump with its three-piston rotating valve must be considered as coming under the Pulsometer type also, in which case the detail description is in error.

Page 189, eight definition: "Starting torque." The small type explanation is contradictory, and should be omitted.

Page 189, ninth definition: "Steel." The definition is rather strange.

Page 190, twelfth definition: "Valve, air—of pressure." Should be, "in friction."

Page 192, third definition: "Well intake" should be, "Well, intake."

Page 192, twelfth definition: "Which is replaced by calcium and magnesium when the water comes"; should be, "which is replaced by the calcium and magnesium in the water coming——"

I realize the difficulty of correcting copies from actions taken on the floor of the convention.

As I have pointed out several corrections, and as others may be offered, I should recommend that Appendix A be accepted as information at this convention. The adoption into the Manual may well be postponed a year without serious inconvenience, and will afford the Committee opportunity and time to put Manual matters into first-class shape.

Mr. Knowles:—Referring to Mr. Tanner's remarks, as I have previously stated, we are not permitted to discuss definitions on the floor of the convention, so I cannot go into details. It will probably be sufficient to say that some of Mr. Tanner's suggestions have been referred to the Committee, and will be given consideration.

The Committee recognizes that some of the objections are well taken, but many of the definitions referred to are now in the Manual. Others are additions, but they will all be considered in due order.

Chairman Felt:—Are there any further remarks? If not, the motion will be considered as being adopted.

Mr. Knowles:—The next subject, Appendix B, appears on page 193 of Bulletin 281, which is "Regulations of Federal and State Authorities Pertaining to Drinking Water Supplies and Sanitary Examination of Drinking Water Supplies." This report consists chiefly of a review of the recent revisions of the drinking water standards as recommended by the Advisory Committee appointed by the Surgeon-General of the United States Public Health Service. The new standards are now in force. Dr. Beach is Chairman of that Sub-Committee, and I will ask him to present the report.

Dr. S. C. Beach (Illinois Central):—There is not very much to say. The report is printed, and we want you to read it carefully on behalf of your respective roads and to know how judgment is given by the state through which the road travels and by the Public Health Service in checking on this judgment and thus obtaining permission to use the water for drinking.

I call your attention in passing to this very satisfactory remark by the Advisory Committee as showing breadth of judgment: "Supplies which on rigid inspection are found satisfactory in other respects but fail to meet the bacteriological standards may be accepted at the discretion of the certifying authority." This places the decision in the hands of the state which is aware of the local conditions and the difficulties that are gone through with by the particular road submitting this sample of water.

In closing, the Sub-Committee regrets that the report of the Advisory Committee was not submitted to the Committee on Water Service for their consideration before publication, inasmuch as they represent the railroads with which they are connected.

Mr. Knowles:—It is moved that this report be accepted as information and the subject be reassigned to the Committee for further study and report.

Chairman Felt:—If there is no objection, that will be done.

Mr. Knowles:—The next subject is under Appendix C, report on Pitting and Corrosion of Boiler Tubes and Sheets, and appears on page 194. This report covers the progress made in the study of pitting and corrosion during the past year.

Mr. Bardwell, Chairman of that Sub-Committee, will present the report.

Mr. R. C. Bardwell (Chesapeake & Ohio):—During the past few months there has been considerable discussion in railway journals on the subject of the trouble and expense caused by pitting and corrosion occurring in locomotive boilers. In these articles stress has consistently been placed on the financial loss. In addition to the consideration of possible economies, there is also the question of safety involved.

I have here as an example, a staybolt taken from a boiler in a typical pitting district. It is noted that the action of the water has caused vigorous corrosion and the bolt, in one section, is only one-half the diameter, or has only one-fourth the cross-sectional area of the original material. If the boiler design requires a bolt one inch in diameter, a thickness of one-half inch can hardly be considered a safe condition.

Your Committee has given this subject continuous study since 1920. Under Appendix C, on pages 194, 195 and 196, of Bulletin 281, we have endeavored to summarize the present knowledge and results of investigations.

It is noted that there are eight fundamental factors which control pitting and corrosion in locomotive boilers. Any one, or all, or any combination of these factors may cause trouble. Arithmetical consideration develops that 176 situations can be developed from eight factors. This indicates the necessity for full and careful investigation of the individual cases in order that the actual cause, or combination of causes, may be determined and the economical remedy applied.

The nearest approach to a practical "cure-all" yet found is in the proper overtreatment with caustic soda, or soda ash, as outlined in the 1925 report and published on page 378 in the Proceedings.

There has been considerable progress made in the broadening of knowledge on this subject, which is a problem for careful study and research. The usual railroad laboratory is, as a rule, rushed for time in handling routine matters and unfortunately there is but little opportunity for investigation of research problems. It is felt that one of the main functions of your Committee is to keep in close touch with outside investigations and correlate the results to a practical application in railway service.

The report is submitted as a matter of information only, and the recommendation is made that the subject be reassigned to the Committee for further study and report.

Chairman Felt:—If there is no objection, that will be done, and we will pass to the next subject.

Mr. Knowles:—The next report is on the Impurities in Locomotive Feedwater and Value of Water Treatment, appearing under Appendix D, page 197. This report continues the work of last year and includes statistics on the value of water treatment on two railroads.

The report on comparison of different methods of water treatment appearing on page 203, was originally assigned to the Committee as a part of the above report. In preparing this report, the Committee has endeavored to make a comprehensive comparison of the different methods of treatment of water. Dr. Koyl is Chairman of that Sub-Committee, and I will ask that he submit the report.

Dr. C. H. Koyl (Chicago, Milwaukee & St. Paul):—Concerning the first part of our report, that which deals with the "Cost of Impurities in Locomotive Feedwater," last year we presented the results of measurements on five railroads which showed that in general every 10 grains per gallon of hardness in the water costs about $1,000 per locomotive per year in boiler maintenance and operation.

In the case of two railroads we utilized the official operating statistics to confirm our deductions, selecting the statistics of two adjoining divisions, one with treated water and one without. But at a late meeting of the Committee, and after our report had gone to the printer, some of the members objected that these operating statistics ought not to be used for this purpose without introducing a factor representing the increase or decrease of work done by the locomotives after water treatment as compared with that before water treatment. The results of applying this factor constitute the Supplementary Report of this year, using as a standard the work done and the expenses of 1921, the last year of hard water, and comparing with these the work done and the expenses of the average of the next three years with treated water on one of the Divisions on each railroad.

On the Illinois Central Railroad the introduction of this factor makes little difference; but on the Chicago, Milwaukee & St. Paul Railway the application of this work factor changes materially the comparison of last year. On the Sioux City & Dakota Division, where the water was very bad and where treating plants were installed in 1921, the reduction of expenses during the next three years remains about as it was, $4,000 per engine per year. But on the Iowa Division, where the water was not changed and where the operating statistics showed little reduction in expense of boiler operation and maintenance, the new report shows that the engines did much more work during 1922-24 than during the standard year 1921, and that on the basis of the work done the expense decreased an average of $2,600 per engine per year.

As a matter of fact, we began using soda ash in these boilers in 1922 and have continued it ever since. The soda ash is blown into the boilers after washing and more is added along the road as necessary; but the operating statistics showed so little improvement that no mention of the soda ash was made in our last year's report. Now, however, we find that the engines have been doing on the average $2,600 more work for the same expense as in 1921, and the Master Mechanic ascribes most of the improvement to the systematic use of soda ash. Of course the use of soda ash in boilers is a form of water treating, and this report shows that for such waters as we have on the Iowa Division soda ash treatment is quite effective

The second part of the report, Comparison of the Different Methods of Water Treatment, provides the information which we consider established and safe to present at this time. Changes are being made in these methods every year and we hope that the work of the Committee may be continued.

Mr. Knowles:—It is moved that this report be received as information.

Chairman Felt:—Is there any discussion? If not, it will be so accepted.

Mr. Knowles:—The final report on this subject, the Relative Merits of the Different Methods of Deep-well Pumping and the respective advantages and disadvantages of each type appears on page 211 of Bulletin 281. In the absence of Mr. Richardson, Chairman of that Sub-Committee, I will say that the report merely gives a resumé of the types of deep-well pumping outfits, together with recommendations, and it is moved that the report be received as information.

Chairman Felt:—If there are no objections it will be so received.

Mr. Knowles:—The next report appearing under Appendix G on page 221 is on the subject of Design, Construction and Maintenance of Pipe Lines, supplemented by monographs on the flow of water in pipe by Mr. F. J. Walter, who is a member of the Committee.

Mr. Hanley, Chairman of that Sub-Committee, will present the report.

Mr. J. P. Hanley (Illinois Central):—The report on the Design, Construction and Maintenance of Pipe Lines appears on page 211 of Bulletin 281. It was the intention of your Sub-Committee to cover those classes of pipe lines commonly used in water station construction and to make the report in such a way that it would be a complete unit. We realized that much information of a detailed and special character is available on pipe and pipe lines, but I believe that our Association has had nothing in its Proceedings heretofore covering this subject as a complete unit.

We hope that the present report will supply this deficiency and that we have arranged it in such a way as to make it convenient reading for any members interested in this branch of railroad work.

Mr. Knowles:—It is moved that this report be accepted as information.

Chairman Felt:—Any discussion? If not, it will be so received.

Mr. Knowles:—The next report appears under Appendix H on page 236, "Design and Construction of Water Station Buildings." I want to make an explanation in this connection. The instructions to the Committee were that in the preparation of this report they should collaborate with the Buildings Committee, and upon the completion of the final draft of the report it was submitted to the Committee on Buildings. The Buildings Committee was apparently in accord with the report with the exception that it was their thought the details of building construction should not be given in the report at this time. Unfortunately, however, when this objection was received the report of the Water Service Committee was in print, and it was too late to make any changes. It does not appear to our Committee, however, that the objection is very serious, and if it is acceptable to the Buildings Committee we will recommend that the report be received as information.

Mr. Grime is Chairman of that Sub-Committee. I will ask him to make the report.

Mr. E. M. Grime (Northern Pacific):—The work of this Sub-Committee appears on page 236 of Bulletin 281. The report indicates in a very general way the dimensions and essential details of the structures which we feel at this time represent good practice for the housing of the various types of equipment required at water stations. The report is compiled in large part from information and typical plans secured from a number of railroads located in various sections of this country and Canada. I would merely call attention to the fact that there is a growing tendency toward the use of fireproof construction of a permanent nature for this class of buildings. The report is presented as information.

Chairman Felt:—Is there any discussion? If not, it will be so received.

Mr. Knowles:—The next report under Appendix I appears on page 240, "Report of Boiler Washing Plants as Affecting Water Supply." Mr. Yeaton is Chairman of that Sub-Committee. I will ask him to present the report.

Mr. F. D. Yeaton (Chicago, Milwaukee & St. Paul):—Insufficient study seems to have been given to the conservation and reclamation of water used in boiler washing plants. The present-day plants seem to be designed to give the hottest usable temperature for the water used through them, and the amount of water used and the cost of reclamation has been given only minor consideration.

The Committee believes that:

(1) Storage tanks should be of sufficient capacity to take care of the maximum number of boiler washouts without waste of water or heat.

(2) Lattice work cooling devices may be provided for the blow-off tank to cool the water as much as possible by exposure to the atmosphere instead of cooling it by adding fresh water. Fresh water should be used only for makeup purpose.

(3) A sludge-collecting system might be installed in the tank bottom for discharging accumulated sludge. This will avoid emptying a tank of water and taking it out of service.

(4) Blow-off water not needed for washout purposes may be utilized at the cinder pit and for other purposes for which the water is suitable.

The report is offered as information.

Chairman Felt:—Are there any comments? If not, it will be so accepted.

Mr. M. Coburn (Pennsylvania Railroad System):—I think we are very much to be congratulated on having this information collected as to the value of treatment. We hope now that the Committee will be able to go ahead and differentiate between the different kinds of impurities and tell us something about that, because it makes a great deal of difference whether you have sulphate scale or carbonate scale as to the damage which the water is going to do. It is a subject of which a good many of our operating officers do not appreciate the value.

In the summary of the methods of treatment, I should like to ask what the Committee means by speaking of the simpler waters in connection with the method of treatment by soda ash.

Mr. Koyl:—The word "simpler" was used perhaps not advisedly. We intended it to mean waters that are not very hard, containing only a few grains per gallon of carbonate or sulphate of calcium or magnesium, and comparatively free from the sodium compounds; in other words, waters easy to treat.

Mr. Coburn:—Some of us on our road think that the difference between the results of the soda ash treatment and the lime and soda ash treatment is overestimated and that the amount of foaming and priming due to sludge is very much overestimated.

Mr. Knowles:—I will say for Mr. Coburn's information that we have a great deal of work to do before we make a final report on this subject, and we hope to complete the work in such a manner that it will be satisfactory to everyone and cover all points that have been raised.

Chairman Felt:—This completes the report of the Committee and they are excused with the thanks of the Association. (Applause.)

DISCUSSION ON RECORDS AND ACCOUNTS

(For Report, see pp. 245-284.)

(Second Vice-President D. J. Brumley in the Chair.)

Mr. H. M. Stout (Northern Pacific—Chairman):—The report of the Committee on Records and Accounts will be found in Bulletin 281, beginning at page 245. There were given altogether seven subjects for study and report. Progress reports are submitted on two of these, and a final report is offered on a third. We have nothing to report with reference to the revision of the Manual.

The second subject, Methods and Forms for Gathering and Recording Data for Keeping up to date the Physical and Valuation Records of the Property of Railways, our first progress report was presented last year, and the second progress report is being presented this year, which you will find under Appendix A, on page 247. You may have noticed in the arrangement of this subject that the numbering of the sub-captions is not continuous. Last year in the presentation of the report, the full schedule was outlined with numbers and sub-numbers, some of which (not consecutive) were covered by that report. Those which were not covered last year are being presented this year with one or two exceptions, which we propose to cover later on.

The report on the subject which was handled by Sub-Committee 2 will be presented by Mr. C. C. Haire, Chairman of the Sub-Committee.

Mr. C. C. Haire (Illinois Central):—The Sub-Committee's report starts on page 247 and, as Mr. Stout has stated, is a progress report.

The first section of the report is definitions of terms. The Sub-Committee after considerable deliberation has arrived at twenty-eight definitions that are used in the nomenclature of records and accounts. These are shown on pages 247 and 248.

The second subject is Organization for Collecting, Compiling, Recording and Filing. This is shown on pages 249 to 254 inclusive. It is a description of a recommended organization together with arguments as to why the Sub-Committee considers this type of organization as an ideal one.

On page 254, under subject three, are Forms for Recording Changes in Physical Property. This has been divided into a number of sub-divisions, the first of which is Record of Sidetracks. This form is not a new one, but is a revision of a form that has been in the Manual and is merely revised to fit present-day conditions.

The second sub-division is Structural Record under (e) on the same page, and this is a form that obviously has some value, or I should say considerable value in a carrier's engineering and valuation organizations. There have been two forms submitted, owing to the need of flexibility in this type of record.

The next sub-division at the top of page 255 is (f) Roadway Machine Record. The need for this kind of record became greater of recent years on account of the growing use of power equipment.

The next form or record is Shop Machine Record, Exhibit 16.

This is an important record, as each year shop machines become more costly and numerous. A comprehensive record is needed of this kind to record the investment in shop machinery.

The last form of this particular class under the general subdivision of Forms for Recording Changes in Physical Property is probably the most important one. It is the Equipment Index, Record of Equipment Changes. There is such a large part of carriers' investment in equipment that this is a record that should be preserved in a very careful manner.

The record that has been designed by the Sub-Committee, Exhibits 17, 18, 19 and 20, conforms, it is believed, with the mandatory requirements of the Interstate Commerce Commission with respect to investment in equipment records.

The last general subject as handled by the Committee this year is the Mandatory Forms Required by Federal Relations. Last year there were several forms submitted under this heading and we now submit the third one, Record of Property Changes.

The Sub-Committee has designed certain forms for this record but calls attention to the fact that little use can be made of it as a roadway record, and the present indications are that it will be impractical to use in the future, owing to the great volume of detail to handle it. The Sub-Committee has in mind working out some appropriate substitute, somewhat similar to the equipment record and will take that up the coming year.

This report by the Sub-Committee is a progress report and it is just another step in completing the assignment. There are a few more forms to design and we hope to have them together at the end of this year, also to review the work of the last two or three years.

Mr. Stout:—As Mr. Haire has stated, this is a progress report, and no action will be asked of the convention at this time.

Before passing from that subject, however, I should like to emphasize the thought that Mr. Haire has given you, which is as stated in the text of the report on page 268. The Sub-Committee, and after the Sub-Committee the General Committee, reviewed the subject of the record of property changes to considerable extent, and they have said there that "the Sub-Committee in its investigation of the entire subject is of the opinion that this record serves no useful purpose to carriers and that as years go by the immense volume of the record will be such as to preclude any possible use. It has been found that those carriers who have attempted to use the record, after a lapse of some years from the date they were valued, found it necessary to seek recourse in the basic record, the Roadway Completion Report, in order to bring the valuation down to date on any basis. So long as carriers are required to maintain a 'Record of Property Changes,' the Sub-Committee recommends two methods as outlined in this report."

The point that I wish to emphasize particularly is the uselessness of this record, and if the convention feels at liberty to do so and thinks it consistent, some action might appropriately be made which might have some influence in having it annulled or discontinued.

The next subject is "The Feasibility of Reducing the Number of Forms in Maintenance of Way and Engineering Departments, Combining Forms and Simplifying Those Retained." The report of this subject will be found in Appendix B, page 269. This is an old subject that was given to us a number of years ago and Appendix B is the result of a great deal of consideration of the problem.

Mr. E. B. Crane, the Chairman of the Sub-Committee, will present this section of the report.

Mr. E. B. Crane (Chicago, Milwaukee & St. Paul):—There is not much to say in addition to what has been said in the report. Considerable time and thought has been given to the subject. The Sub-Committee came to the conclusion that this subject was too great for it to handle in detail, so it attempted to collect what information it could and just handled the subject in a general way. The report is submitted as information and the recommendation is that the subject be discontinued.

Mr. Stout:—The next subject assigned is "Methods of Records and Accounting for the Determination of Proper Allowances of Maintenance due to increased Use and Increased Investment," collaborating with the Committee on Economics of Railway Operation. The Committee on Economics of Railway Operation presented their report last year on a corresponding subject, which was approved by the Association. A beginning has been made in the study of our branch of the subject, but the matter has not progressed far enough to offer a preliminary report at this time.

The next subject is "Revision of the I.C.C. Classification of Accounts." No constructive work has been done on this subject the past year. We have, however, been watching the development of the revision of the classification by the Bureau of Accounts of the Interstate Commerce Commission.

At a meeting of this Committee in Washington last fall we had with us a member of the Bureau of Accounts sent to us by Mr. Wiley, the Director, in his disability. We were invited to make suggestions in the revision of the classification for investment of road and equipment. More recently Mr. Leighty, a member of our Committee, has been in touch with Mr. Barnes, of the Interstate Commerce Commission, and through him we have received further invitation along this line.

We endeavored to have a meeting with a representative of the Interstate Commerce Commission in connection with the revision of this classification last week, but it failed of realization, but arrangement has been made that some contact will be had with them the latter part of the month.

This is given to the convention for information to show that the work of the revision of the classification is proceeding.

The sixth subject is "Comparison of Daily and Monthly Time and Material Reports." The first progress report on this subject was presented last year and the second one, which also is a progress report, will be found in Appendix C. This begins on page 276. Mr. J. F. Hande is Chairman of that Sub-Committee and will present this section of the report.

Mr. J. H. Hande (Baltimore & Ohio):—Those of you who have read this report have probably noticed we have covered a good deal more territory than the caption of our assignment would indicate. That comes about from the fact that last year another one of our Sub-Committees presented a report on forms for showing comparative maintenance costs per track mile and per unit of principal items of maintenance.

When that report was presented a question was asked as to how the information was to be obtained. The gentleman inquiring at that time said, "I do not see anything in this report of the Committee recommending how these accounts are to be kept." He questioned whether the Interstate Commerce Commission would be inclined to think that the matter was being carried too far. As there seemed to be some doubt, we undertook to lay out a plan of maintenance accounting, present forms and clear up a little of that doubt.

On page 278, we developed a chart which shows in a skeleton form all of the reports that are built upon the foreman's daily reports, and if you will look at that chart you will find a series of six reports at the upper lefthand corner that are the foundation for the entire accounting and statistical procedure necessary to get a clear statement of maintenance results.

Last year we designed Block No. 1, Daily Labor Report. This year we come down and take the next step in the process and show forms for the recapitulation of labor, shown in Block 7 on that chart, and the distribution of labor in Block 8. All of these operations are aimed at obtaining results that are shown in the forms in Blocks 36 and 37, which were designed by the Sub-Committee I referred to a minute ago.

The forms covered by Blocks 7 and 8 are shown in this report facing page 281 and on pages 282 and 283.

Naturally we have had to go over into the accounting side of this and the clerical side a great deal, but I think for a clear understanding these two forms are essential for Maintenance Engineers to consider, particularly the ones on pages 280 and 283, in which the sub-primary accounts are distributed and from which the Maintenance Engineer can get such information as he wants on unit costs of doing work, which is getting to be a more and more important subject. The report is presented with a suggestion that the caption of our assignment be changed so that it will fit our assignment as we are now understanding it.

Mr. Stout:—This is the concluding number of our assignment, but before we leave the platform I wish to recall to your mind the number of times the question of practical application of the conclusions that have been reached by the various committees has been brought before the different conventions.

Last year we brought before you a labor report, a suggested daily time report, the best that we could devise—the best that we could agree upon, at least, and it would be of material assistance to us if we could know at this time how many, Mr. Chairman, if any, have adopted or made a trial of that record. If it is right, it ought to be used; if it is wrong and somebody by trial has proved it deficient, we would be beneficiaries if you would tell us that you have tried it and found it incomplete or inadequate, and in what respect it has failed.

Chairman Brumley:—We would be very glad to receive any suggestions as to the use of the forms referred to by Mr. Stout.

Mr. C. C. Cook (Baltimore & Ohio):—It seems to me that we have come to the parting of the ways as to the use of sub-accounts in maintenance of way expenditures. Since 1914, at least, the sub-accounts have been in the classification of operating expenses. I think it is accurate to say that not five per cent of the railroads have used those sub-accounts, probably a less percentage than that. If they are not of any value, it seems to me that when the proposed revision of the classification comes up for discussion, this Association would be in a poor position to say they would like to continue those sub-accounts. I think they would have to agree with the accounting officers that they ought to be removed. Here for the first time the Association goes on record as suggesting that practical use be made of them to determine unit cost. I think that the railroads have been criticized, and that maintenance of way departments have been criticized because they have not known their unit costs by which comparisons as between different railroads or as between different divisions of a railroad or sub-divisions of a railroad can be made.

These forms that are suggested here I think can be made use of in that way. Taking one item as an example: Applying new rail; it would not be unfair to compare the cost of applying new rail per ton on one division with the cost of applying new rail per ton on another division, even though the average weight of rail applied was not exactly the same. There are so many other elements that enter into the cost of applying rail that more largely affect it than does the difference in weight of rail, that the figure that you would derive would be valuable in any event.

I think the attention of the railroads should be drawn to these forms and some effort should be made to get the data from the Accounting Department according to these sub-accounts, and probably the statistics brought before this convention. I think probably that would be a way that this Committee could follow up their suggestion.

Chairman Brumley:—Is there any further discussion of this report?

Mr. M. Coburn (Pennsylvania Railroad System):—It is my understanding that on the Pennsylvania we are trying to put in these forms that Mr. Stout has mentioned.

Mr. Stout:—Do you know whether the time return book that was presented last year was included in that set?

Mr. Coburn:—Mr. Crowell knows more about that than I do.

Mr. H. C. Crowell (Pennsylvania Railroad System):—Yes, Mr. Stout, it was included.

Chairman Brumley:—Has any member of the Association tried these forms? We would like to get that information to Mr. Stout if any of you have had any such experience.

Mr. Hande:—The Baltimore & Ohio has used forms of this character and even in more detail than is shown here, and is getting excellent practical results in comparing the figures from the various divisions and broadcasting to the Division Engineers comparative results. I cannot go any further than that as to practical results, but they are in use daily.

Chairman Brumley:—The report of this Committee has been submitted as information. The work is to be continued during the ensuing year. If there is no further discussion, I wish to say that in my opinion this Committee has undertaken a very difficult task. Their work involves not only engineering, but the accounting of railroads, and sometimes I think must border upon the legal phases of railroad operation. The Committee is certainly to be complimented on the excellent work it has done in presenting this progress report to this annual convention.

The Committee is dismissed with the thanks of the Association. (Applause.)

DISCUSSION ON SHOPS AND LOCOMOTIVE TERMINALS

(For Report, see pp. 285-313.)

(Second Vice-President D. J. Brumley in the Chair.)

Mr. F. E. Morrow (Chicago & Western Indiana—Chairman):—The report of this Committee this year is upon four subjects: First, General Layout of Engine Terminals; second, General Layout and Design of Passenger Car Repair Shops; third, Ventilation of Engine Houses; and, fourth, Storehouses for Shops and Locomotive Terminals.

The Chairman of the Sub-Committee on Engine Terminal Layout is not present. In his absence I will briefly present the report, which is given on page 286 of Bulletin 281. The report has not attempted to precisely and in detail indicate just how an engine terminal should be designed, but has attempted to give the general requirements that should be considered in individual problems in an engine terminal design. Our conclusions are given at the bottom of page 293, and are as follows:

(Mr. Morrow read the conclusions on page 293.)

Mr. F. E. Morrow:—Those five recommendations are recommended for adoption, and I wish to make that motion.

Chairman Brumley:—The five recommendations just read by the Chairman are, on his motion, recommended for adoption and insertion in the Manual. Is there any discussion?

(The motion was carried.)

Mr. F. E. Morrow:—The next subject is Appendix B, page 294, General Layout and Design of Passenger Car Shops. Mr. Peck, representing Mr. Sillcox, was to be here to present this report, but he does not seem to be present. In his absence, I will read the conclusions that are recommended for adoption. They are given at the bottom of page 303.

(Mr. Morrow read the conclusions on pages 303 and 304.)

Mr. F. E. Morrow:—Those conclusions, 1 to 18, are presented for adoption and inclusion in the Manual, and I so move.

Chairman Brumley:—The motion is on the adoption of eighteen conclusions under design of passenger terminals for inclusion in the Manual. Is there any discussion? If not, those in favor of the motion will say "aye"; opposed "no." It is unanimously carried.

Mr. F. E. Morrow:—The next subject is "Ventilation of Engine Houses." This report will be presented by Mr. L. P. Kimball, Chairman of the Sub-Committee.

Mr. L. P. Kimball (Baltimore & Ohio):—This subject was treated in a preliminary report presented to the convention last year and has now been revised and placed in form for adoption by the Association. I wish to call particular attention to the fact that these recommendations do not apply to houses which are equipped with mechanical system for smoke removal consisting of special jacks, ducts, fans and stack. Such a system is not recommended for general use in connection with ventilation.

Mr. F. E. Morrow:—I move the adoption of the conclusions for inclusion in the Manual.

Chairman Brumley:—It has been moved that the conclusions on "Ventilation of Engine Houses," Appendix C, be adopted for inclusion in the Manual. Is there any discussion? If not, those in favor of the motion will say "aye"; opposed "no." The motion is carried unanimously.

Mr. F. E. Morrow:—The next subject is on "Storehouses for Shops and Locomotive Terminals." This will be presented by Mr. A. T. Hawk, Chairman of the Sub-Committee.

Mr. A. T. Hawk (Chicago, Rock Island & Pacific):—The report on this subject, which is shown on page 310, Appendix D, Storehouses for Shops and Locomotive Terminals, is made not to be considered as a final report, but simply showing our ideas at this time, and we would appreciate it if during the coming year you would have your storekeepers read this subject very carefully and give us all the criticism that this subject will bear. Next year we hope to present it and have it approved for the Manual.

Chairman Brumley:—You have heard the report on Storehouses for Shops and Locomotive Terminals. Have any of the members any suggestions to make at this time If not, Appendix D will be received as information and the subject continued in next year's outline of work.

This concludes the report of the Committee, and the Committee is excused with the thanks of the Association. (Applause.)

DISCUSSION ON SIGNALS AND INTERLOCKING

(For Report, see pp. 315-351.)

Mr. F. B. Wiegand (New York Central—Chairman):—The report will be found on page 315. Your Committee presents report on Automatic Train Control and Signals for Highway Crossing Protection. With reference to the report on automatic train control, your Committee has nothing to add to what is already published in Appendix A. If any of the members desire to ask any questions, we will endeavor to answer same.

The report on automatic train control is submitted as information. I move its acceptance as such.

The President:—If there is no objection, the report on Automatic Train Control will be accepted as information. Has anybody any question to ask on the subject of automatic train control?

Mr. F. B. Wiegand:—The report on Signals for Highway Crossing Protection will be found in Appendix B. Mr. A. H. Rudd, Chairman of the Sub-Committee handling this subject, will present the report.

Mr. A. H. Rudd (Pennsylvania Railroad System):—The Committee report is an information report on pages 343 to 350, a progress report. The first subject deals with the location of signals for highway crossing protection, on pages 343, 344, 345 and part of 346. The A.R.A. recommended requisites state that the railroad standard highway crossing signs and signals shall be mounted on the same post. It does not state where the post shall be located. The suggestion in the seventh paragraph on page 346 is perhaps worth considering, namely:

> "Perhaps as good a rule to advocate as any would be to locate the signal in the center of a *street* if it is wide enough to do so without great expense, when assured that the local people will not require flood lighting or illuminating it to give a Christmas-tree effect, and to locate it on the side of a *road*."

Those are problems that are coming up, that are before us, and that a great many men in this Association have to meet. A number of the states are trying to require signals placed in the center of the road whether in built-up, illuminated territory or not. In a great many of the states the public service people want them in the middle of the road, and the highway commissioners insist on having them at the side of the road because they do not want their pavements broken up.

Recently there was a conference in Illinois at which four or five neighboring states were represented and they are very much interested in the proper location of the signals to indicate the approach of the trains.

The second subject on page 346, the matter of painting, might also well be referred to Committee IX.

The third subject, covering the elimination of advertising signs, should be advocated by every member individually.

The fourth subject, on pages 346 and 347, the Association might well co-operate with the Joint Board on Interstate Highways if such Joint Board desires such co-operation.

Your attention is particularly called, on page 347, to the fact that this Board on Interstate Highways has made no provision for the cross-buck sign recommended at this meeting by Committee IX, pages 395 and 396, Bulletin No. 282, possibly because such signs would ordinarily be erected on the railroad right-of-way instead of on the highway. If this is not the reason, it would seem that, if this Association adopts the report of Committee IX referred to, the matter should be handled officially with the Joint Board on Interstate Highways and the United States Bureau of Public Roads.

The fifth subject, co-operation to attain uniformity in the signals indicating the approach of a train, is most desired, and the situation as outlined in Subject 6 is well worth serious consideration.

The next is the undertaking of various state commissions to establish a standard for a particular state.

Your attention is particularly called to the statement at the top of page 350.

This entire proposition of highway crossing protection is a matter in which the A.R.E.A. as such and the individual members thereof can accomplish great results by co-operating, and produce confusion worse confounded if they individualize instead of subordinating their own ideas to the general good.

I move the acceptance of this report as information.

The President:—If there is no objection, this report will be received as information.

Mr. A. H. Rudd:—Requisites for Automatic Signals for Highway Crossing Protection, pages 350 and 351. These requisites were adopted by the Signal Section on letter ballot 1217 to 0, and are now the recommended practice of the A.R.A.

I move that these requisites be approved for publication in the Manual by reference as follows: Requisites for automatic signals for highway crossing protection: Manual of Signal Section, A. R. A.

(The motion was seconded.)

The President:—You have heard the motion, which has been duly seconded. All in favor please say "aye"; contrary. It is carried.

Mr. A. H. Rudd:—The American Engineering Standards Committee on the code on color of traffic signals has completed its report and included in that report are the requisites which you have just adopted. That report has gone to the sponsors for a vote. The Highway Commissioners and the sponsors are opposed to it, and as far as I can find out the only point of difference is that the committee of which I was a member and the American Engineering Standards Committee recommend a red stop sign with white letters and the Highway Commissioners want an octagonal yellow sign with black letters. I hope that they can get together, because the code is valuable and it is needed. This is presented as information.

Mr. F. B. Wiegand:—Mr. Chairman, that concludes the report of your Committee on Signals and Interlocking.

The President:—I congratulate the Committee on Signals and Interlocking. We put through a great deal this morning. Those regulations contain a great deal more than one would imagine from the time taken to deal with them here, and the information contained is of great value to the railroads at large. I compliment the Committee on the work they have done, and dismiss them with the thanks of the Association. (Applause.)

DISCUSSION ON SIGNS, FENCES AND CROSSINGS

(For Report, see pp. 389-434.)

Mr. T. E. Rust (Waterloo, Cedar Falls & Northern—Chairman):—The report of the Committee will be found beginning on page 389 of Bulletin 282. Seven subjects were assigned the Committee, on six of which the report is being made. Of these six subjects all but one are presented merely as information.

The first subject is revision of the Manual, and before asking Mr. G. N. Edmondson, the Chairman of the Sub-Committee, to make the report, I might suggest that we consider and vote upon separately each of the four divisions of the subject, as shown near the top of page 390. The first of these is the highway crossing sign—a subject which may and I hope will arouse some discussion. The second is revision of the bridge sign. The third consists of various minor corrections and revisions which are principally by way of cutting down the space occupied in the Manual, and the fourth is a revision of the specifications for bituminous crossings. Mr. G. N. Edmondson will present the report.

Mr. G. N. Edmondson (New York Central):—The first subject, "Revision of the Highway Crossing Sign," is covered from pages 390 to 397, inclusive, Bulletin 282, and in connection with that report, page 391, paragraph 5, with reference to the sign to be used with the flashing-light signal in the state of New York, since this Bulletin was published, an order has been issued by the Public Service Commission covering such highway crossing sign to be used only with a flashing-light signal, and no changes to be made in the other approved grade crossing signs.

I would also like to call your attention to the three paragraphs at the top of page 393, showing the height of signals which reflect the height of the sign on such signals.

On page 395 the Committee present a proposed crossing sign to replace the sign on page 456 of the Manual. On page 394 are four paragraphs showing the changes in this sign from the sign now in the Manual. Also on page 396 is shown a proposed sign to be used with the flashing-light or wig-wag signal; this sign was worked up at the request and in conjunction with Committee X.

The Committee recommends the adoption of these two signs for publication in the Manual. I make that as a motion.

The President:—You have heard the motion? Is there any discussion?

Mr. C. W. Baldridge (Atchison, Topeka & Santa Fe):—In looking at this proposed crossing sign, I was struck by one factor which seems to me should be shown on all crossing signs at this day and age of the world which is not yet shown. All of us have known how frequently automobiles, in particular, are struck on crossings where they have darted out from behind one train into the path of another on an adjoining track. It seems to me that our crossing signs should carry a board between the crossbuck sign as shown here and the stop state law board, on which should be shown the number of tracks to be crossed at that place. I am going to offer this as a suggestion to this Committee that they consider for next year's work the insertion or addition of a board to the crossing signs to show the number of tracks which are to be crossed at the crossing governed by that sign.

Mr. G. N. Edmondson:—In connection with that, in the notes there is a place where additional signs are needed, it specifies two tracks. It was shown on the old standard. We assume that covers the situation where necessary.

Mr. C. W. Baldridge:—It is all very well to state that there is a place there for additional signs if they wanted them, but I believe we should go on record recommending that all our crossing signs show the number of tracks that are to be crossed. It is an important matter, particularly where there are more than two tracks, for instance. It is important at every place.

The President:—Do you make that in the form of a motion, Mr. Baldridge, or a suggestion to the Committee?

Mr. C. W. Baldridge:—I move the question of placing an additional board on our crossing sign posts on which is to be shown the number of tracks to be crossed, be referred to this Committee for a report for or against at next year's convention.

(The motion was carried.)

The President:—Mr. Baldridge, it is not your intention to hold this up?

Mr. C. W. Baldridge:—Simply to refer that question to this Committee for next year's consideration with instructions to bring in a report next year for or against it.

The President:—It has already been moved that this report be adopted, as presented by the Chairman. That was duly seconded. Is there any further discussion on it?

(The motion was carried.)

Mr. A. H. Rudd (Pennsylvania Railroad System):—The Special Committee on Highway Crossing Protection of the Signal Section met day before yesterday and instructed me that if this four-foot crossbuck sign were adopted, I should present their thanks to this Association for having acceded to our wishes after two or three years' fight. They are very much pleased.

Mr. G. N. Edmondson:—On page 398 the Committee present a revision of the bridge sign now shown in the Manual on page 462. The revision consists of adopting the decimal method of numbering bridges, which the other sign did not have.

I make a motion that this sign be adopted and published in the Manual, replacing the present standard.

(The motion was carried.)

Mr. G. N. Edmondson:—The third subject consists of seven revisions of the material now in the Manual. Item 1, shown on page 397, consists of revision of a table now in the Manual on page 443, and takes from that table material with regard to fencing requirements and spacing of posts over 20 feet, 20 feet being the limit in our present right-of-way fence specifications; also the addition of the word "feet" in one column in order to definitely show what is referred to.

The second item is the revision of the characteristics of different kinds of barbed wire now in the Manual. This includes bringing this up to date.

The third item covers the table on page 400, replacing the table on page 444 of the Manual, and brings this information up to date and corrects it.

The fourth item covers the table on page 401, replacing the table on page 445 of the Manual. We found some inaccuracies in this table and present the new table to replace it.

The fifth item on page 402 covers diagrams and descriptions of various types of barbed wire, replacing information on page 446 of the Manual. This has been brought up to date.

The sixth item covers nails and sizes shown on page 403, which replaces two pages of the Manual, pages 447 and 448, and simply combines that information on one sheet.

The seventh item covers an addition to the present statement on fence staples in the Manual.

I make a motion that these tables be adopted and published in the Manual, also the corrections made of what is now shown in the Manual.

The President:—You have heard the motion. Is there any discussion?

Mr. C. W. Baldridge:—In the table giving information regarding the smooth wire on page 400, I would like to suggest to the Committee that they shorten the picture of the wire, as shown sidewise, just enough to provide an additional column in this table and in that column insert the second column of the table on page 401, so far as it applies, giving the diameter of the wire in the same table with the rest of the information.

It is true that the diameter is given on the next page, but that makes it necessary to hunt from one page to the other for the information, and it seems to me that space could readily be provided for the column and insert that information all in one table.

Mr. T. E. Rust:—The Committee has no objection to that change.

The President:—Any further discussion? All in favor please say "aye"; contrary. It is carried.

This revision of the Manual is approved, with the suggestion made by Mr. Baldridge.

Mr. G. N. Edmondson:—The fourth subject is Specifications for the Construction of Bituminous Crossings. The figure "3" on page 405 of the proposed form should be written out, and on page 406 in the second line of the paragraph on flangeways the word "about" should be changed to "above." The changes proposed in these paragraphs cover a revision to agree with the specifications of the Association on ballast. When originally made up, these covered only crushed stone, but washed gravel ballast is covered, and it should be included in these specifications. There is also a rearrangement of the paragraphs giving the same information in a different portion of the specifications.

There was also a slight change in connection with rock asphalt on information that has been received by the Committee this year. I make a motion that these changes in the specifications for the construction of bituminous crossings be adopted and substituted for the present information in the Manual.

The President:—You have heard the motion. Is there any discussion? If there is no discussion, we will consider this as carried without taking a vote.

Mr. T. E. Rust:—The second subject is "Methods of Apportioning the Cost of Highway Improvements adjacent and parallel to Railroad Rights-of-Way." Mr. R. E. Chamberlain, Chairman of the Sub-Committee, is not present, but I believe that any presentation of the report is unnecessary as it simply consists of data regarding the methods of apportioning the cost in the various states and a table bringing this out in a graphic way. I move that this report be accepted as information.

The President:—If there is no objection to this, it will be so received.

Mr. T. E. Rust:—The third subject is "Elimination of Highway Grade Crossings." Inasmuch as there was some little criticism of our report on this subject last year, it might be well to preface the report this year with a brief statement. The subject was first assigned to our Committee in 1923. The Committee prepared an outline of study and elaborated on some parts of that outline, presenting its report in March, 1924. There not being any written or verbal criticism at that time, the Committee naturally concluded that it had correctly interpreted the assignment and the wishes of the Association. The report which was made in 1925, a year ago, was exactly what might have been forecast from the first report made in 1923, and the report which we are submitting this year is intended simply to close up the subject from the angle already started. It is not pretended that this is necessarily the most valuable work which can be done on the subject of grade crossing elimination. The Committee felt and still feels that this general survey of the subject was an advisable preliminary to such other work, if any, as the Committee may be directed to undertake. Mr. A. B. Griggs will report for the Sub-Committee.

Mr. A. B. Griggs (Atchison, Topeka & Santa Fe):—The Sub-Committee report appears at pages 412 to 424 inclusive in Bulletin 282. It is the third and final report of the Committee on the subject as assigned, viz., "Elimination of Highway Grade Crossings." The report following the outline as published at page 630 of the 1924 Proceedings.

A partial report was made last year on Design. The present report concludes that item under the sub-headings of "Over-grade crossings—Highway over Railroad," "Under-grade crossings—Highway under Railroad."

Construction methods: Under this topic a number of methods are suggested, all of which at some time or place have been employed.

At page 417 appears a paragraph on costs. After due consideration by the Committee it was decided not to publish the cost of any particular project, as such information would be little or no assistance nor guide to an Engineer in designing a proposed project.

At page 417 also appears a bibliography of grade crossing elimination data.

At page 415 is a photographic reproduction of the under-crossing, the plans of which appear at page 599 of the 1925 Proceedings.

At pages 415 and 416 are shown some typical under-crossing plans for street crossings.

At pages 418 to 424 appear suggested progress plans, profiles and cross-sections, showing the conditions as they will appear at important stages in the progress of a given project. The purpose of these plans being that they will serve as a guide to the contractor in bidding on the work, as well as to both the contractor and the Engineer in carrying on the work.

The President:—Unless there is some objection to this matter being received as information, it will be so received.

Mr. T. E. Rust:—The next subject is Improved Methods of Preventing Corrosion of Fence Wire. While the report is short, the Committee is really getting under way some valuable tests in connection with the American Society for Testing Materials.

The text of the report, I think, explains itself, and it will not be necessary to ask Mr. Johnson to report. Unless there is objection, I think the report should be received as information.

The President:—Is there any objection? If not, we will receive it as information.

Mr. T. E. Rust:—The next subject is the Use of Natural Rock Asphalt as a Substitute for Plank in Road Crossings. I will ask Mr. F. D. Batchellor to report for the Committee.

Mr. F. D. Batchellor (Baltimore & Ohio):—Appendix E on page 427 gives the result of the study which we made on the use of rock asphalt. The first page gives the history and at the top of page 428 we have given what we thought was the proper rock asphalt to be used for crossings. We would like to make one correction in the paragraph on "Test of Natural Rock Asphalt for Bitumen," in the fourth line after the clause "From this a test sample shall be taken" add the word "dried."

The table referred to in the next paragraph has not been published in the report. This table indicated that rock asphalt was being used in the states of Indiana, Illinois, Ohio, Missouri, Kentucky, Tennessee, Mississippi, Louisiana, and South Carolina, and in use by ten railroads that we had reports on.

On the center of page 428 we have shown what we think is a good cross-section for a rock asphalt crossing. On the top of page 429 we have given our reasons why we think that the rock asphalt is a better crossing where it can be used than the plank.

The other pages show photographs and examples of installations which have been made.

This report is offered as information.

The President:—Unless there is some objection, this report will be received as information.

Mr. J. L. Campbell (Southern Pacific):—I would like to ask the Committee if they think that this asphalt will stand up against the rail without breaking up.

Mr. F. D. Batchellor:—No, we think that there should be a flangeway, and if you notice in the cross-section which we have presented, we have shown an additional thickness of the rock asphalt around the rail, it being our idea that this would take care of part of the vibration caused by the rail, but we believe that a flangeway should be used.

The President:—This section of the report will be received as information.

The Chair desires to state that Mr. Rudd has brought to my attention the fact that the Illinois Commerce Commission on Highway Crossing Protection have just issued an order under date of February 23, which conforms to the standards that we have just adopted as proposed by the Committee on Highway Crossings and Fences. I think we may congratulate ourselves on the work that the Committee has done. and dismiss it with the thanks of the Association. (Applause.)

DISCUSSION ON YARDS AND TERMINALS

(For Report, see pp. 353-388.)

Mr. J. R. W. Ambrose (Toronto Terminals Railway—Chairman) :—Of the seven subjects assigned to the Committee, we are only reporting on five. This year, they are progress reports.

The first subject is the usual revision of the Manual. The Committee have not made any recommendations for changes in, or additions to, the Manual this year, by reason of the fact that many of the subjects we are now considering have a bearing on the material that is already in the Manual and will require a complete revision of the Committee's subject-matter therein, so we feel that we would rather wait until we can make a comprehensive change than do it piecemeal.

The second subject, that of Passenger Terminals, was dealt with by Mr. H. L. Ripley, and he will give you a synopsis of the work that was done.

I would like to say that we are extremely anxious to have discussion, constructive or otherwise, because as you will see we are just going through subjects that have tremendous fields, and any sort of discussion will probably open some avenue of thought that we can explore in the future.

Mr. H. L. Ripley (New York, New Haven & Hartford) :—The subject assigned to Sub-Committee No. 2, Joint Use of Passenger Terminals, being one of the two upon which this Committee was instructed by the General Committee to report, will be found on page 355 of Bulletin 282. This is only a report of progress, with no conclusions other than tentative ones having been reached by the Committee. More research will be required before the Committee will be prepared to formulate any definite recommendations.

Two questionnaires were sent out, and a considerable amount of information received. The responses to these two questionnaires were very gratifying to the Committee. Certain essential, or the more important features, brought out by these questionnaires will be found tabulated and the questionnaires themselves are summarized in Appendices A and B, respectively, attached to this report, with a summary of the significant portions appearing as Appendix C.

Information was received by the Committee on 101 jointly used passenger terminals of considerable magnitude. It is clearly apparent that the practice of using terminals jointly is well-established and the prevailing tendency towards a consolidation of railroads will probably increase this tendency as time goes on. It is believed that there are practical advantages to be gained by consolidation where conditions warrant, and it is hoped that a practicable and equitable basis for compensation or distribution of charges can be developed to cover the use of such jointly-operated and jointly-owned passenger terminals that will be fair both to the owner and to the tenant lines.

The Committee expects to use the information collected to date, together with other information which it hopes to receive, and subsequently, perhaps at the next annual meeting, it hopes to establish an outline for such a basis of compensation.

There are certain advantages in connection with consolidation of passenger terminals. The justification for the consolidation of such stations and terminals depends upon many local conditions and in each particular case must receive individual attention. Some of the advantages that may be hoped for through consolidation of facilities may be enumerated as follows:

> Space saved; time saved; organization reduced; maintenance cost decreased; better flexibility of service; convenience to the public; easier interchange of passengers; gain in public good-will; better through train and car routings; decreased cost for equal service; rise in value of adjacent property and, incidental to that, the possibility of releasing properties now owned and used for passenger service for sale commercially, etc.

There are certain disadvantages in connection with consolidation; these are possibilities not necessarily to be experienced. Some of them are as follows:

> One of them is unwieldy size and space, as it is entirely possible that consolidation may be so extensive as to make this a matter of supreme importance. It may require increased capital investment. It will require the necessity for rearrangement of city streets. It may cause congestion of streets and approaches. It may cause increased total annual expenses, including fixed charges.
>
> It will require the building of new track approaches through built-up areas as a rule; delays to trains through bunching service or congestion in case of late trains may be increased. Congestion, especially of the concourse, where even a short tieup in the yards from fog, etc., may result. Increased walking distance to reach facilities and trains may be necessary. Necessity for moving terminal facilities farther away from community center to get sufficient area for development may be experienced. Increased cost to certain carriers now favorably situated may follow. There may be adverse effect on property values in the vicinity of the location abandoned, and there may be adverse effect upon some carrier having present strategic advantage of location.

Economic conditions in their broader aspect should be studied, as well as the local conditions which affect the particular project and the specific matters just enumerated.

Introduction of the automobile into general use has had a profound effect upon passenger service. Distances from the station, measured in miles, remain the same, but distances measured in minutes are reduced to a fraction. What of the future? At present the number of passengers traveling is decreasing, it has fallen about twenty per cent since 1920, and that decrease has been widely distributed throughout the country.

Will the requirements for larger and jointly-used passenger terminals increase, decrease or stand still in the immediate future? Will changes to come be in the amount or in the character of the business handled? Is the present a transition period in passenger service when it is good judgment to go slow before spending new money on station construction or consolidation of passenger stations?

The taxicab has in the last ten years revolutionized travel to and from the station and revolutionized travel between the stations. What of the motor coach in the next ten years? Must the joint passenger terminal of the future be developed to take care of an entirely new character of business in a new way? Must provision be made for a joint use of the terminal by train on the one hand and for an extension of the train service by motor coach on the other hand?

The Committee has speculated upon these questions. It has not attempted to answer them. They are worthy of the closest study and the best thought of the Association. May I suggest that they are questions that are very opportune, questions ripe for discussion and questions that must be answered?

The President:—Is there any discussion on this information? If not, it will be accepted as information.

Mr. C. W. Baldridge (Atchison, Topeka & Santa Fe):—I think that we all know how frequently we pick up a newspaper, particularly a local newspaper in the country, and find a demand that the railroads of the town unite in joint terminals.

As a consequence, a few thoughts have come to me which I had better read than talk, because I can write them easier than I can say them.

The joint use of a passenger terminal which is already in operation is past the consideration stage, but a proposition for the formation of a new group and the construction of a new joint passenger terminal properly calls for careful study and consideration.

Naturally, while there are some advantages gained by the use of joint terminals, there are also some disadvantages.

Considering first the advantages to the traveling public, and, of course, the traveling public must be considered first in railway matters, it is interesting to note what benefits are received.

People can travel upon one train at a time, consequently any person starting on a journey can go to an individual station just as easily as to a joint terminal, except, of course, as to the question of location, and advantage of location is as likely to be with the individual station as with the joint terminal; therefore, the benefit of a joint terminal, if there is any benefit, goes entirely to the outsider who wishes to go through the town without a stop. It is only when a traveler reaches some point in his journey where he must change to the train of some other railway that the joint terminal is of any value or importance to him.

If, at the point of change, a joint terminal is used the traveler can make his change of cars without leaving a nickel in the town if he so desires.

Being able to change from one train to another in the same station may be a benefit to the traveler or it may not be, depending somewhat upon the size and arrangement of the station.

Consider the case of a certain Union Station in a middle western city, one that claims the greatest amount of changing of trains in the world. The traveler who must change cars there, after alighting from his car, must, *on an average:*

(1) Walk half the length of his train.

(2) Climb forty-four steps (and he has no option of using an elevator, for there are none for use of the public).

(a) Walk half the length of the entire concourse, the total length of which is not much, if any, short of five hundred feet.

(4) Enter the main ticket office room and walk from fifty to one hundred feet to the entrance to the main waiting room.

(5) Walk half the length of the main waiting room, parallel to and of the same length as the entire concourse.

(6) Squeeze his way through two rather small doors (set tandem), into the exit concourse.

(7) Walk down another forty-four steps.

(8) Again walk half a train length to get into a train which may be the one standing on the track adjoining the one from which he alighted.

The traveler has put in a good ten minutes of walking and climbing, from which there is no escape. It is not much better than taking a taxicab or a transfer buss to another station. Judge for yourself whether it is a benefit or not.

In a great many cases a joint terminal must be so located that many, and sometimes all, trains entering it lose considerable time in getting to and from it. This loss of time affects not only the transferring traveler, who may be getting some benefit out of a joint station,. but it affects all other travelers on the train who are receiving no compensating advantages.

The joint terminal in a large city—one large enough to accommodate several roads—is apt to be a disadvantage to many travelers, particularly to elderly people, or weak or sick people, who cannot very well stand the long walk resulting from large waiting rooms and long concourses, which must lie between the taxicab stand and the tracks where the cars must be boarded.

The confusion of a very large station is also a disadvantage, particularly to inexperienced travelers.

When all things are considered, the margin of benefit to the public in general from a joint passenger terminal is not likely to be very great, if there is any, and it is strange that people living in any town should clamor for a joint passenger station in their own town.

It is, however, the traveler whom we are interested in, and the problem is to determine at what points there is sufficient changing of trains to justify the greater expense and inconvenience usually necessary to get trains into and out of a joint terminal.

In cities where practically all passengers stop for a few hours or more, such as New York, Washington, Los Angeles, etc., there is no justification for a joint terminal unless such a terminal can be made to produce an actual economy for the railroads and through them to the public.

In great transfer points, such as St. Louis, Kansas City, Omaha, etc., the convenience accruing to the large number of travelers who must change cars may be sufficient to justify some expense being incurred by the railways and the public in providing a joint passenger station.

Because conditions differ so greatly at different terminals, rules of a general nature only can be formulated.

To a large extent, each joint terminal proposition must be studied as an individual problem and a decision reached on the merits of each case.

Except in important railway centers, where transfers or changes of trains predominate, a large joint terminal is likely to cost more in capital invested and the inconvenience of operation than such advantages as may result will justify.

The main problem to be solved is whether or not a joint passenger terminal can be built and operated at a saving over the construction and operation or the continued operation of individual stations; and where an individual station which is fit and suitable for a good many years more of service must be scrapped or abandoned in order to unite in a joint terminal, the required saving will be very hard to make .

Mr. T. E. Rust (Waterloo, Cedar Falls & Northern):—I can tell Mr. Baldridge why the natives in the small towns want these joint terminals, because I live in one of the small towns. They would rather have one respectable railway station than have their civic pride insulted by two or three little doghouses.

The President:—Any further discussion?

Mr. R. C. White (Missouri Pacific):—To clarify the atmosphere, I would like to ask Mr. Baldridge if his remarks concerned an imaginary station, or were intended as a description of an actual union station situation, and if so, where.

Mr. C. W. Baldridge:—Do you refer to the case that I just described?

Mr. R. C. White:—Yes; the station you described as "forty-four steps up—walk a mile, etc."

Mr. C. W. Baldridge:—It is an actual station. That station is the Union Terminal at Kansas City.

Mr. R. C. White:—I do not think the gentleman is familiar with the operation of that station. The Chief Engineer of the Kansas City Terminal is a member of the Committee whose report is being considered. I would like to have him tell Mr. Baldridge and the members of the Association just how the Kansas City Union Station is operated, particularly with respect to transferring passengers when the connection is close. It is not necessary to climb forty-four steps and walk a mile.

Mr. J. V. Hanna (Kansas City Terminal) :—Mr. Chairman, I am afraid there is some truth in what Mr. Baldridge has said.

Mr. R. C. White :—Mr. Chairman, I will have to question the information of the member of your Committee. He is seemingly not informed.

The President :—He has not finished yet.

Mr. J. V. Hanna :—Mr. Chairman, I beg leave to call attention to the fact that I said "some truth," not "all truth."

I presume Mr. Baldridge has counted the steps and that the number is correct. Provision was made in planning the station for elevators to eliminate that climb for invalids and elderly people. They were omitted purely because of financial conditions. A great deal of this long journey that Mr. Baldridge describes would occur at any large station, whatever its design might be, and it is only the uninformed or people not accustomed to traveling and who are afraid to trust themselves to the Red Caps furnished for their convenience, who have to make the journey that Mr. Baldridge described; it is not a necessity at all.

His statement leaves, without going into the whole story, an exaggerated idea of the inconvenience. Mr. Baldridge, I am afraid, has picked out the very worst case that could happen and has presented it as the ordinary case. Of course, a man who has been on a long journey may find it quite a relief to make the trip that Mr. Baldridge described. He does not have to make it if he does not want to. If he does, we can, I think, put it in the category of benefits rather than of disadvantages.

Mr. R. C. White :—With Mr. Hanna's explanation I withdraw the statement as to not being informed.

Mr. C. W. Baldridge :—Mr. Chairman, I did not intend to say that that was the average condition or the general condition. I simply cited that as what might happen in a large terminal. However, I am going to tell the gentlemen over here of another station which he probably knows. I have been through the Kansas City Terminal probably as many times as he has. I am going to tell of another station that is worse. If you go to the new terminal in Dallas, Texas, and want to go to another train or go to town, the first thing you do is go to the stair, climb forty-five steps (I have counted those also), walk about 100 feet and climb down forty-five steps to get to the same level you were before. You have to do that whether you are going to town, changing trains or anything else.

Mr. J. V. Hanna :—I would just like to say that difficulties in the design of a large passenger station necessarily exist, and the ultimate arrangement that is adopted in a structure of this kind, as in a good many other engineering problems, is eventually a compromise. We must strike a balance of advantages and disadvantages, and I believe it rarely ever happens that you can get everything you want without having to take something you do not want.

The President :—Is there any further discussion?

Mr. V. T. Boughton (Engineering News-Record) :—There is a historical matter I would like to call to the attention of the Committee. I refer to the table on joint operation of passenger terminals. The Troy Union Station is the oldest in the country. According to the Delaware & Hudson history it was organized in 1851 and opened in 1854.

The President:—Is there any further discussion? There being no further discussion, this will be received as information.

Mr. J. R. W. Ambrose:—Before taking up the next subject, I might just remark that a good many of the troubles that are experienced, such as Mr. Baldridge has spoken of, might have been avoided if they would take the problems up with this Committee and also that they will help this problem along by answering the questionnaires that Mr. Ripley will send out. They look rather difficult to fill in, but it should not prove laborious. It is all information that will ultimately help to overcome the objections which Mr. Baldridge has to the problem.

The second subject is "Scales." Mr. Harrison, who was the Chairman of that Sub-Committee, unfortunately is not here today. I am not a scale expert, therefore cannot explain the fine points involved, however this is information presented as a progress report.

The President:—Does any one wish to discuss the subject of Scales? There being no discussion, Appendix B on Scales will be accepted as information.

Mr. J. R. W. Ambrose:—Appendix C covers the subject Freight Yard Design, and that has been dealt with by Mr. J. E. Armstrong. He will give you a resumé of what he has done during the year.

Mr. J. E. Armstrong (Canadian Pacific):—The report of this Sub-Committee appears on page 371 of Bulletin 282. This report is the first of a series which will be submitted outlining the information required, and the use of that information in determining the proper design of a yard. It is confined to the requirements governing the number and length of receiving, classification and departure tracks only and the determination of the type of yard in which these tracks are to be assembled. Subsequent reports will cover the other tracks and facilities required in a complete yard design.

It is recommended that this report be accepted as a progress report and that no conclusions be drawn from it for insertion in the Manual until such time as the proposed series of reports, covering yard design, have developed to a stage where more nearly complete conclusions in regard to this assignment may be drawn.

Mr. J. R. W. Ambrose:—We would like discussion on this subject. If there is even a suggestion that you can offer as to ways and means of studying it, we want it. The Committee has run into great difficulty in trying to find out how to go at the subject. It is such a tremendous proposition.

Mr. Robert H. Ford (Rock Island Lines):—I think the Committee has done excellent work on Appendix C. As they have asked for suggestions, I would like to point out that in considering redesign or rehabilitation of terminal yards, that one of the first essentials should be a thorough unbiased study of the existing methods and performance at the terminal under review. This should be undertaken before any attempt is made to prepare plans. To secure this, a complete time study of every switch movement should be made for at least a 24-hour period. If the information thus collected is properly classified and intelligently examined, it will serve as an excellent guide in design, as well as for corrective action on yard practices which yard operatives frequently consider as essential merely because they have adjusted themselves to a facility that while perhaps efficiently operated, is nevertheless obsolete and expensive in many ways and not easily discernible otherwise. There is a direct relation between grade reduction and modernized yard facilities and both of these in turn are affected by the changing conditions of trade, as reserve stocks of merchandise in practically all lines of industry are now much less than formerly, the merchant depending more and more upon the transportation agency for quick, prompt and reliable service. Consequently, the time element in terminal yards is equally as important as on the line.

There is much more on this line that will suggest itself to the Committee.

The President:—Any further discussion? The Committee deserves some discussion on this subject.

Mr. G. D. Brooke (Chesapeake & Ohio):—Mr. Chairman, I would like to offer a suggestion that the relation of road facilities to the terminal is a very important matter in connection with this study of the need for terminals.

Mr. R. B. Jones (Canadian Pacific):—The second of the introductory paragraphs, page 371, outlining the general conditions under which an additional yard is justified, does not, I believe, put sufficient stress on the inadvisability of duplicating existing yards. This paragraph would, I believe, be improved by substituting for the last sentence, "An additional yard is only warranted when it can be clearly shown that the existing yard cannot be made large enough to handle the immediately prospective traffic, and that a new yard large enough to handle all the traffic and so permit of abandoning the existing yard cannot be economically provided."

The clause dealing with length of receiving and departure tracks on page 373 is not entirely clear. Is it the thought of the Committee that all receiving or departure tracks should be long enough to handle the maximum train?

Mr. J. E. Armstrong:—Mr. Chairman, I hope we may have more discussion along this line. Mr. Jones has raised two points that I believe I cannot accept for the Sub-Committee or reply to finally for the Sub-Committee without further consideration. It is an exceptional case, speaking broadly, for an existing yard to be abandoned because of the building of a new yard to replace it on account of capacity alone. Usually when a yard is outgrown, a new yard is built to take certain classes of traffic from that yard and that yard is retained to handle the remaining traffic.

In regard to the length of receiving and departure tracks, it is impossible to say, generally, that the track should be the length of the longest train, the length of the average train or vary in length from the longest train to the shortest train. You have a number of different options and the one to be adopted must be determined by the traffic and other conditions at the particular yard.

This matter of yard design your Sub-Committee has found to be not only very interesting but very difficult to handle. I think if there is one thing that most railway engineers feel competent to do it is to design a yard. Almost any man who has been an Engineer on a railroad knows how to design a yard, until he begins to do it. To assemble the necessary information and put it down in concrete form, so that the man who admits that he does not know how to design a yard can follow it through and make some kind of a stab at a good design is extremely difficult.

Possibly we have not tackled our assignment in the right way. If anyone has suggestions in regard to improving the presentation, not only detailed suggestions such as Mr. Jones and Mr. Ford have offered, but general suggestions in regard to handling the subject, we would be glad to hear them.

The President:—Is there any further discussion?

Mr. H. J. Pfeifer (Terminal Railroad Association of St. Louis):—The recommendation as to number of classification tracks seems a little too broad. In many yards there are classifications of such small volumes that a special track to take care of them is not justified.

Since the capacity of a yard is the number of cars that can be classified in an hour or day, the number and length of classification tracks should be limited so that each can be filled in a reasonable time, which is usually not in excess of 24 hours.

Mr. J. V. Hanna:—Just following up Mr. Pfeifer's idea, does it not mean that if you put a number of classifications on one track in order to reduce the number of tracks, since the cars have to be dropped in on that track as they come from the train or drag that is being switched, the cars on that track have to be switched again? Does not that mean that you must balance the disadvantages of re-switching certain classifications against the additional cost of enough classification tracks to permit switching them only once?

Mr. H. J. Pfeifer:—In some yards on the Terminal Railroad Association of St. Louis as many as one hundred different classifications are necessary if everything is classified to final destination. There are certain classifications in every large terminal that have to be re-worked, either in the same yard or in some other yard. I do not believe that it is always economical to set aside a classification track for a class of traffic that will accumulate less than ten cars in 24 hours.

Mr. J. E. Armstrong:—Mr. Pfeifer, have you based your discussion on the first sentence of each of those paragraphs or the entire paragraph? For example, it is stated, "An analysis of the consist of the trains which are to be passed through the yard will usually indicate a possible number of classifications greatly in excess of the number of classification tracks which could reasonably be provided. Conference with the appropriate operating officers will, however, establish a permissible grouping of these separate classifications so as to reduce their number and still adequately meet the requirements of the traffic."

The President:—If there is no further discussion, we will accept Appendix C on Freight Yard Design, suggesting Economies in Operation, as information, to be dealt with further at the next convention.

Mr. J. R. W. Ambrose:—Appendix D is the retardatory problem. That was dealt with by Mr. Otto Gersbach, and he will give you a synopsis of what he has done during the year.

Mr. Otto Gersbach (Chicago Junction):—This report consists largely of descriptive matter and is shown on page 377 of Bulletin 282. In preparing the report it was not the intention to go into detailed descriptions of the devices shown but to merely call attention to what has been done in the line of developing mechanical devices for controlling the speed of cars in hump yards. You will note that after mentioning of the different devices we have given references to articles in various engineering periodicals that give more detailed description. We realize that the mechanical retarder is just in its infancy, and that within the next few years, as it continues to be used, there will be great progress in its further development.

The President:—Is there any discussion on this subject, gentlemen?

Mr. J. R. W. Ambrose:—Mr. President, I feel that this is a matter in which there is a greater possible saving to railways in the immediate future than any other question that we are discussing or considering today. I think the field is very large and perhaps a little incidentally to the subject I might tell you what happened in one of our committee meetings, in fact the last one. I can foresee for this apparatus, together with some other automatic devices, the possibility of operating a hump with one man. That would involve some mechanical means of pushing the cars over the hump, automatic selection of the routes, and by a system of track circuits connected with these retarders, the car would be guided absolutely to its place of rest completely under control with one man.

I felt this so strongly that I asked the Committee to put that thought in their report so that we might have the subject handed back to us for further study. I was promptly told that I was visionary and perhaps a little insane and they would not consider it; nevertheless I do feel that this is worthy of a good deal of discussion. There have been some new and recent installations on the Illinois Central. If there are any officers of that company here, Mr. Blaess, or anyone else who are familiar with it, I would be very glad to have a few words from them about this installation. I do not limit that request to the Illinois Central men. If some of the New York Central men or any others are present, I would like to hear from them. The Committee has visited some of these yards and was much impressed with several of them.

The President:—Can we not get a little discussion from someone on this?

Mr. E. R. Lewis (Michigan Central):—I might say that we all, I think, recognize this appliance as something of the future, something that will probably be very largely used. I believe that anyone who has studied the subject at all would recommend that hump yards built in the future be built to a profile which is suitable for car retarders, with the idea of installing them if and where so decided, with the least expense. There are many yards in the country now, probably most of them not built to the profile that is at all suitable for the car retarder as we know it now, and expensive alterations are necessary if they are to be installed. There has been suggested to me this morning a use for the car retarder that I had not thought of, that of the ore dock, that usually has an incline down which the loads have to be handled with an engine. The possibility is that the car retarder might help a great deal in ore dock operation.

Mr. W. H. Woodbury (Duluth & Iron Range):—Mr. Ambrose spoke of being visionary. I would like to ask if the Committee or any one ever heard of the suggestion of a magnetic retarder.

Mr. Otto Gersbach:—We made a careful investigation and did not find anything on that.

The President:—Any more discussion? If not, Appendix D, Mechanical Means for Controlling or Retarding Movement of Cars in Hump Yards, will be received as information.

Mr. J. R. W. Ambrose:—In regard to the future work of the Committee, Mr. President, we ask that you reassign to us the subjects that we have now.

This completes the report.

The President:—The Board will take cognizance of that, Mr. Ambrose.

The Committee will be dismissed with the thanks of the Association and complimented upon the work they have done. They have given us something to think of during the next year, anyway. (Applause.)

DISCUSSION ON UNIFORM GENERAL CONTRACT FORMS

(For Report, see pp. 435-455.)

Mr. Clark Dillenbeck (Reading Company—Acting Chairman):—You will find the report of Committee XX, Uniform General Contract Forms, on pages 435 to 455 in Bulletin 282. There were nine subjects assigned to this Committee, five of which have been completed and will be presented for final action. As usual, the work of this Committee has been divided among three Sub-Committees, and under Appendix A you will find the report of Sub-Committee No. 1. Mr. J. C. Irwin is Chairman. In the absence of Mr. Irwin, I will ask Mr. E. L. Taylor, a member of that Sub-Committee, to present the report.

Mr. E. L. Taylor (New York, New Haven & Hartford):—The report of this Sub-Committee is on page 437 of Bulletin 282. The Sub-Committee has collected data and made a study of a Form of Agreement for Furnishing Water from Railway Water Systems to Employees and Others. This form is recommended for adoption. I move that this form be adopted.

Mr. C. W. Baldridge (Santa Fe):—I noticed that the proposed contract form in which the railway company is to furnish water to others does not carry the protection to the railway company which the next form, in which the railway company is to be the purchaser, provides for the benefit of the party from whom the railway is to purchase water.

In Paragraph 7 it provides that bills for water shall be furnished, etc., but it does not provide for any cancellation of the contract in case bills are not paid. It seems to me that there should be some protection to the company.

Paragraph 8 should have a provision following it, or inserted at some other point, covering the prompt termination of the contract if payments are not made or contract stipulation not lived up to.

We should also carry a provision that the railway company will not be liable for damage for failure to supply water due to causes beyond its control.

Article 3, page 439, is a similar case, but where the railway company is the purchaser, and that paragraph reads, "The Water Company agrees to use its best efforts to furnish an uninterrupted supply of water to the Railway Company, but it is understood and agreed that the Water Company shall not be liable for breaks in water pipe, failure of pumping apparatus or any other causes beyond its control."

I should like to ask the Committee why they have not given the railway company the same protection when they are on the other side of the contract.

Mr. E. L. Taylor:—These features were considered by the Committee. With respect to your first question, that we should provide for termination if the bills were not paid, it was thought this contract would not be used except in relatively unimportant situations where the railroad was merely giving the water service as an accommodation to employees or to some neighbor; ordinarily the contract would be terminable on thirty days' notice, so there could be no real danger in a failure to pay the bill. There would not be the loss one might think, except perhaps one month's payment.

It seems to us that Section 11 does protect the railroad company for failure to supply. It seems unnecessary to put this record in again, but Section 11 says, "The Consumer agrees to indemnify the Railway Company and save it harmless from all claims and expenses that may arise or be made for loss or damage resulting to the employees or property of the Consumer or to any other persons or property, arising out of the construction, maintenance or operation of the water facilities used in furnishing water to said Consumer or the use of the water furnished, as herein provided."

In other words, the whole arrangement is at the risk of the consumer. If this objection is important enough, the Committee would prefer to lay it over for another year, and I would ask the last speaker to advise whether I have answered the questions.

Mr. C. W. Baldridge:—I realize, of course, that in most cases these contracts for water to be furnished by the company to employees and others are unimportant, but it is impossible to tell when some of them may become very important. If I were writing up a contract, I would put the same protection in that contract that I would want in the other contract or would be willing to concede in the other contract. I think the Committee should consider it further the coming year.

Mr. C. A. Wilson (Consulting Engineer):—I was on the Committee that handled this contract. The Committee considered just what the last speaker has mentioned, and it fully believed that Sections 7, 8 and 11 would cover every suggestion that he made. To add to those, as he suggests, would only make the contract a little more diffuse in words and not so concentrated as we want to make it. We believe that those three paragraphs cover every question the gentleman has raised.

Mr. W. H. Woodbury (Duluth & Iron Range):—I believe Mr. Baldridge is exactly right. I think this thing should be referred back to the Committee. I move it be referred back.

The President:—You have heard the motion, which has been duly seconded. Is there any further discussion on it?

Mr. W. C. Barrett (Lehigh Valley):—If the railroad company furnished any extensive amount of water, it would be necessary legally to organize a separate water company. Therefore, any water furnished by the railroad company is rather in the way of accommodation than anything else and is really very unimportant.

Mr. W. H. Kirkbride (Southern Pacific):—I think this matter of railroad companies furnishing water to outsiders is a very important matter. It generally starts as an accommodation to railroad employees of a certain terminal town, and as the town grows there comes a time when the railroad becomes a public service corporation with respect to furnishing water. Then very involved difficulties will arise in connection with collecting bills. I think the Committee could well afford to give attention to the matter of protecting companies against furnishing water under certain conditions, whereby they would only furnish the water to an organization of one or two citizens who would then sell the water and distribute it to the various people concerned.

I think it would be well to consider this matter further. We should consider the idea of protecting railroads as much as possible against the furnishing of water to outsiders.

Mr. C. W. Baldridge:—Over a great deal of the country, it is very true that the water furnished by a railroad to outside parties is an unimportant matter, but if you get out in the Southwest, where sometimes every bit of water used in the entire community is hauled 100 miles, or more perhaps, by railroad, it is not so unimportant as it is in other places. It is my judgment that the contract form for furnishing water to outsiders should be made just as carefully as any other contract form. It is not good policy to assume it is an unimportant matter, and if it is so unimportant, we do not need to make a contract. If it is sufficiently important to make a contract, we should make a good one.

Mr. C. A. Wilson:—I rise to a point of order. What has been done with the first motion?

The President:—There has been no motion on that. We are simply having discussion on it at the moment. The amendment will have to be put first, Mr. Wilson, but I thought possibly some of the gentlemen on the Committee would like to say something further in reply.

Mr. Wilson:—I see, it was a motion to amend.

The President:—That is the way I understood it, that Mr. Woodbury's motion was to amend.

You have heard the motion by Mr. Woodbury, seconded by Mr. Baldridge, that these contracts be referred back to the Committee for further consideration and report next year. All in favor say "aye"; contrary. It is carried.

Mr. E. L. Taylor:—The Committee submits for discussion the Form of Agreement for the Purchase of Water, appearing on page 438. We would be glad to have discussion of that here on the floor so we may know what you think of it.

If there are no comments on that, we will proceed to the remainder of the report.

The President:—Just a moment, Mr. Taylor. The Chair understood your motion to cover both—the agreement for the purchase of water and the agreement for the furnishing of water from railway water systems to employees and others.

Mr. W. H. Woodbury:—No, sir; I intended that to mean only to correct the contract in which the railroad company furnished the water. The other, I think, is all right.

The President:—Is that clearly understood on the part of the convention, that the motion covered only the form for furnishing water? Mr. Baldridge in his first remarks covered both, and I thought Mr. Woodbury's motion covered both.

Mr. C. W. Baldridge:—Mr. Chairman, in my first discussion I simply quoted from the second contract as a matter of illustration, not as a criticism. The second contract, commencing at the bottom of page 438 seems to me to be all that can be desired.

Mr. E. L. Taylor:—The second agreement is a tentative draft submitted for discussion.

The President:—Is there any discussion on the second agreement, the Form of Agreement for the Purchase of Water? If there is no discussion, that will be accepted as a tentative draft for further consideration at the next convention.

Mr. E. L. Taylor:—The Committee also recommends that the proposed form of Maintenance Bond should be withdrawn from the outline of work, as our investigation shows there is no necessity for such a form.

The President:—The Board will take cognizance of that.

Mr. E. L. Taylor:—The Committee also recommends that the proposed "Form of Agreement for Furnishing and Boarding Men" be withdrawn from the outline of work, as investigation shows that in the localities where there might be use for such a form, the State Laws and local requirements are such as would make it impractical to use a general standard form.

The President:—The Board will take cognizance of that also in connection with the outline of work.

Mr. Clark Dillenbeck:—The next subject is Appendix B, page 440, Revision of the Manual.

The Committee has no recommendations to make for changes in the Manual at this time.

The second subject is Form of Agreement for Joint Use of Freight Station Facilities. This form is printed on pages 441 to 448 inclusive. It was submitted last year for information and criticism was invited.

There have been no changes in the form as printed in the Proceedings last year, having received no criticisms of same. I, therefore, move that this form be adopted for printing in the Manual.

The President:—You have heard the motion, that the Form of Agreement for Joint Use of Freight Station Facilities be adopted for insertion in the Manual. Is there any discussion?

Mr. E. B. Crane (Chicago, Milwaukee & St. Paul):—On page 442, Section 5, paragraph (b), it specifies that the expense for maintenance shall be in accordance with the classification of the Interstate Commerce Commission; on page 443, Section 6, no definition is given as to what additions and betterments are. I think it would be a good idea to make the same reference to the classification as for the maintenance expense. Then, again, reads the first sentence, "In the event that any additions to, or betterments or improvements of," etc. I am wondering what the Committee had in mind by the use of the word "improvements." The classification covers additions and betterments only. I think probably that would cover anything that was intended to be added to the principal sum on which rental was to be charged. It occurs to me improvements might be made and the expense charged to maintenance and that the words "Improvements of" should be eliminated.

The President:—The Chair will ask Mr. Dillenbeck to read through the headings of this agreement, pausing after each one, and if anyone desires to discuss any of these clauses opportunity will be given to discuss the clause as it is mentioned.

Mr. Clark Dillenbeck:—No. 1, Grant and Description; No. 2, Scope; No. 3, Employees; No. 4, Operation and Maintenance; No. 5, Rental; No. 6, Additions and Betterments.

Mr. C. W. Baldridge:—I lost track there and let you get by No. 5. At the top of page 443, Section (d) reads, "Such proportion of the cost of taxes and insurance, light, heat, water, telephone service and other accessories for joint use, as the number of tons of freight handled through said freight house," etc.

Turning over to the next page, you will find at the top of page 444 that Company B must pay its own insurance on its own cars and its own freight, while in Section (d) on page 443, apparently Company B is responsible for their proportion of all of the insurance charges. I would suggest that the following words be added on the first line in Section (d): "including cars or freight of A Company." That would then make the A Company responsible for their own insurance or the insurance on their own cars and freight, the same as the paragraph on that page makes the B Company liable for insurance on their own cars and freight.

Mr. Clark Dillenbeck:—Paragraph (d) is proportion of the cost for the joint facilities, as I understand it, and has not anything to do with each company's own cars and freight.

Mr. C. W. Baldridge:—I do not understand paragraph 7 provides for each company. It says B Company shall be responsible for its own insurance. That might be cleared up in paragraph 7 by saying each company shall be responsible for the insurance on its own cars and freight.

Mr. E. L. Taylor:—It seems unnecessary to follow that suggestion, because not only do we have the heading on page 442 for joint use of said freight house, platforms, etc., but we also, under Section (d) on page 443 use the words "for joint use." Cars and freight cannot be considered as being jointly used. It seems unnecessary to make the change as suggested.

The President:—Does that answer your question, Mr. Baldridge?

Mr. C. W. Baldridge:—I hardly think it covers it, but I am willing to leave it to the Committee. If they are satisfied, I shall not object.

Mr. Clark Dillenbeck:—Additions and Betterments; Custody and Property.

Mr. E. B. Crane:—My criticisms of Section 6 were to the inclusion of the words "or improvement," following the word "betterment," in the first and eleventh lines, and the neglect to specify that the expense of the "Additions and Betterments" shall be in accordance with the classifications of the Interstate Commerce Commission, as was specified in Section 5 with reference to the expense of maintenance.

Mr. E. L. Taylor:—I think we should accept that change; so it will be specific in the record, we will have the beginning of Section 6 read this way: "In the event that any additions or betterments to the facilities of the A company to be used jointly by the B company hereunder, and properly chargeable under the current rules and regulations and classification of the Interstate Commerce Commission shall at any time," etc.

Mr. H. C. Crowell (Pennsylvania Railroad):—Should not the Sub-Committee Chairman have added the words, "to capital account," after the word "commission," in the revision he has just read?

Mr. E. L. Taylor:—We accept that change.

Mr. H. C. Crowell:—If it is not too late, I would like to go back to paragraph (b), on page 442. After the word "and," would it not be well to insert "other items chargeable under the current rules . . . . to the general account, maintenance of way and structures?" In other words, there are some items that are not purely maintenance items. For example, there are depreciation and retirement charges and the expense portion of betterments, all of which I assume should be divided in the same way as purely maintenance items.

The President:—I would suggest, Mr. Crowell, that you move that this form of agreement be referred back to the Committee for another year, and that suggestions, such as you are making, be sent them by letter in order that they may be considered. The Committee is hardly prepared to consider these various suggestions and their effect on the agreement form while they are here on the platform.

Mr. H. C. Crowell:—I make that as a motion. I apologize for making the suggestion at this late hour. It should have been made, of course, by letter.

The President:—The difficulty is the Committee cannot deal with it at the moment, and it is either necessary to ignore it or to have a year in which to consider the suggestions.

Mr. H. C. Crowell:—In view of that suggestion and others that have been made, I will make a motion that the contract form be referred back to the Committee for revision in accordance with the comments that have been made.

Mr. G. D. Brooke (Chesapeake & Ohio):—I will second that motion. I would like to ask as a matter of information if the Committee intends this contract form to cover the joint use of team tracks.

Mr. Clark Dillenbeck:—Yes; when there are team tracks in connection with the freight house.

Mr. G. D. Brooke:—Does the Committee consider it proper to pay the rental of team tracks on the basis of tonnage handled over the platform?

Mr. Clark Dillenbeck:—What paragraph do you refer to?

Mr. G. D. Brooke:—Paragraph 5(a).

Mr. Clark Dillenbeck:—No special consideration was given to the team track division of expense. We are very glad to receive these criticisms, but regret we did not get them a year or two ago. We have been working on this agreement for two years, inviting criticisms, and this is the first one to be received. It would be a great help to us if we could get these criticisms and make use of them, because these forms of agreement are new subjects. We would be glad to receive suggestions. We are perfectly willing to give this form further consideration, and shall be pleased to receive written criticisms.

Mr. R. H. Ford (Chicago, Rock Island & Pacific):—I would like to ask the Committee if in the preparation of the contract forms they discussed them with the lawyers. Have they drawn any criticisms from the lawyers at all? I speak of that because railroads ultimately have to go through that form. Another thing is that as these contracts deal so vitally with railroad facilities, it is very important that they be legally correct. I have noted with some apprehension the willingness to accept them, indicating they are worthy of careful consideration and especially from a lawyer.

The President:—Is there any further discussion on this motion that the Form of Agreement for Joint Use of Freight Station Facilities be referred back to the Committee for another year's consideration?

Mr. G. D. Brooke:—It has also been suggested that the use of icing facilities be given consideration at the same time. I am sorry that my suggestions came so late, but I think it is due to my having recently handled a contract of this kind where several phases of station operation were dealt with, so I am in a better position to offer the suggestion now than formerly. So far as I am concerned, I am willing now to leave the matter in the hands of the Committee.

Mr. E. L. Taylor:—May I ask the last speaker if in his reference to icing stations he has knowledge of any such facilities that are used jointly under a joint operating arrangement. I am under the impression that those facilities are usually used under a tariff arrangement.

Mr. D. J. Brumley (Illinois Central):—The Illinois Central Railroad Company has under consideration a joint terminal in which all the facilities will be pooled and used by the tenant companies, the joint use of freight houses, the freight platforms, the icing station, team track facilities and all the facilities that are usually found in a modern local freight terminal.

It occurs to me that the distribution of cost for maintaining and operating the icing station should be considered by the Committee and worked out like the team track facilities, etc.

The President:—If there is no further discussion, we will put the question.

(The motion was carried.)

Mr. Clark Dillenbeck:—The next subject is Form of Agreement for Use of Railway Property for Public Highways.

As stated in the report, we have prepared a form of agreement which we do not consider in proper shape to submit as yet to the Association.

The President:—If there is no objection, that will be received as information.

Mr. Clark Dillenbeck:—The next report of Sub-Committee No. 3, is Appendix C, of which Mr. E. L. Taylor is Chairman and he will present the report, to be found on page 448, Form of Agreement for Purchase of Electrical Energy, and Form of Agreement for Joint Use of Poles on Railway Rights-of-Way.

Mr. E. L. Taylor:—Before starting on that report, I should like to answer the gentleman from the Rock Island. We have a pretty good lawyer —although perhaps he has not passed the bar examinations—on our Committee, Professor C. Frank Allen. He has spent a great many years in contract work and has really studied the legal end of it, so aside from any help we may get from our company lawyers, I feel that the Committee has really a first-class man right within its midst.

Mr. R. H. Ford:—I have no doubt that Professor Allen is an expert attorney—there are a great many of them—but we railroad men know the importance of these contract forms passing through our respective law departments and you all know that it is a very rocky road.

I want to say again that with all due regard for the Committee and their legal knowledge, I hope that on all these forms they will during the year get legal advice.

Mr. E. L. Taylor:—We appreciate very much your thought in this matter and there is no hard feeling at all.

Last year when the Form of Agreement for Purchase of Electrical Energy was considered there was a suggestion that it should be made more comprehensive. The Committee gave that suggestion quite a little thought and it was felt that this form should be comprehensive enough for the purchase of electrical energy under ordinary conditions, but that it would not be suitable for traction purposes, so we have revised the form by adding under the title a note setting forth that idea, reading: "This Form of Agreement is not intended to be used in connection with purchase of a large volume of electrical energy for traction purposes."

This form, as it appears on page 448, is recommended for adoption. There has been also one small change in verbiage in the opening paragraph to make it consistent with other forms.

I move that this form be adopted.

Mr. E. B. Katte (New York Central):—I would like to add that in my opinion it is a wise provision to limit the contract form to lighting and minor power purposes, since there are so few contracts, up to the present time, covering the purchase of large volumes of power for electric traction purposes. It is hardly possible to standardize the form at the present time. I think that every contract thus far awarded for electric traction power has been of a special nature and has contained many special clauses, thus it would be premature to attempt to standardize a contract form for electric traction power purposes.

The President:—It has been moved and seconded that the Form of Agreement for Purchase of Electrical Energy under Appendix D be approved for insertion in the Manual. Is there any further discussion? All in favor please say "aye"; contrary, "no." It is carried.

Mr. E. L. Taylor:—The Committee also recommends for adoption the Form of Agreement for Joint Use of Poles on Railway Rights-of-Way, as it appears on page 452.

This is the same as it appeared in last year's Bulletin 273, except that at the end of Section 8 it has been changed to read: "In case of termination hereof by the Railway Company by notice, as provided in Section 14 hereof, prior to the date to which rent shall have been paid."

To bring your mind again to what was said last year, this joint pole line agreement was considered for possible use with a telegraph company, but such an agreement is so comprehensive and so far-reaching in its scope that we felt it best to limit the form by the note at the head, reading: "This form of agreement is not intended to be used as a general agreement with the telegraph company operating on the lines of a railway company."

I move the form be adopted.

Mr. R. A. Baldwin (Canadian National):—Would it not be advisable to have some clause in the proposed contract to provide for the inspection of the pole line proposed to be erected on railway rights-of-way? I know of cases on the right-of-way of the railway with which I am connected where we have allowed power companies to build transmission lines on the railway's right-of-way, and I know there is a clause in the agreement which provides for the inspection of that transmission line; I think the power company also have the right to operate gas cars. I know it is a clause which has given us considerable concern.

Mr. E. L. Taylor:—Mr. Baldwin, may I ask would such a power line be a joint pole line?

Mr. R. A. Baldwin:—No, sir; an independent one.

Mr. E. L. Taylor:—This agreement is intended only for joint pole lines. It is a mutual agreement between the parties interested and the parties agree that one of them shall be responsible for the maintenance, and the agreement also provides that if any defective maintenance is found by the other party, it can be brought to the attention of the maintaining company, or can be taken care of in an emergency by the company which finds the defect.

I think the situation you have in mind is more in the nature of a lease agreement than a joint pole line agreement.

The President:—Any further discussion on this motion? All in favor please say "aye"; contrary, "no." It is carried.

In thanking this Committee for the work they have done, the Chair desires to point out that the getting out of these contract forms is extremely difficult. We have turned back considerable of their work to them for reconsideration. It would be of the utmost help to the Committee if all those who are interested in these contract forms would keep the matter before them throughout the year and communicate with the Chairman of the Committee and give him the benefit of their suggestions. The Committee welcomes that and are anxious to get suggestions from everyone on these subjects. The more suggestions they receive, the better their work will be when they present it next year.

Mr. C. A. Wilson:—I just want to say a word. It did not seem to me that my fellow-members made it quite clear on the question of whether we consult with the lawyers. Most of the members on this Committee do consult their own attorneys in their own companies and we take into consideration all the objections they raise and, as a rule, they are approved by the attorneys of the companies with which the members are associated. Those of us who are not connected directly with companies consult attorney friends on the subjects who are interested in these matters. So I want to make it clear that the lawyers have had a hand in every contract that has come up. Not only that, but our President has called your attention to the fact that every contract we have presented for adoption, this convention has had before it for a year, and you have had a chance to consult your lawyers and send into us objections to the contracts. I wanted to make it clear to the convention that the Committee is not cutting its work entirely out of its own timber.

The President:—The Chair might add to what Mr. Wilson has said that this Committee is in a peculiarly difficult position in regard to the feature of consulting lawyers. We have no committee or legal committee of this Association; we have no legal members with whom they can co-operate as an official committee. I do not know that there is any association of railway legal departments to whom they could refer, either, consequently they have to do just what Mr. Wilson says. It is quite possible that when these contract forms are finally approved by the Association that almost every one of them, when being put into effect, will be gone over and criticized and possibly added to by the legal department of the railway concerned, so that about the best our Committee can expect to do is provide a guide on which to have the legal department approve of a contract for any particular railway.

The Committee has the thanks of the Association and is relieved. (Applause.)

DISCUSSION ON MASONRY

(For Report, see pp. 457-470.)

Mr. C. C. Westfall (Illinois Central):—The Masonry Committee was given a program of six subjects for this year. One of these subjects was report on the "Report of the Joint Committee on Concrete and Reinforced Concrete." The Committee has had this report before it for about three years, and it tried for this year's work to concentrate its efforts on this one subject. Therefore the Masonry Committee report for this year is confined to a report on Specifications of the Joint Committee on Concrete and Reinforced Concrete.

The Committee presents this report as information, but presents it from two standpoints—one for the benefit of the members of this Association, and the other for the benefit of the Joint Committee which has asked for criticism.

The Committee, therefore, recommends that the report shall be accepted as information. It also offers the recommendation that a copy of this report be transmitted to the Joint Committee through the proper channels.

This Joint Committee on Specifications for Concrete and Reinforced Concrete was formed in 1920. A progress report issued about 1921, and in 1924 the report now under consideration was issued to the bodies from whom the members were chosen to make up the Joint Committee.

I think that the specifications are pretty familiar to those members who are interested in concrete, but it has been an unfortunate fact that there have not been many criticisms or comments offered upon the specifications.

The specifications have been formally presented to the other constituent bodies who had members on the Joint Committee, these being the American Society of Civil Engineers; the American Society for Testing Materials; the American Concrete Institute, and the Portland Cement Association.

At the meetings at which the reports were presented to these other societies, there were a few criticisms, or rather individual papers offered, but in general the subjects of the papers were individual items of the specifications and the criticisms were not to a great extent constructive.

The Masonry Committee in presenting its report has tried to make a thorough study of the specifications and has made certain recommendations which it thinks will be to the benefit of the Joint Committee specifications.

Mr. President, I might pick out some of the more important parts of the specifications and speak on them. There are a few suggestions under the heading of Definitions which are not worth while discussing.

Under Aggregates, the Joint Committee specification does not permit the use of slag. The A.R.E.A. specifications permit slag under certain restrictions, and this Committee recommends that slag be considered as an acceptable aggregate.

Under Metal Reinforcement, the Joint Committee specifications permit twisted bars and rail steel bars, while the A.R.E.A. specifications do not permit the use of these materials. The Committee recommends that the provisions of the A.R.E.A. specifications be followed.

There has been considerable discussion on the merits of a certain table in the Joint Committee report on the proportions of concrete. The Masonry Committee recommends the elimination of certain material in the Joint Committee report and the elimination of certain notes which carries with it the elimination of the table which was discussed at last year's meeting.

Under Surface Finish, the Masonry Committee in its specifications which now appear in the Manual, had a very satisfactory specification or treatise on surface finish, and the Committee feels that the material in the Joint Committee's specifications on this subject would be materially improved by combining with it certain of the information in our Manual. This is treated in detail in the report, and I think it is not worth while reading.

In Design, the Joint Committee report has departed considerably from the usual practice. The Masonry Committee has given this feature study and is not willing to accept all of these departures.

Section 112 of the Joint Committee report provides that "The distance between lateral supports of the compression area of a beam shall not exceed twenty-four times the least width of compression flange." The Masonry Committee has recommended that a formula be used which would provide a sliding scale for the compressive stresses in the flange of a concrete beam similar to the provisions made for I-beams in our steel specifications and suggests such a formula.

Under Flat Slabs, the Masonry Committee is not prepared to approve the recommendations of the Joint Committee. This subject, however, is one that requires very careful study and consideration, and the Masonry Committee has not felt that it could make a definite recommendation on the design of flat slabs at this time.

Under Columns, the Joint Committee has again departed considerably from current practice, and the Masonry Committee is not prepared to recommend those provisions. The Joint Committee's recommendations depart very materially from the current practices, and current practices are not very similar.

On both of these subjects, the Committee presents discussion by individual members of the Masonry Committee, one by Mr. Condron on the Design of Concrete Columns, and one by Mr. Hirschthal on Flat Slabs. These both appear in Bulletin 282 containing the report.

Under the subject of Footings, the Joint Committee report provided for the design of footing without considering the weight of the concrete in the footing itself. The Masonry Committee has recommended that all of the load on the base of the footing be considered in the design.

Under the subject of Unit Stresses, the Joint Committee had recommended rather higher unit stresses than have been used before and the Masonry Committee did not feel that it could recommend this departure.

In the fiber stress in concrete and flexure, the Joint Committee recommended a working stress of **four-tenths of** f_c', of the ultimate compressive strength of the concrete. The Masonry Committee recommends that this should be taken as .325 f_c'.

The extreme fiber stress in flexure adjacent to supports of continuous beams in the Joint Committee report is .45 of the ultimate strength of the concrete. The Masonry Committee recommends 37½ per cent.

The shearing stress in beams with stirrup or bent up bars or the combination of the two, in the Joint Committee report is recommended as .12 of the ultimate strength of the concrete. This Committee recommends 7½ per cent.

The Joint Committee does not give any value to tension in concrete. The Masonry Committee feels that in reinforced concrete this is proper, but in plain concrete the tensile strength of concrete should be taken into account and recommends 2½ per cent of the ultimate strength of the concrete.

The Joint Committee report when studied by the Masonry Committee was found to be somewhat confusing in the matter of symbols and the Committee has recommended that this be clarified by the Joint Committee.

This is expected to be the end of the discussion of the Joint Committee report by the Masonry Committee, unless that report is changed in the future. The Masonry Committee would welcome any discussion by the members so that such discussions can be presented to the members of the Joint Committee with this report.

The President:—If there is no objection, this report will be accepted as information. It is urgently hoped that there will be some discussion of it as an assistance to the Committee in further consideration. If anybody has any discussion, we will be glad to hear it. If there is no discussion the Chair would urge upon you that later on when you have had time to go over this report more carefully you write the Committee Chairman and give him some written discussion to help him out. It is of the greatest assistance to these committees to get written discussion from the members at large.

We will now dismiss the Committee with the thanks of the convention. (Applause.)

DISCUSSION ON STRESSES IN RAILROAD TRACK

(For Report, see pp. 471-472.)

Prof. A. N. Talbot (University of Illinois—Chairman):—The report of progress of the Committee on Stresses in Railroad Track outlines work which has been done on rail joints. Measurements have been made of the strains in different parts of the splice bars, both in field and laboratory tests. It may be of interest to note that the tension found in the track bolts showed great variation even on the same joint. These variations ranged from a very loose bolt to a tension of 40,000 lb. or more. A sixty-eight year old trackman, who had been with the Illinois Central since 1879, when told to tighten a nut a little, put 40,000 lb. tension into it and would have gone farther if he had not been stopped. The effort has been made to learn the effect which the tension in the bolt has upon the action of the joints. This has been found to vary with the different types of bars, a plain flat bar requiring less tension than the usual form of angle bar. It has been found repeatedly that the stress at the outer edge of the lower flange of the angle bar is very small and may sometimes be compression instead of tension. The data are being worked up as rapidly as possible and further tests are being made in the laboratory. It is hoped that a report will be ready for presentation during the year. For information it may be added that with the load at the ends of the rail the intermediate bolts of an angle bar joint loosen somewhat and the end bolts tighten, and that the angle bar at its middle moves inward somewhat at the bottom and at the bolt.

The President:—Does any member present wish to ask this Committee any questions in regard to their work?

I might say that it has been the practice of the Special Committee on Stresses in Track to issue a fairly voluminous and comprehensive report every other year. This is the off year, when they only report progress. They are gathering data, and their information is always valuable. Possibly some member would like to ask questions of the Committee while they are here.

Mr. J. L. Campbell (Southern Pacific):—The work of the Special Committee on Stresses in Railroad Track has always been outstanding in its characteristics of the exact application of applied science. It represents that class of the highest grade of work that has been undertaken by this Association, and I wish to call the attention of the Association to the fact that all of our work is necessarily trending in the same direction. The work which this Association is doing now is more exact, it is of a higher grade—necessarily so—than it was in the early years of the work of this Association, when the founders of the organization had to start down at the bottom and take the simpler things to begin with. That work was exceedingly well done. The work of this Association has now progressed to the point where we must necessarily make a more exact application of applied science. The result is going to be that the quality of the work of this Association will become refined from year to year, and eventually I anticipate there will be no organization of any kind in the country that will be doing a finer grade of work than this Association will be doing.

In doing that, we will eventually—very largely at least—solve the intricate and difficult problems that are yet unsolved in the transportation business.

The President:—Would anyone else like to say anything in connection with the work of the Committee on Stresses in Railroad Track?

Mr. Mils Myrin (Thief River Falls, Minn.):—I would like to ask a question of the Committee. Would they consider a rail joint of a different make?

Prof. Talbot:—The Committee has made tests only on the joints which are in use in tracks. That is as far as the work has gone.

Mr. Mils Myrin:—I understand that. I just asked if they would consider a different cut of rail joint. If they would be interested, I would show it to them.

Prof. Talbot:—I am sure the Committee would be glad to have its attention called to any of the forms which are in use anywhere.

Mr. Mils Myrin:—It is not in use. I never had the nerve to put it into practice.

Prof. Talbot:—We will be glad to know of it at any rate.

Mr. R. T. Scholes (Chicago, Burlington & Quincy):—I would like to ask a question of Professor Talbot as to how the joint bars compare under positive loading and negative loading, whether the stresses appear to be approximately equal or whether they are in excess when the axle is over the joint?

Prof. Talbot:—So far we have not made tests on joints in the track loaded to produce a negative bending moment. For such conditions it has been found that the negative bending moment in the full rail forms from 40 to 60 per cent of the maximum positive bending moment. It would be well to learn the action of the joint under the conditions of negative moments. I should like to add that the Committee would be glad to have suggestions by any member of the Association on other tests or kinds of information that are desired.

The President:—If there is no further discussion, we will dismiss this Committee with the thanks of the Association. (Applause.)

DISCUSSION ON RAIL

(For Report, see pp. 473-629.)

(Past-President J. L. Campbell in the Chair.)

Mr. G. L. Moore (Lehigh Valley—Chairman):—The Rail Committee has been intensely interested in the experimental use of rail, which has been going on for the last few years, containing a higher content of manganese than has been the former practice. Recently, however, a patent has been taken out covering the manufacture of the rail made of this kind of steel, and Mr. G. J. Ray, before we start with the regular work of the Committee, wishes to make a statement to the convention.

Mr. G. J. Ray (Delaware, Lackawanna & Western):—I have been put in a peculiar position in regard to this so-called higher manganese rail on account of the patent which has been taken out by one of our employees. I want to make a short statement to the convention so that you will all know my personal position in the matter, and straighten out the situation so that you will definitely understand that the road that I represent has nothing to do with the patent end of this proposition. We are only interested as we always have been, in attempting to get a better wearing rail and a safer rail. We have done much experimenting, and I think some of the steel companies will verify my statement that we have spent a lot of money in experimenting with all sorts of combinations in order to get a better wearing rail and a safer rail.

On January 5, 1926, a patent was granted to H. J. Force on rail steel. The application for this patent was filed on July 17, 1925. As soon as Mr. Force received his patent papers he took steps to notify several of the steel companies and also some of the railroads that he would expect a royalty of $3.00 a ton and also indicated that in case of infringement legal action would be taken for triple damages.

Assuming that Mr. Force's patent is good (personally I think it is worthless) and that he could do all that he claims, most of us would probably use this rail.

Note a few of the claims summarized as follows: With this steel the section is stiffer, shows greater ductility, has a higher average hardness, breakage and rapidity of wear and disintegration are reduced, transverse fissures are materially eliminated. In fact, this steel is of such superior quality that it is possible to reduce the size of rails; also, difficulties and losses ordinarily encountered in the manufacture of steel rails under present processes are avoided. In other words, it is claimed that this invention will make it possible for us to use lighter rails with greater safety and permit the steel companies to manufacture this material at less cost.

For the benefit of those who are not familiar with many of the facts, permit me to say to you that Mr. Force is the Chemist and Engineer of Tests of the Lackawanna Railroad. For the past 17 years the speaker has been Chief Engineer of the Lackawanna Railroad and during this time has had entire charge of the rail problem. Our general steel inspector has charge of all operations at the mill and reports directly to the Chief Engineer. The only work handled by the Chemist and Engineer of Tests is such chemical analyses as are required.

My object in addressing the Association on this subject is threefold: (1) I wish to correct some of the errors in the statements that have been sent out in an attempt to advertise the patent in question. (2) I wish to make it plain to all concerned that the communications concerning this patent which Mr. Force sent to the steel companies and to officers of some of the railroads were sent out without the authority or consent of his superior officers and should have been handled as a personal matter instead of emanating from the Chemist and Engineer of Tests of the Lackawanna Railroad. (3) I have received many inquiries concerning this rail from officers of other railroads. I have gladly given out information and advice to the best of my knowledge and belief, but in all cases I have been very cautious not to strongly recommend this steel and I have been careful to state that in my opinion the rail has not yet had a sufficient trial to warrant any extravagant statements. I want to make it clear that I am in no way interested in the patent granted to Mr. Force and had no idea that he applied for a patent until after it was granted.

As early as January, 1911, we accepted one heat of steel rolled at the Lackawanna plant in Buffalo, the test ingot showing carbon of 0.56 and manganese of 1.21. This rail was carefully watched in service, but did not give any better life than other rail from the same plant. Part of this rail was laid on a curve and had to be turned in 18 months. It was all removed from the track by the end of 30 months. Two failures occurred during the life of the rail.

Two more heats of this steel were rolled at the same plant in July, 1920. They did not get the manganese as high as it should have been, both heats ranging between 1.05 and 1.10. The rails from these heats did not last in the track long enough to develop transverse fissures.

In January, 1921, the Lackawanna Steel Company rolled two more heats. The carbon and manganese of the two heats in question was 0.64 and 1.34 and 0.57 and 1.34, respectively. The tests on both heats showed up very poorly. Therefore, I did not expect good results from this steel. As a matter of fact, both heats had to be removed from the track within less than three years on account of the development of an excessive number of transverse fissures.

I have given you these facts in order that all concerned may know that increasing the manganese and reducing the carbon will not necessarily either postpone or eliminate transverse fissures. The members of the Rail Committee will remember the discussion which took place on this question of higher manganese and low carbon at the joint meeting with the Manufacturers' Committee on September 14, 1920. At that meeting there was a free discussion and at my request the Bethlehem Steel Company consented to roll 2,000 tons of this rail for test. This rail was rolled in

September and October, 1920. The officers and employees of the Bethlehem Steel Company took great pains in rolling this tonnage of special steel. Mr. Bent deserves especial credit for his interest and assistance in making a success of all of the rollings made by the Bethlehem Steel Company. As a result of this care, the first 2,000 tons proved to be first-class rail in every respect. The tests at the time of the rollings showed up remarkably well, and the rail has since shown up well under our traffic. In this 2,000 tons of steel no failures have occurred with transverse fissures and the rail is still in the track. It was on the strength of this test rolling that we arranged with the Bethlehem Steel Company to roll a considerable tonnage of this rail in the fall of 1924 and again this past year.

I am inclined to believe that this steel, when carefully made, will give good service. From the tests we have made to date, I have hopes that carefully made steel rail with manganese between 1.30 and 1.50 and carbon 0.60 to 0.70 will wear well and probably postpone the development of transverse fissures to a later date than we must expect with high carbon rail.

Mr. G. L. Moore:—The Committee proposes revision of the Manual as follows: Revised Specifications for Spring Washers, shown as Appendix A to the report; recommended Design for Track Bolts, including corresponding joint bar punching, shown as Exhibit A. Mr. Adams will present the subject.

Mr. Lem Adams (Union Pacific):—Our first item here proposed for adoption by the Association is that of a design for track bolts. We have been trying to get a standard design for track bolts that could be adopted by all of the railroads throughout the country, and on page 483 we have Exhibit A that is not quite complete, as since the compilation of this Exhibit we have received a request from one of the railroads using the elliptical shoulder that we include the one-inch, one and one-eighth inch and one and one-quarter inch bolts, and these sizes will be included in the table of dimensions before it is offered for printing.

I move that the design for track bolts submitted in the report in Exhibit A (with the aforementioned inclusions) be accepted as the American Railway Engineering Association standard and printed in the Manual.

Chairman Campbell:—It is moved and seconded that the design for track bolts, illustration of which you will find on page 482, Exhibit A, be adopted for inclusion in the Manual. Is there any discussion?

(The motion was carried.)

Mr. Lem Adams:—The second item proposed is Revised Specifications for Spring Washers on page 478 of Bulletin 283, where you will find the revised specifications. This is quite similar to that adopted by the Association a few years ago, but has been revised to include both the helical and the elliptical spring washers.

The Committee recommends the adoption of this specification as standard for the Association.

Chairman Campbell:—Is there any discussion on this motion?

Mr. R. B. Jones (Canadian Pacific):—I cannot agree that the specifications submitted should be included in the Manual in their present form. My reasons for objecting are: First. There appears to be distinct conflict between certain clauses. Under clause 4 it is provided that the test specimens shall be subjected to the preliminary load ten successive times. The first paragraph of clause 8 indicates that the object of these ten applications is to eliminate permanent set. Clause 16 (a) provides that previous to being offered for inspection each individual piece shall have been subjected, as a part of the routine manufacturing process, to shock or pressure sufficient to eliminate permanent set. If the permanent set is eliminated during the routine process of manufacture, what is gained by the ten successive applications of the preliminary load? If it is not so eliminated, why specify that it shall be eliminated?

Secondly. Some of the terms used are not clear. In the table of preliminary and test loads for the different sizes of washer the preliminary load for the low spring pressure washer is given as "down to solid." What does this mean? If maximum micrometer thickness is intended then "down to solid" is not the way to express it. I have had occasion to test washers that would normally be classified as helical low spring pressure washers, and it is a very difficult thing to determine when the washer is down to solid, as the ordinary man would understand that statement. When the washer is down to the maximum micrometer thickness, it is, in the testing sense, by no means down to solid. The maximum micrometer thickness of such a washer occurs usually at the ends and is due to shear. When a washer of this type is compressed in a testing machine, it does not follow that the maximum micrometer thickness will be normal to the platens of the testing machine. I have records of tests made at McGill University which show that a washer of this type can normally be compressed to below its maximum micrometer thickness and definite reactions measured.

Thirdly. Elliptical washers and helical low spring pressure washers are each required to pass a test for reaction, that for elliptical washers being definitely stated and that for helical low spring pressure washers being indefinitely indicated. Helical high spring pressure washers, however, are not required to meet any reaction test. Why should not the reactive value of all spring washers be determined in a manner similar to that indicated for elliptical springs by giving an appropriate preliminary test load, an appropriate backoff, and a corresponding test load?

It seems to me that with a spring washer the only thing we are interested in is the reactive pressure we will obtain at some stage of looseness in our bolt that develops between bolt tightenings. There is progressive looseness developing due to wear all the time, and if I buy a spring washer of any kind, I am interested to know what the pressure will be when I have had my joint in position for some time. I want to have some idea of what reactive pressure I buy.

Casual reading might lead one to suppose that reaction for the helical high spring pressure type of washer is provided for by the variation between the preliminary load and the test load, but this does not follow, as there is no assurance that the preliminary load will compress the washer to the so-called test height of maximum micrometer thickness plus .02 of an inch. It is quite conceivable that a washer may be so manufactured that it cannot be compressed to within .02 of an inch of its maximum micrometer thickness by the high spring pressure preliminary load. Such a washer need have no spring action whatever, yet it would pass these specifications.

The Committee may be satisfied that the specifications will include such spring washers as it is desired to purchase, but unless it can be demonstrated that they will also exclude such washers as it is desired not to purchase, I submit that they should not receive the stamp of approval from this Association.

Mr. J. B. Emerson:—The Chairman has asked me to comment on the apparently very just criticism of what may be an ambiguity of wording or a lack of clearness in the presentation of the idea of the Committee. In the first criticism dealing with the preliminary loads, the apparent conflict between clause 4 and clause 16 (a) is doubtless because we have not made it sufficiently clear in the wording of this specification. In clause 16 (a) we have endeavored to make it compulsory that the manufacturer shall put all the product, each and every piece thereof, through a perfectly routine jigging test, which is supposed to eliminate permanent set in the washers to any degree which would materially affect their reaction.

Under clause 4 we subject each test specimen ten successive times to the preliminary loads in order to absolutely insure that the specimens which we have under test are free from any set. This might or might not have been successfully accomplished by the routine manufacturing operation, and if not, it will show up right away in the difference in the height of the washer.

First, it shows whether or not the other requirement of specifications has been met, and, second, it absolutely insures the relative integrity of the test itself, which is necessary as we measure the acceptance or rejection of washers by a definite amount of height which must be measured to hundredths of an inch, and preferably to thousandths of an inch, since the washers are calibrated for maximum thickness to thousandths.

Again, the number of preliminary loads has a relation to the criticism, which is perfectly true, that the maximum calipered thickness of a spring washer is usually at the end where it is increased on account of shear. To the best of my observation in testing washers, the preliminary loads which are stipulated in this specification invariably flatten, during the course of the loading high spots down to approximately the same thickness, even to the matter of thousandths, as the body of the washer. That also applies to fins and accidental overfills and things of that nature. In other words, the preliminary loads are a part of the test service to check whether or not the set has been taken out; second, they serve to make uniform the diameter, which is preliminary to the micrometering of the thickness for the purpose of measuring the distance between the platens of the machine, which must be more than .02 of an inch in excess of the maximum micrometered thickness. I do not know whether this explanation will entirely cover the situation, but I am certain that was the purpose and intent of the Committee in adopting it.

Again, the requirement under low spring pressure, that the preliminary loads should be loads down to solid, was undertaken because in the case of the low tension spring washer, which is a simple helical coil, I think we all recognize that it owes its entire reaction or its entire spring pressure to the cross-section of the material and to the size of the hole in the middle. Coming down to solid for a preliminary load simply means flattening it under the testing machine, not necessarily to precisely its thickness, but bringing it down until it is flat, and in the stipulation of loads we might have put there a preliminary load of 1500 pounds for the 750-pound test load, and for the 850-pound test load twice that, and all the way down. I think the Committee would have no objection to substituting such figures, but in each and every case "down to solid" seemed to meet the situation for the low pressure washer.

On the low pressure washer, we used the same reserve factor over the maximum micrometered height for determining whether or not it has met the requirements of the specification.

I might say for the Committee in regard to the requirement in clause 6 of a reaction requirement for the elliptical spring, and the absence under helical springs of a requirement of reaction, the Committee very strenuously sought a reaction requirement for the high pressure helical spring washers which could be commercially met by the manufacturers. As a matter of fact, if I may speak for a moment personally in this matter and not for the manufacturers of any particular type of washer, I believe that the helical spring washer is different in principle of application from the elliptical spring washer. One meets a certain set of conditions and the other meets another set of conditions. There admittedly is not as much reaction with spring pressure in the high pressure helical washer as there is in the lower pressure elliptical washer. The situation is that to sustain pressures up as high as 40,000, 50,000 and 60,000 pounds (the idea is that pressures of that amount are obtained) the surfaces will be held in such close and intimate contact that but little abrasion will follow between the respective surfaces and, consequently, the need for considerable take-up is not so great, while in the lower tension washer in which the surfaces are not held so rigidly in contact, more wear will proceed and necessarily, therefore, a greater take-up is necessary.

I think that is about all I can say in that connection.

Mr. R. B. Jones:—I do not know that my memory retains all of your remarks, but in connection with the last statement that the high pressures of these high pressure helical spring washers in themselves will keep the joint tight and minimize wear by keeping it tight, I submit that it is perfectly obvious that the only static tension you can have in a track bolt is the tension which you develop in it by the action of the wrench.

My angle to the spring washer question is briefly this: If you give a man a joint to assemble, and give him a low pressure helical spring washer today, he will assemble the joint, put the washer on and wrench up his bolts just exactly as he has always done. The individual has some method of judging the necessary weight on the wrench. We can instruct them as we like, but the man with the wrench will tighten up the joint until he thinks it is right. He does not care what the name of the washer is. Similarly if you give him a high pressure washer tomorrow he will tighten it up to the same extent as he did the low pressure washer. That is exactly my point in connection with the reaction of spring washers.

You talk of a washer here, a high pressure helical spring washer. The maximum size has a high spring pressure preliminary load of 45,000 pounds specified. I do not believe anyone in this room thinks for a moment that you can ever put 45,000 pounds tension in a track bolt by wrenching up the nut. We are not interested in it. It may be something the washer can do, but it is not necessary to the service. I submit the correct method of testing any washer is for the Committee to say, indicating a range if they care to, what the normal pressure is that a washer may be expected to start working from in the track, specifying a reaction in distance from that pressure and specifying a load, the reactive pressure, which the device will develop on that reaction. My chief quarrel with this specification is that the helical high spring pressure washer indicated need not necessarily act as a spring at all. It is quite easy to conceive of a washer being so formed that no load will compress it to within .02 of an inch of its maximum micrometer thickness.

Chairman Campbell:—Is there any further discussion? The motion is on the adoption of the revised specifications for spring washers for inclusion in the Manual. If there is no further discussion, all in favor of the motion will say "aye"; contrary "no." The motion is carried unanimously.

Mr. G. L. Moore:—The report to do with mill practice and rail failures will be presented by Mr. Emerson.

Mr. J. B. Emerson:—It does not appear to me necessary to discuss the usual routine rail failures to any length except to call attention to the fact that the curve of failures per hundred track miles for the five-year observation period is continuing on its downward course which it has reassumed since the rollings of 1917.

We went up from seventy-four failures per hundred track miles for the five-year period in the rolling of 1914 to eighty-two in 1915; 105 in 1916, 137 in 1917 and 125 in 1918. In 1919 it dropped down to 115. It looks very much as if next year it will be down to 100 and perhaps the dream curve, so ably prophesied by Mr. Wickhorst, is again going to be approximated within the next two or three years in the actual statistical records.

The only remarks I have to make on mill practice are in connection with the subject which Mr. Ray has already discussed, and that is the use of rail in the higher manganese range from 1.25 per cent to 1.50 per cent. Though still in the experimental stage, as a metallurgist, I know that rail made from that particular analysis in furnaces to which close attention is paid, produces better-looking ingots and, in my judgment, a harder rail which should give longer wear. Tests show it has somewhat greater toughness for the same hardness than any other commercial rail steel that I have encountered.

Mr. L. J. F. Hughes (Rock Island Lines):—The full benefit of general statistics on rail failures is only realized when such statistics have been carefully studied and compared with similar statistics for the individual roads. To this end I have gone through the rail failure reports made to the A.R.E.A. by the Rock Island Lines and have compared results for our road with the average conditions of railroads throughout the country, as reflected in the report of this Committee.

In the right-hand column of Table 1, on page 484, there is given the total rail failures per 100 miles of track after 5 years' service, for rail rolled each year from 1908 to 1919. Omitting the decimals, I shall briefly give the failures per 100 miles, after 5 years' service, first for the Rock Island and then for all roads as taken from the Committee report. The figures are as follows:

Year	*Failures per 100 miles Rock Island*	*Failures per 100 miles all railroads*
1908	170	398
1909	161	279
1910	47	198
1911	92	176
1912	54	107
1913	30	92
1914	43	74
1915	31	82
1916	30	105
1917	96	137
1918	52	125
1919	37	116
1920	57	...

At first glance it would seem that our road is obtaining a very high quality of rail, for in every case the failures have been from one-half to one-third as great as the average for all roads in the country. But such is not the case. These rail failure statistics, as compiled by this Committee, do not take into consideration the amount of traffic to which the rails have been subjected, and until some scheme has been devised which will properly reflect the influence of traffic on rail failures, little benefit can be obtained by comparing performance on individual roads with the average for the entire country.

Some interesting facts showing the influence of weight of rail on failures are brought out from a study of the failures for the Rock Island, which I have just given. For rail rolled in 1909, after five years' service we had 161 failures per 100 miles; for rail rolled in 1910 we had only 47 failures per 100 miles, a reduction of over 70 per cent. But in 1910 we began renewing 85-lb. rail under our heaviest traffic with 100-lb. rail, and the increase in section largely accounts for the marked decrease of 70 per cent from failures in 1909 rollings. For 1911 rail the failures per 100 miles jumped back to 92, practically a 100 per cent increase, whereas for all roads there was a decrease of 11 per cent. But during 1911 we laid only 85-lb. rail. There was no 100-lb. rail purchased that year. For 1912 there was a marked decrease, the failures dropping to 54 per 100 miles. From 1912 to date 100-lb. and 90-lb. rail only has been laid, and from 1912 on our failures follow the general curve.

The effect of traffic on rail failures can be illustrated from the record of two equal lots of rail laid on our road in 1913. In that year we laid approximately 90 miles of 100-lb. rail and 90 miles of 90-lb. rail. At the end of five years the 100-lb. rail had 53 failures per 100 miles and the 90-lb. rail had only 7 failures per 100 miles. The first inference would be that the 90-lb. rail was far superior in quality to the 100-lb., but as a matter of fact, both lots of rail were rolled at the same mill, during the same month and under the same specification. At the end of 1925, after 12 years' service, the 100-lb. rail shows 268 failures per 100 miles, and the 90-lb. rail 90 failures per 100 miles. The answer to the big difference in the number of failures is that the 100-lb. rail has carried 110,220,000 gross tons traffic and the 90-lb. rail only 56,970,000 gross tons.

It is true that the Committee has made an attempt to take traffic into consideration as shown in Fig. 4, page 489, of the Bulletin. It is stated that the number of failures per 100 miles per year for the various mills is divided by a traffic density factor, "based on the average ton miles of revenue freight per mile of track of the various railways into whose tracks the output of the mill was placed." But it is not shown just how this factor was determined. In order to secure some idea regarding this traffic density factor I have divided the failures per 100 track miles in column 2 of Fig. 3 by the corresponding quantities in Fig. 4 and the resulting factors for the various mills are as follows:

Algoma	1.18
Bethlehem	2.10
Cambria	4.80
Carnegie	3.21
Colorado	1.02
Dominion	1.11
Illinois	1.20
Inland	0.26
Lackawanna	1.03
Maryland	1.70
Pennsylvania	2.35
Tennessee	1.50

In other words, the rail from the Inland Mill was subjected to the lightest traffic of all the mills, the factor being less than unity, and the rail from the Cambria mill was subjected to the heaviest traffic, having a factor of 4.8. That is, Cambria rail carried 18 times the traffic of Inland rail. But these figures do not give a very concrete idea of the traffic conditions. As an alternative, I would suggest grouping all the railroads reporting, in traffic groups. Tentatively, I would suggest four, viz.: Eastern lines, heavy traffic; Eastern lines, light traffic; Western lines, heavy traffic, and Western lines, light traffic. Rail failures could then be shown as in Fig. 3 for each of the four groups. This scheme would have the advantage of giving at least some idea of the relative traffic conditions of the various groups, and in addition, it is possible that certain mills might have rail in all groups, and a comparison of mill output under varying traffic and geographical conditions would be of great value. But even this method is a makeshift and until we can have rail failures per million gross tons of traffic reported by the various roads, the collection of rail failure statistics will not be of great value.

In conclusion, I wish to call the Committee's attention to what in my opinion is an unfair representation. I refer to the grouping of failures by mills in Fig. 3 and 4, pages 488 and 489.

In Fig. 3 the output of the Dominion mill is shown to be the poorest of the lot, by the long black line across the page, and 79 failures per 100 miles of track per year. Directly below it the Illinois mill makes a very good showing with a comparatively short black line, and 11 failures per 100 miles. By referring to Table 4 on page 491, I find that the good showing of the Illinois mill comes from the record of 11,219 miles of track with a total of 4,530 rail failures, while Dominion gets a black eye because of 1.27 miles of rail with but 4 failures. It is obviously unfair to compare so small an output as 1¼ miles with 11,000 miles. It is possible that the mile and a quarter of Dominion rail was laid under traffic or other conditions conducive to rail failures. There is also built up for this mill the astounding total of 396 failures per 100 miles, and all from 4 actual failures in a mile and a quarter of track. This result shows the absurdity of including so small an output where other mills have thousands of track miles in service. I think this particular lot of steel should be eliminated from further studies of rail failure statistics.

Mr. John B. Emerson:—I would like to comment on the last part of your statement first. Rating a mill on such a small mileage is a rather ridiculous thing on its face. The situation is that any mill as a rule is covered by reports for several rollings. One must realize first that this is a report of one year's rolling only, whose conduct is observed over a period of five years. They are not averages of five years, it is the one year's rolling over a period of five years and I did not realize that the quantity was so small. There is a chance from year to year that the quantity of rail from any given mill reported by reporting railways will be in any individual year a small fraction of that reported the year before or the year after.

It may be that the reason is that that particular year they purchased very little rail; it may be, as again I am quite certain it is in this case, that in this particular year the largest purchaser of Dominion rail made no report to the Engineer of Tests, so the bulk of the tonnage is left out.

Those fluctuations exist in every year's rolling, from every railroad, from every mill, and it is only as mass statistics which are to be taken as index figures that these statistics in my judgment are worth anything whatever to the Association.

Again in the relation between the traffic density factor rating of mills and the rating by the older method that gave no consideration at all to traffic, I am in one hundred per cent agreement that our statistics would be worth a great deal more if we had an index of the traffic which had passed over the failed rail and if any member of this Association can furnish in connection with their rail failures an estimate of the traffic which has passed over the failed rail, then we will hit the ball a hundred per cent. But in the absence of that, we have taken for the five-year period over which this rail remained in track, an average of the five-year reports of the Bureau of Railway Economics, which lists at the end of each year for each railroad the average traffic density as computed in ton miles per mile of track per year. For instance, that will list the Rock Island Lines, let us say, as about three million, and it will list the Pennsylvania Railroad as about thirty million, and it will list Pittsburgh & Lake Erie as a carrier up around forty million. Those figures, eliminating everything but the digits of the millions, will make the ratios range from one to forty.

Then, if an individual mill has sent ten per cent of its output that year onto a road whose index figure is forty, we divide the failure rate of that road by forty. Another percentage goes to a road whose index is 10, and we divide its failure rate by ten, etc. Then we add these rates up and divide by 100 for the average. The mill rating is then weighted by about the average traffic density of all the roads into whose track the entire year's output of that mill was sent. It is the only way that we know to do now unless we can get the traffic over each failed rail; that seems to be impossible for the reporting lines to furnish.

Mr. A. L. Davis (Illinois Central) :—May I ask if the Committee has made an effort to ascertain whether any of the railroads can furnish the Committee with information it needs? I agree with Mr. Hughes of the Rock Island that you can not get any fair comparison unless you get this data. I am satisfied there are a number of railroads, members of the Association, that stand ready to furnish this.

Mr. J. B. Emerson :—In answer to that, we sent out a general questionnaire on this particular subject to every reporting railroad in the United States. Most of the single track railroads said, "We can furnish you approximations, but we do not like to do it, because it is guess-work. We do not know from our records on any particular rail how much has been fed in from one branch, going along the main line and then carried off on another branch." On the four-track railroads or the double-track railroads, in which it is sometimes carried on one or the other, they all reported it was absolutely impossible for them to do so.

Again, for nearly five years we have carried on our form for statistics on transverse fissure rails, a request that the amount of traffic passing over the failed rail be furnished. I am quite safe in saying that on less than one-half of one per cent of the rail reported to us have we ever received a statement of how many pounds passed over that rail. I think if I said one-hundredth of one per cent it would be equally correct.

Mr. A. L. Davis:—It is a little difficult for me to believe the Illinois Central is the only road that is prepared to furnish tonnage statistics.

Mr. L. J. F. Hughes:—I might say for the Rock Island Lines that we report the number of tons passing over every rail that we have reported to the Committee as failing through a transverse fissure. I think the subject is one that it might be well for the Committee to go into further. I believe if the Committee would devise some way in which they would like to have this matter reported, the railroads would be able to furnish the information. The biggest difficulty is this: We can give the tonnage on any part of our line for any length of time. There is no difficulty in that, but, say we get 100 miles of rail, one mill's rolling, we may send that to eight or nine different places, and each place will have different tonnage passing over it in that time.

Now, then, it seems to me if some way can be devised to secure the weighted average tonnage in cases like that, and a uniform method of reporting decided on, then it can be figured and reported just as we now do for transverse fissure failures.

Mr. C. R. Harding (Southern Pacific):—The Southern Pacific has made an elaborate effort to do something along the lines that have been discussed. We went to considerable pains to determine the tonnage of traffic passing over failed rails. The results were disappointing, because it could be seen on the face of it that they were not true. We go to an elaborate amount of work on many statistical studies and the results do not mean anything when we get them. In the matter of failed rails there are other factors like, for example, the curvature. If the Southern Pacific eliminated all of the failures occurring on curves, the rail failure rate would be tremendously lower than with curves and tangents both included. Whenever we have looked into the problem from the viewpoint of curves versus tangents, we have found that curvature had a great deal more to do with the failure than the tonnage which had passed over the rail. Furthermore, the type of power used on a district has a great deal to do with its rail failure rate. We have rail in the track after thirty years' service, the accumulated tonnage carried being very great but the failure rate is much smaller than for other rail which has been in service a short time under heavy power and carried less total traffic.

The question is involved and might as well be considered on a simple basis for comparative purposes.

Chairman Campbell:—This is a very interesting discussion, but time will compel us to proceed.

Mr. G. L. Moore:—The next subject is Transverse Fissures.

The Rail Committee felt it was required to issue Rail Report No. 92 in order to give the railroads the benefit of the data and information with reference to transverse fissures, which was in the possession of the Rail Committee.

I just want to call attention to one or two things in this report.

"The Rail Committee has reason to believe that the shattering crack is the nucleus of the transverse fissure, and that without its pre-existence no detail transverse fatigue failure has ever been developed from the interior zone in the rail head admittedly stressed by service conditions. It is recognized that the growth or development of a transverse fissure from a shattering crack or nucleus must await the impingement of the rolling load, and that the less the area of contact, the heavier the load, and the greater the number of repetitions, the more rapidly the fissure will grow.

"The Rail Committee has reason to believe that the real crux of this problem lies in determining the cause of the shattering crack at the steel mill. When the cause is determined, its elimination may be reasonably expected.

"In 1923 the Rail Committee, also representing the Engineering Division of the American Railway Association, entered into a joint study of transverse fissures sponsored by the Department of Commerce of the United States Government, under the general direction of the Bureau of Standards. Other members of this conference comprise the American Society of Civil Engineers, through their joint sponsorship of the Committee on Stresses in Track, and the Rail Manufacturers."

The Rail Committee has compiled the data and information which it promised to furnish this joint conference. This information has just been compiled and is now being forwarded to the Bureau of Standards.

Chairman Campbell:—Is there any discussion on this important subject of transverse fissures? If not, the Chairman will proceed.

Mr. G. L. Moore:—Relation of bolt tension to mechanical strength of the joint and rail battering will be presented by Mr. McDonald.

Mr. Hunter McDonald (Nashville, Chattanooga & St. Louis):—The investigations which I have carried on have been set forth in the report and it is hardly worth while for me to do more than undertake to direct attention to a few of the high spots in that report.

This report is merely one of progress. Such conclusions as are announced are my own and have not been passed upon by the Committee. The report will serve to direct attention to some lines of investigation which can be followed up with profit by other investigators who are better equipped for research. The proper tension of bolts to develop the full strength of the joint must be determined before further progress can be made in the study of the movement of rails through joints and the maintenance of proper bolt tension. This investigation is being made by the Committee on Stresses in Track.

My measurements of rail batter were made at a point one-half inch from the end of the rail. The exact point at which such measurements should be taken should be defined, since results will vary greatly as the point of measurement is shifted in either direction. Rail battering cannot be prevented, but it can be decreased by improvement in the quality of the rail.

There are some other points, but I feel that any one who will take the time to read what has been written here will readily appreciate them.

Chairman Campbell:—I wish to take this opportunity of conveying to Mr. McDonald the very great appreciation of the Association for the very splendid piece of work he has done. This is a matter you will want to take and look over and study. It is this kind of work that makes the work of this Association very valuable.

Mr. G. L. Moore:—The subject of welding of traction and signal bonds will be presented by Mr. Adams.

Mr. Lem Adams:—The Committee reports progress on this subject and presents as Appendix D on page 557, metallurgical report on the effect of welding in changing the structure of rail. While the studies so far made are indeed very interesting, the Committee is not ready to make recommendations concerning the relation of the stresses in track to the change in rail structure, but presents Appendix D as information only.

Mr. G. L. Moore:—Specifications for girder rails will be presented by Mr. Emerson.

Mr. Emerson:—The use of girder rails is becoming rather more prevalent in city streets under steam railroad equipment than before. The Committee on Track undertook the preparation of designs for the special track work of girder rail and were assigned jointly with the Committee on Rail the preparation of standard specifications for girder rail. There appeared to be no particular reason why, if the standard specification for girder rail of the American Electric Railway Association was to be revised, we both should not go at it together, because their specification for girder rail in existence last year was apparently largely based on the A.R.E.A. specifications for standard T section steam railroad rail of about twelve years before. The only thing necessary for our purpose was to get together and bring it up to date.

That was done in a joint conference between the Committee on Track, the Committee on Rail, and two other committees, the American Engineering Standards Committee and the manufacturers of girder rail. We ironed out the specifications as here presented, having been at the same time adopted as the standard specifications for girder rail of the American Electric Railway Association and the American Engineering Standards Committee. It is submitted for your ratification.

Chairman Campbell:—Is there anything to be said on this?

Mr. G. L. Moore:—I move that the specifications for girder rails as shown in Appendix E be adopted and printed in the Manual.

(The motion was carried.)

Mr. G. L. Moore:—Rail canting will be presented by Mr. Harding.

Mr. C. R. Harding:—The subject of rail canting will come up under the next Committee. Mr. Clark is the Chairman of the Sub-Committee.

Chairman Campbell:—The Chairman of the Committee informs me this Committee is quite willing to pass this subject over and let it be handled by the Track Committee.

Mr. G. L. Moore:—That concludes the report of the Rail Committee, Mr. President.

Chairman Campbell:—If there is nothing further, I take great pleasure in dismissing the Rail Committee for the present, with the thanks of the Association for the excellent work it has done. (Applause.)

Mr. L. J. F. Hughes:—Mr. Chairman, I did not hear anything said about Appendix F, the study by the Reading Company on "Structure of Typical 100 and 130-pound Rails."

I have studied this report and have prepared a discussion on it. However, I do not wish to take up the time of the Committee, and if it is not going to be reported on this year, I can submit my discussion to the Committee, just as the Committee sees fit.

Mr. G. L. Moore:—It is not going to be reported on this year, and the Committee did not intend to call particular attention to that subject at this meeting.

Chairman Campbell:—We will be very glad, Mr. Hughes, to have you submit that for the consideration of the Committee.

Mr. L. J. F. Hughes—(by letter):—A study of the matter contained in Appendix F brings to mind several important questions which I hope will be of interest to the Committee.

This report is the result of an examination of 9 rails of varying degrees of hardness. The hardest rail of the lot was rail A, a 130-lb. rail, which gave the highest Brinell readings in every position. In discussing the peculiarities of rail A, there follows the statement: "The extraordinary hardness is due to a comparatively rapid cooling, evidently caused by an accidental event after its finishing and during the final cooling." The point I wish to raise is: Is it an established fact that this particular rail was subjected to rapid cooling during its process of manufacture? Did the investigator know the conditions of the finishing of this particular rail, or is it just a surmise that rapid cooling was the cause of the fine grain structure and attendant hardness? All through the report we find the statement that rapid cooling will produce close packing of the lamellæ in the pearlite, but there is no proof or substantiation given of this important phenomena.

Again in the discussion under part III of grain size, pages 588 to 595. This is an interesting and clever method of explaining the variation in grain size as found under the microscope. In reality, what is done is to find the ratio of the spacing of the lamellæ of varying degrees of coarseness to the spacing of the lamellæ most closely packed. The question arises, how does the investigator know that he has found a normal section, one in which the angle (ϕ) is zero? In Figure 2, page 594, there is shown a micrograph of rail 1. The upper grain is supposedly a normal section. The ratio of the spacing of the lamellæ in the lower grain to the spacing in the upper grain is the same as the cosine of 24 degrees; therefore, it is claimed that the section cutting the lamellæ of the lower grain is at an angle of 24 degrees to the plane of the lamellæ. But the question still rises, how is a normal section known? If the section showing the closest packing is considered the normal section, how sure is the investigator that some still closer packed section may not be found after a closer search? Later on the spacing of the lamellæ in the normal section known as (μ) is considered for each rail, and it is demonstrated that this factor varies directly as the hardness of the rails. This being so, it would seem that a micrograph of each rail showing the normal section would permit of a graphic comparison of the values (μ) and be of more benefit to the average reader than the series of micrographs which are given.

In section (VI), page 617, the 9 rails are listed according to the values of (μ) or distance between the lamellæ, the chemical content, and the average Brinell is also tabulated. The author then attempts to show that there is no relation between the carbon content and the hardness of the various rails. It is quite true that in a number of cases the carbon content does not vary consistently with the hardness, but it is also a fact that the hardest rail, rail A, has a high carbon content of .81, while the softest rail, rail 2, has the lowest carbon content of all, namely, .69. It would, therefore, seem that there is nothing definite established as to the relation between carbon content and hardness for these 9 particular rails. The question also arises, are the three items, Brinell, distance between lamellæ, and carbon content, strictly comparable? The Brinell readings we know are the average of Brinells taken at 9 different locations in the head of each rail. Has the same method been adopted in securing the value (μ)? This minute quantity measured in ten-thousandths of a millimeter, how many times has it been measured for each rail? Surely it should be determined from the same location and for the same number of times as the Brinell readings. And lastly, has the carbon content been obtained from analysis of drillings taken from 9 different locations the same as the Brinells? We are all familiar with the variations between mill and check analysis. Here is attempted a demonstration that the timehonored theory of hardness increasing with carbon content is all wrong, but it is not shown how accurately the carbon content has been determined, or from what position the analysis was made. At the close of section (VI) there follows this statement, "From this it is evident that the coarseness of the pearlite with its attending softness, is dependent not on the carbon content but on the velocity of the cooling the transformation range "(Ari)." It has not been proven entirely that softness does not vary with the carbon content, although some evidence therein has been furnished. But there has not been a thing introduced to back up the final clause of this statement, regarding the influence of velocity of cooling. Similarly, I hardly believe that statement 4 under recapitulation has been definitely proven.

Doubtless the conclusions reached by the author are entirely correct, but before accepting them, I think the subject is worthy of further study.

Of the 9 rails reported on, all but 4 were higher in carbon content than the maximum allowed in the specifications of this Association. The rails examined were all approaching the eutectoid structure. It would be interesting to know if the same relation between spacing lamallæ and hardness would obtain for rails in the lower carbon range, say, from .62 to .69 carbon, or rails in the hypo-eutectoid range. Also, it would be of great interest to know if accelerated cooling, such as wider spacing in the hot beds, would actually produce a harder steel. This properly should be determined by examination of rails, which had been followed through the mills, and the hot bed spacing and rate of cooling accurately determined. If it is found that we can obtain a hard rail, without an abnormally high carbon content, by attention to such details as hot bed spacing and finishing temperatures, the cost of such an investigation will have been well worth while.

DISCUSSION ON TRACK

(For Report, see pp. 631-686.)

(Past-President J. L. Campbell in the Chair.)

Mr. J. V. Neubert (New York Central—Chairman):—I wish to refer you to page 631, under "Action Recommended," especially under the second paragraph, which should read as follows: "That the conclusions in Appendices B, C, E, G and I be adopted as recommended practice and published in the Manual as outlined in these reports." E was omitted.

In Appendix A, Revision of the Manual, on page 633, the Committee recommends the following changes in the Manual and to adopted plans:

Revise specifications for Switches, Frogs, Crossings and Guard Rails, adopted March, 1921, printed on pages 214-220, 1921 Manual, as follows: Add to Section 14 (Bolts) the following paragraph:

"Bolts with countersunk heads, button heads or cone heads shall be provided with locking necks or other effective locking means to keep bolts from turning."

I so move.

Chairman Campbell:—It is moved and seconded that the changes specified be adopted for inclusion in the Manual.

(The motion was carried.)

Mr. J. V. Neubert:—Change Section 24, reading "Nut Locks. Nut Locks shall be of good strong spring steel," to read:

"24. Spring Washers. For heat treated or high tensile bolts, spring washers shown on trackwork plans shall conform to specifications of the American Railway Engineering Association for high spring pressure and where nutlocks (N.L.) are specified on present trackwork plans the term 'spring washers' shall be understood."

I so move.

(The motion was carried.)

Mr. J. V. Neubert:—Revise Plan No. 773, adopted March, 1925, Solid Manganese Steel Crossings, Angles below 40 deg. to 30 deg. inclusive. An investigation developed that we could include within this down to angles of 25 degrees, and we so recommended that this change be included from 40 to 25 deg. inclusive.

I so move.

(The motion was carried.)

Mr. J. V. Neubert:—We have for adoption to be printed in the Manual, proposed revised Specifications for Steel Tie Plates. These revised specifications in brief are as follows:

(a) Unified specifications of the A.R.E.A. and A.S.T.M. (the A.S.T.M. really has been ready to adopt this, and if it is adopted here, they will also adopt it.) The usual advantages accruing through standardization of quantity production.

(b) Elimination of determinations for manganese and sulphur in chemical tests. Cheapening the process of production without injury to the product. It is believed that these elements have no important influence in steel suitable for tie plates.

(c) Elimination of tensile tests. Cheapening the process of production by the elimination of a non-essential requirement. It is believed that the bend test specified provides adequate means for determining acceptable physical properties in steel for tie plate purposes.

(d) Decrease in some of the permissible variations from specified dimensions. A more uniform product. To the extent that changes have been made it is believed that they are within good mill practice.

(e) Clause covering permissible variation in size and location of spike holes. It appears to be the experience that the effectiveness of spikes is increased as they more nearly fill the holes in the plates.

(f) Shipment clause eliminated, as we do not feel that it belongs in the specifications.

On page 636 we have a reference which should not have been printed. That was for the benefit of the Sub-Committee and the Committee.

I so move you that these specifications be adopted and printed in the Manual.

Mr. C. W. Baldridge (Atchison, Topeka & Santa Fe):—I would like to ask the Committee a question with reference to Section 8, which now reads, "Test specimens shall have two parallel faces as rolled." In the case of a good many types of tie-plates now manufactured the faces as rolled are not parallel. Would it not be preferable to strike out the word "parallel" and say "Have two faces as rolled?"

Mr. J. V. Neubert:—I do not see any objection to the change at all.

Chairman Campbell:—The Committee accepting the change, it will be included.

If there is no further discussion, all in favor of accepting these revised specifications will say "aye"; contrary "no." They are adopted.

Mr. J. V. Neubert:—The proposed specifications for soft steel cut track spikes are offered for adoption to be printed in the Manual. Unified specifications of the A.R.E.A. and A.S.T.M., which, if they are adopted by this Association will be adopted by the latter society, have the usual advantages accruing through standardization of quantity production. Elimination of chemical tests; cheapening the processes of production without injury to the product by the elimination of a non-essential requirement. It is believed that the bend test will insure the use of proper materials.

Elimination of tensile tests; the same as referred to above. Increase of 100 per cent in bend tests; one test per five tons in place of one test in ten tons. It is believed that this is the best and most practical test for determining the fitness of materials for the purpose—hence the increase.

Increase in permissible variation over specified dimensions and decrease in permissible variation under specified dimensions for body of spike. It is believed that the tendency of spikes to throat-cut in service warrants placing the greater part of total allowable tolerance in the range above the specified dimensions.

On page 639 where it reads, "Refer to changes," etc., that should be eliminated from the report, the same as referred to in regard to tie plates. I move that these be adopted and printed in the Manual.

Chairman Campbell:—Is there any discussion? If not, all in favor of the motion will say "aye"; contrary "no." The motion is adopted.

Mr. J. V. Neubert:—Appendix B will be handled by Mr. C. R. Harding, the Chairman of the Sub-Committee.

Mr. C. R. Harding (Southern Pacific):—The report of Sub-Committee No. 2 appears on page 639. Plan No. 778 is plan of manganese steel insert crossings, steam railroad over electric railway, angles below forty-five degrees to thirty degrees, inclusive. Mr. Chairman, I recommend that plan No. 778 be adopted as recommended practice.

Chairman Campbell:—It is moved and seconded that this plan be adopted as recommended practice. Is there any discussion on it? If not, all in favor of the motion will say "aye"; contrary "no." It is adopted.

Mr. C. R. Harding:—Plan No. 774 shows a solid manganese crossing, steam railroad over steam, small angles, twenty-five degrees down to fourteen degrees in fifteen minutes, double rail construction. It is to be noted that two alternate designs are shown. This plan is offered as information only to invite criticism. Mr. Chairman, I move its acceptance as information.

Chairman Campbell:—If there is no objection, it will be so received.

Mr. C. R. Harding:—Plan No. 775 shows solid manganese crossing, single rail construction, steam railroad over steam, angles fourteen degrees in fifteen minutes down to eight degrees in ten minutes. This plan is also offered as information to invite criticism, and I move its acceptance for that purpose.

Chairman Campbell:—If there is no objection, it will be so received.

Mr. C. R. Harding:—The next subject, "Tie Spacing and/or Timbering Under Crossings," plan No. 720, is offered as information to invite criticism. It is recommended that the subject be carried over for future work, and I so move, Mr. Chairman.

Chairman Campbell:—There being no objection, it is so received.

Mr. C. R. Harding:—Plan No. 321 shows tie spacing under frogs of standard numbers. With the advent of the one-piece guard rail it seemed desirable to have the same tie spacing under all frogs of standard numbers.

Plan No. 321 is offered as information, showing one way in which this can be accomplished. I recommend its acceptance for information.

Chairman Campbell:—If there is no objection, it is so received.

Mr. C. R. Harding:—Plan No. 325 shows a standard frog filler. This plan is offered as information. It is hoped that by the adoption of some such plan the number of rolls held in stock by the manufacturers can be reduced and that the tolerances and dimensions can be fixed. This plan is merely offered for information at this time. Criticisms in writing will be welcome.

Chairman Campbell:—The plan is so received.

Mr. C. R. Harding:—Plan No. 213, details for split switch point derail, was offered last year as information to invite criticism; it has been revised during the year and is now presented for adoption as recommended practice. I recommend its adoption, Mr. Chairman.

Chairman Campbell:—It is moved and seconded that Plan No. 213 be accepted for publication in the Manual. Is there any discussion? If not, all in favor of the motion will say "aye"; contrary "no." It is adopted.

Mr. C. R. Harding:—Index sheets, pages Roman numerals I and II, list all of the latest plans and specifications offered by the Track Committee and adopted or received as information in the past. Page Roman number III shows a list of revisions, not appearing in the plans and specifications on date of last printing. These will be found useful as references.

I move their acceptance as information, Mr. Chairman.

Chairman Campbell:—If there is no objection, they will be received as information.

Mr. C. R. Harding:—Plan No. 643 shows self-guarded frog. This plan is offered to invite criticism and comment. It is the plan of this Committee to issue standard drawings of self-guarded frogs of other numbers. It is very desirable to have criticism of this, the first plan, during the coming year. It is offered as information, Mr. Chairman.

Chairman Campbell:—This will be received as information.

Mr. C. R. Harding:—That is all I have, Mr. Chairman.

Mr. J. V. Neubert:—During the year we have had some inquiries in regard to plans we should make for the length switch for using the thirty-nine-foot rail. It is the intent as soon as the Track Committee can get at it to make a switch nineteen feet and six inches long, which will possibly be a substitute for the present twenty-foot. Nineteen feet and six inches is just one-half of the thirty-nine foot rail.

Mr. Harding has just referred to the subject of tie spacing, etc., under frogs and crossings, etc. We would be glad if railroads would give us good information on it, because it is data needed to support the crossing. We worked hard this year and we have had three or four hard battles in discussing it. It came to the point that a number of the members did not want to take up this subject. Next year we are going to make it a special subject for this Committee and we want your help.

The next is Appendix C. In the absence of the Chairman, Mr. S. B. McConnell will handle this subject.

Mr. S. B. McConnell (Canadian Pacific):—Specifications for Hickory Handles for Track Tools, printed on page 644. In its preparation we have consulted with eight or ten of the larger manufacturers of track tools, the forestry engineers of several of the railways, and we have consulted with the United States Forest Products Laboratory at Madison. We have had help from them all. The Forest Products Laboratory preach conservation of material. Some of the manufacturers take just the opposite view, discarding anything that is not pure white hickory.

We think we have adopted a sane specification and recommend it to the Association for adoption and to be printed in the Manual.

In connection with the plans, they vary very slightly, if any, from those in present-day use, so that it is no innovation.

I would move that the report be adopted.

Chairman Campbell:—It is moved and seconded that these specifications for hickory handles for track tools be adopted for inclusion in the Manual. Is there any discussion? If not, all in favor of the motion will say "aye"; contrary "no." The motion is carried.

Mr. J. V. Neubert:—Appendix D will be handled by the Chairman, Mr. E. D. Swift.

Mr. E. D. Swift (Chicago & Western Indiana):—"Effect of Brine Drippings on Track Appliances and Tests of Tie Plates Subject to Brine Drippings." The title is a little more comprehensive than the work the Sub-Committee has covered. This report appears on page 647-654 inclusive as Appendix D. The text of the report is brief. Probably the most interesting part of the report is Exhibit A on page 648, this being a graph showing the depreciation in weight of the plates that were used in this test.

On pages 649 to 654 there are photographic reproductions of specimen plates taken from the test. These pictures, shown as they are in pairs, contain a top view and a bottom view from different plates of the same group. The numbers appearing on these photographic views refer to the indexed numbers in the graph.

We wish to make a couple of suggestions for correction. In Appendix D, paragraph marked Exhibit A, change to read, "Exhibit A shows graphically the loss of weight in ounces per inch of area," cutting out the words "percentages" and "in" in the first line and substituting the word "of." It then reads, "Exhibit A shows graphically the loss of weight in ounces per inch of area."

Make a corresponding correction in the graph, cutting out "per cent" in the top of the figure, and revising the wording over the figure to read, "Loss of weight in ounces per square inch of area of plate."

This report is offered as information.

Chairman Campbell:—If there is no objection, Appendix D, with the changes specified, is accepted.

Mr. Hunter McDonald (Nashville, Chattanooga & St. Louis):—I would like to inquire of the Committee whether they have any opinion to express as to how far persons in the selection of tie plates should be guided by the results shown in these diagrams.

Mr. E. D. Swift:—Personally I have no opinion to offer in that regard, Mr. McDonald. This report is intended to cover merely the actual experience, the actual results derived from the conduct of this test.

I believe it was the intention when the test was instituted or that it was the thought at that time that a more comprehensive report probably could be made.

The plates, as is stated in the report, were taken out of the track before the logical conclusion of the test. The reason for that, as is also stated, was the need for renewing the rail. The plates were in the tracks of the Chicago Junction Railway at the Union Stock Yards, Chicago. That company decided to renew the rail last year and of necessity the plates had to be taken out.

During the progress of this test, the Sub-Committee, several periods each year, took out a few plates of each group, cleaned and weighed them, in order to determine the amount of loss. There were some unbalanced results. The curves plotted from the information thus derived were not very regular.

I believe (it is my personal view) that a test of this kind, in order to be really comprehensive, should be made with plates of one size. The plates in this test were furnished by various manufacturers and they were of several sizes, both in area and in thickness. The Sub-Committee did not attempt to determine anything excepting the losses to be found as between the weights when they went in and the weights when they were taken out.

Mr. J. V. Neubert:—For Mr. McDonald's information I may add when this subject was first assigned to the Track Committee several years ago, it was planned to handle it by a questionnaire sent to a number of railroads. As Mr. Swift has said, you have quite a difference in the size and dimensions of the plates, and there is such a wide difference in variation in the practice of various railroads that the Committee suggested that we use the Chicago Junction Railway as a test on account of these tie plates and similar conditions with the salt brines from the refrigerator cars, that we believed would get the quickest results. So the various experimental plates that are used in this test are the ones that were obtainable at that time.

If you do make your test, one thing to be remembered is this: I have made some tests under different conditions and I have found that the loss of metal on a tie plate from corrosion that is not in service and is exposed, is entirely different than that on the tie plate that is actually in service. A great many people feel that the exposed portion of the top of the tie plate is the one that corrodes the most. I have always contended, and I believe that it can be proven, that the bottom of the tie plate corrodes equally, if not faster, than the top or the exposed part, because that tie plate is continually in moisture and it gets enough change of temperature and moisture that practically keeps oozing or eating and corroding the plate. So in case that any of the members do make any tests, I would suggest that you put some experimental plates in an exposed condition, not in service, and also compare them with those that are in service. It may give you a little bit different comparison.

Chairman Campbell:—Is there any other question about this information? If not, it will be received as information.

Mr. J. V. Neubert:—The next is Appendix E, which will be presented by Mr. Clark.

Mr. H. G. Clark (Chicago, Rock Island & Pacific) :—The conclusions of this Sub-Committee in its report are on page 655. They are short and concise. Those conclusions result from a questionnaire sent to the Chief Engineers of 47 of the largest railroads in the United States and Canada, asking their definite opinion as to the canting of rail inward in track. The replies to that questionnaire is indicated in paragraph 1 of the conclusions, and shows that a very large percentage, practically three-quarters of the railroads responding, did cant their rail inward to a greater or less extent.

The recommendations of the Committee are:

(1) That rail should be canted inwardly.

(2) That inclined tie plates should be used to produce the desired result.

(3) That the amount of cant should be left to the individual railroads.

(4) That these recommendations be printed in the Manual as its final report.

I so recommend.

Mr. John V. Hanna (Kansas City Terminal) :—On No. 3, that the amount of cant should be left to the individual railroads, did the Committee undertake to go into the question of the merits of the 1 in 20 as against the 1 in 40, and, if so, why did they come to this conclusion?

Mr. H. G. Clark :—The Committee did not go into the merits of the amount of cant. The idea of the Committee was to obtain the individual recommendations of the Chief Engineers of the various railroads addressed. We got responses indicating all the way from 1 in 18, 1 in 20, 1 in 22, 1 in 38, 1 in 40, and up as high as 1 in 88.

The result of those answers, with no predominance as to the amount of the cant, except as between 1 in 20 and 1 in 40, left the Committee in a position where it only wanted to recommend that the desirable practice lay somewhere between 1 in 20 and 1 in 40.

Mr. J. V. Hanna :—I would suggest, then, that this might be a desirable line for the Committee to follow; that they might follow this particular phase of the subject further and see if they can not clarify the situation.

Mr. C. W. Baldridge :—If you will look back to page 476 of this same Bulletin, you will find the Rail Committee have today recommended: First, rails should be canted inward; second, inclined tie plates should be used to produce the desired cant; third, amount of cant should be 1 in 20. They did not sidestep it.

Mr. J. V. Neubert :—Mr. Chairman, if you will permit, Mr. Hanna, I believe if we go to the design of the tie plates, it is going to bring up this same discussion and the same duplication. The Rail Committee has already taken twenty-five minutes of our time. We are trying to absorb it. You can bring it up when we come to tie plates.

Mr. J. V. Hanna :—Then I question the advisability of saying anything about the amount of cant in the part of their report to be included in the Manual. It is hardly ready to go in the Manual until they have gone into that phase.

Mr. H. G. Clark:—We can discuss this subject as to the amount of cant for the next hundred years and never get any closer to it than we are at the present time. It has been under discussion, and a great many extensive studies have been made as to whether we should have 1 in 20 or 1 in 40. A great many men actively interested in this subject do not seem to think or do not feel that the practical conditions will enable you to arrive at any definite amount of cant. It has been handled by the former Sub-Committee, with, I believe, a Committee of the Mechanical Division, having to do with the taper on wheels, and they got nowhere in arriving at any satisfactory conclusion.

I think it is just as satisfactory to conclude the subject now so far as the amount of cant is concerned as it will be ten years from now or longer, because we will never get any closer to it.

Chairman Campbell:—Is there anything further on this interesting subject? If not, the motion is on the adoption of the recommendations of the Committee as they appear at the bottom of page 655. All those in favor of adopting the first recommendation of the Committee that the rail be canted inwardly will say "aye"; contrary "no." The "ayes" have it.

All in favor of the second recommendation that the inclined tie plates should be used to produce the desired result will say "aye"; contrary "no." It is carried unanimously.

All in favor of adopting the third recommendation that the amount of cant should be left to the individual railroads will say "aye"; contrary "no." The "nos" have it.

It is not necessary to take any action on the fourth.

Mr. J. V. Neubert:—The next is Appendix F, which will be presented by Mr. J. deN. Macomb.

Mr. J. deN. Macomb (Atchison, Topeka & Santa Fe):—This subject was reported in the Proceedings two years ago, and the material here offered is in addition to what is there shown. The material here offered covers three subjects—track inspection, office statistics, and recommendations based upon the other two. Under the sub-heading of Track Inspection, on page 656, the two lines immediately following, our attention has been called to the fact that we propose to take the rail contour with an instrument while running at ten miles per hour, which was hardly our intention, and to obviate that, the Committee has stricken from the wording following the sub-heading Track Inspection, the words, "the track being gone over on a motor car at very moderate speed." That clause now reads: "Inspection of rail in track should be made, and the following conditions noted."

The material contained in this exhibit is offered as information.

Chairman Campbell:—If there is no objection, it will be so received.

Mr. J. V. Neubert:—Appendix G, Design of Tie Plates, will be presented by Mr. J. R. Watt.

Mr. J. R. Watt (Louisville & Nashville):—The Sub-Committee has its report on pages 659 and 660 of Bulletin 283. This subject has been before the Committee for a number of years, and in 1921 a progress report was submitted. The table shown on page 660 has been before the Association in practically its present form since 1924. The Committee feels the report is in shape for final adoption, and I so move. It is proposed to substitute this report for the subject-matter now at the top of page 203 in the 1921 Manual.

Chairman Campbell:—Is there any discussion on the motion?

Mr. H. J. Pfeifer (Terminal Railroad Association of St. Louis):—In this conclusion provision is made for a flat tie plate, whereas in the conclusion just adopted you say that the rail should be canted by means of a canted tie plate. To be consistent, reference to a flat tie plate should be omitted.

The recommended width of tie plates is limited to a maximum of 7½ inches. As many roads use ties with a 9-inch face, the use of wider tie plates should be considered, at least made possible, without violating the Manual of Recommended Practice.

Mr. J. R. Watt:—The Committee considered that question at considerable length and felt there was a need for a table of dimensions for tie plates to be used as a guide in designing them. There is still considerable demand for flat tie plates, regardless of the conclusion we reached, and we felt it would be valuable to some roads to have that information. There is no great difference in the dimensions of the tie plates, whether they be flat or canted.

As to the width of the plates, we did not believe that it would be good main-line practice to go over 7½ inches. However, there would be nothing to prevent having plates sheared 8 inches wide if desired. The main idea of this report was to determine the section of the plate. In case of cross-rolled plates, they could be made any length desired.

Mr. J. V. Neubert:—In answering Mr. Pfeifer, we recommended the three designs. It was the advice of some very able representatives of this Association that we should go ahead and make up a plan for a flat tie plate only. Others have advocated the 1 in 20, and still others preferred the 1 in 40.

The majority of the railroads, I believe I am right in stating, have gone into the use of the canted tie plate in the last year or two—more of the 1 in 40 than the 1 in 20. That is the reason we have the three types of plates in order to fit all the conditions.

Prof. A. N. Talbot (University of Illinois):—The last suggestion is in line with what I had in mind, that it is desirable to have information on the meaning of this so that the tie plates can be checked up with any particular design of rail, the height of the rail, the position at which the load is assumed, whether in the middle or to one side of the middle, and the assumed angle of inclination of the resultant pressure.

As I understand it, the Committee intends that the relative dimensions of the tie plates shall be such that (taken in connection with the position and width of the base of the rail, the height of the rail, and the position of the wheel bearing on the rail) the force resulting from the wheel load and the average lateral pressure on the rail will intersect the tie near the middle of the tie plate, or sufficiently outside of this point to insure that the gage of the track will tighten rather than widen under the action of traffic. It is evident that for the range of rail base given in the table there will be a variation from the position of the resultant given in last year's report and in the resulting eccentricity of the tie plate with a given rail. It occurs to me that the recommendation of the Committee would be strengthened if a statement were included naming the particular size of rail or dimensions of rail for which the several tie plates will give the eccentricity of tie plate desired by the Committee.

Mr. J. V. Neubert:—In answering Professor Talbot, with whom we try to work very closely and he certainly has given us some very valuable information, in regard to the angle of the line resultant which has been used by this Committee, it is the formula given in Volume 15 of the Proceedings for 1914, page 587. That means that *T* equals the 14% of *W*, *W* being the weight, and that angle is seven degrees and fifty-eight minutes.

I did not have time to write you, Professor Talbot. I think you wrote to Mr. Watt and thought it should be about six degrees. That is where we got the seven degrees and fifty-eight minutes. We have studied the subject of tie plates very thoroughly, with the idea of producing as near as practical the same amount of pressure on the outside edge or toe of the plate with the corresponding inside toe of the plate, and taking the line of resultant for a 10-inch plate, in order to get it mathematically correct, it is necessary to know the width of base and the height of rail.

For example, the New York Central 105-lb. Dudley section rail, which has a 5½-in. base and 6-inch height with 10-inch tie plates. On your line of resultant, giving both pressure on the inside toe and outside toe the same, it produces a mathematical distance on the shoulder side of 2 63/64 inches, so we confined that to three inches. If I am correct—if not, I wish Mr. Watt would correct me—the dimensions shown in the table are nearest the balanced dimensions to suit variable rail conditions that we could get for the size of plates and the dimensions shown.

On page 660, if we would work out a design of plate for every individual section, we do not know where it would lead to. That is the reason we balanced these up. We may be an eighth of an inch off, or something like that. We would also like you to tell us whether our angle is right. We have taken it from the 1914 Proceedings. That is the way we arrived at the degree used.

Mr. P. C. Newbegin (Bangor & Aroostook):—Some of us use a lighter rail than shown there; for instance, the Bangor & Aroostook standard rail is the 80-lb. A.R.A. Type A, with 4⅝-inch rail base. It might be well for some of us to have another line showing the rail base narrower than shown as 4¾.

Mr. C. W. Baldridge (Atchison, Topeka & Santa Fe):—In Bulletin 263, issued January, 1924, this Committee gave us a set of sections of rails showing the lines of force, which aids a great deal in designing the tie plate. I believe that the matter that was given us at that time should go into the Manual as an aid to anyone who wants to go to a little greater refinement than the table which the Committee has given at this time will furnish them.

I believe that the table as given by this Committee is as close as we can spare space in the Manual to present.

Mr. J. V. Neubert:—We will be very glad to do that. One reason we did not want to do it was because I was one of the originators of that same sketch.

Mr. C. W. Baldridge:—It is very excellent.

Mr. J. V. Neubert:—Absolutely. When you get that, you get something right.

Mr. J. R. Watt:—The first paragraph of our report reads as follows:

"The Committee submits herewith plan and table of dimensions for tie plates 9 to 12 inches long. These designs have been arrived at not only by analysis, as shown in Appendix I, Bulletin 263, but also by careful study of the dimensions of tie plates in general use at the present time."

We have sent out two questionnaires and have prepared our analysis and tables very carefully, keeping in mind present practice. We felt it was sufficient to give our method of analysis in the Proceedings, and in the case of large users of tie plates they might want to design them according to our methods rather than use the table. However, for ordinary use we felt that the tables gave the dimensions with sufficient accuracy. We have referred here to the methods of analysis in case anyone wants to look them up.

Mr. J. V. Neubert:—As I understand it, you want that diagram put in this year's report.

Mr. C. W. Baldridge:—I made that as a suggestion for consideration in the future.

Mr. J. V. Neubert:—We will accept that, and Mr. Watt will add that to his motion to include and print it in the Manual.

Chairman Campbell:—If there is no further discussion, all in favor of adopting this design of tie plate for inclusion in the Manual, say "aye," opposed "no." The motion is carried.

Mr. J. V. Neubert:—Appendix H is to be presented by Mr. L. B. Allen, in the absence of the Chairman, Mr. J. B. Myers.

Mr. L. B. Allen (Chesapeake & Ohio):—Our report is on page 661, Cause and Prevention of Rail Battering and Principles of Joint Design. A questionnaire was sent out to all railroads represented in the A.R.E.A., a copy of which has been made a part of this report. The object of this questionnaire was to ascertain from the various railroads their opinions and experiences in regard to the subject, from which we hoped to determine means to eliminate the causes of rail chipping and battering, and to fix, in so far as we could, the principles of joint design. Answers to the questionnaire were received from 49 railroads, and a summary of the answers is shown. There is also included in the report a brief of the answers received from each railroad.

The Committee has been unable to formulate definite rules on the subject, and it is recommended that the report be received as information.

Chairman Campbell:—If there is no objection, it is so received.

Mr. Maurice Coburn (Pennsylvania Railroad System):—I note that the Committee asks to be relieved from further work in connection with this subject. The Rail Committee are willing to work on it further. It seems to me that we have not reached the bottom of it yet. It is a very important matter, and there are some angles of it which have not been discussed.

I have had an idea for a good many years that as we have developed a stiffer joint with stronger bolts, the battering has increased. I am quite positive that effect can be shown on our own railroad. Where we have had the stiffer joint, we have had more battering. Our light rail has gone through many years of service with no battering, while our heavier rail with the heavier joint has had a good deal of battering. We understand that the roads using a long, thin angle bar have less battering than we have with the short, stiff bar. It therefore seems to me that the Committee should not be relieved of this subject at this time.

Chairman Campbell:—The Committee on Outline of Work will take this under consideration.

Mr. Hunter McDonald (Nashville, Chattanooga & St. Louis):—The last speaker has stated that the Rail Committee was willing to go ahead with this investigation. If you turn to the Bulletin containing that Committee's report, you will find that it is only on the question of rail battering. The Rail Committee does not feel that it should continue the subject of design of rail joints.

I do not speak advisedly except from what is in print in the Rail Committee's report.

Chairman Campbell:—If there is nothing further, the Chairman will proceed.

Mr. J. V. Neubert:—Appendix I, in the absence of the Chairman, Mr. J. B. Baker, will be presented by Mr. O. F. Harting.

Mr. O. F. Harting (Terminal Railroad Association of St. Louis):—The work of this Sub-Committee for the past year is reflected on pages 672-676, inclusive, and is being handled under five sub-divisions.

Information on Subject "A," Girder Rail Construction, and subject "B," T-Rail Construction, is given on pages 672, 673 and 674, and was collected by means of a questionnaire.

Subject "C," Standard Specification for the Manufacture of Open-Hearth Steel Girder Rails of Plain, Grooved and Guard Types, was presented by the Rail Committee earlier in the session.

Subjects "D" and "E," Special Track Construction; plans and data pertaining to these subjects have been collected, but additional time will be necessary to prepare details that will illustrate the recommended practice.

We offer as conclusions for adoption and insertion in the Manual those printed on page 675, and we offer the general remarks printed on page 676 as information only.

Chairman Campbell:—It is moved and seconded that the recommendations of the Committee from No. 2 to 14, inclusive, appearing on page 675 be adopted for publication in the Manual. Is there any discussion?

Mr. J. V. Neubert:—There may be some technical errors. We use joint bars and splice bars. We can not get anyone to tell us which term to use, so we use them both.

(The motion was carried.)

Chairman Campbell:—If there is no objection, the information in General Remarks on page 676 will be received as information.

Mr. J. V. Neubert:—In the absence of the Chairman, Mr. W. H. Petersen will present Appendix J, The Value of Nutlocks for Rail Joints with Special Reference to Heat-Treated Bolts of Large Diameter.

Mr. W. H. Petersen (Chicago, Rock Island & Pacific):—The work of this Sub-Committee is shown on pages 677 to 686. In order to determine the value of nutlocks, a questionnaire was sent out to various railroads, and we received answers from forty-three railroads. We have tabulated the replies and made a summary of the answers to the fifteen questions. We did not feel that there was any conclusion to be arrived at, and are therefore submitting the matter as information.

Chairman Campbell:—This finishes the report of the Committee, and if there is no objection the information in Appendix J will be received as information.

In dismissing the Committee, I wish to convey the appreciation of the convention for the large amount of valuable work it has done during the year. (Applause.)

DISCUSSION ON COOPERATIVE RELATIONS WITH UNIVERSITIES

(For Report, see pp. 1205-1208.)

Mr. Robert H. Ford (Chicago, Rock Island & Pacific—Chairman):—The report of the Committee on Co-operative Relations will be found in Bulletin 285, on page 1205.

Recommendations for future work are along the lines which the Committee has been working. Four suggestive paragraphs are presented, as follows:

(1) The result of the studies so far undertaken indicate that in few, if any, of the university or college faculties is there a clear conception of the kind of training required to fit young men for railway service.

(2) This is largely due to the fact that the college faculties have been unable to secure necessary information from responsible railway officials.

(3) The railways should not take into their service more college trained men than they can assimilate.

(4) The engineering schools do not specialize beyond the three branches of engineering; viz., civil, mechanical and electrical.

Messrs. Cushing, Ketchum, Howson and Katte will refer to them more in detail after an opportunity has been afforded for remarks from the floor.

Prof. S. L. Conner (Tufts College):—From the manner of presentation of the Committee's report by its Chairman, it would seem that we are to discuss its paragraphed findings separately. With this assumption, I would reply to the statement in paragraph one. I am inclined to believe that this comment may bear out some of the statements that are so prevalent in relation to engineering education and its shortcomings, which probably have been based on facts that are not always to the fore or to the point. It appears to me that the college faculties have been responsible for the training of men who are carrying on the railroad work to-day. I do not think they have made much of a failure in their work of preparation as is evidenced by this meeting.

The colleges, I believe, stand ready to do what is right in relation to the training of men for railroad work. To summarize my opinion of this paragraph would be to record me as taking the position that we used to take as children behind the statement "It may be so, but I don't know. It sounds rather strange."

Chairman Campbell:—If there are any other representatives of colleges or universities on the floor, we would be glad to hear from them. Has anyone anything to say?

Prof. S. L. Conner:—Mr. Chairman, I wish to respond to the findings of the Committee as recorded in paragraph two. The statement "That this is largely due to the fact that the college faculties have been unable to secure necessary information from responsible railway officials" I think would be evidenced to any faculty member who sat in this convention since the first meeting. This representative organization here assembled is working towards ultimate practice. I believe that it is true that you cannot hope to standardize railroad practice any more than you can expect to standardize education. I think, however, the proposition involved in the statement in this paragraph is of much greater importance than indicated there, involving, as I believe, that most important of all relations—the cooperation and assistance of the whole railroad industry.

I take this opportunity to call attention to the statements made last year in the Proceedings, particularly those of Dean Ketchum, where he called attention to the fact that the industry has gone into the situation very definitely to reach men, to bring them out and place them in positions after graduation and offering them definite progress after they have completed their college work. I mention this because I am responsible for the training of sixteen men who will graduate this year and who are majoring in railroad engineering work with me. These men have reached a stage in their development where I am disturbed as to just what to do and just what is the best advice to give them. I want them to go into railroad work as I know there is plenty of opportunity for them to grow, although I know the progress is slow. It is very difficult for me to say anything to them about the prospects of future promotion in railroad work other than there are many opportunities. One result has happened this year, which is of moment to the railroads, in that a good many of our men have taken examinations for the Interstate Commerce Commission. I mention this because the beginning salary with the government is something like $1,860 a year with a six months' probationary period, after which time a man is raised to $2,000. That seems to put a pecuniary value on education and the present generation is much interested in the financial return immediately upon graduation.

We have to deal with the present generation of college students and our professorial contact proves many things. We find that groups of students today are quite different from groups that we used to deal with years ago, that is, as far as knowing things. Undergraduates are not actuated solely by an opportunity to secure a job; they are actuated by what they can get for the $6,000 that they have invested for four years, as they want a return on it. If the railroads talk about $100, $110 or $120 a month proposition and thus place these amounts as their financial measure of the graduates' value, it will result in very little satisfaction to railroad officials as far as securing the best type of technical graduates.

I find it rather difficult in my section of the country, Massachusetts, to interest men in railroad work, and that it is difficult to get them to think of the larger railroad corporations throughout the country. Since this condition exists the result is that industry and the government have come right into our school and have taken our men for different kinds of services, offering them definite lines of promotion. If railroad policies of securing technically educated personnel have not changed in the last fifteen years, then these facts must be a warning to them to recognize present conditions.

I realize that the problem before this Committee is a difficult one and a tedious one to solve and they should be encouraged to carry on the work as I believe the future of transportation, its growth and development must be carried on by technical graduates. I believe that this Association is doing a work that is really worth while in the appointment of their Committee. I would like to offer a practical suggestion in relation to the problem, and that is that the American Railway Engineering Association have a representative on the platform of the Society for the Promotion of Engineering Education at its Annual Meeting in June to present this problem from all its angles so that the people interested in engineering education may realize that their problem is not limited solely to one phase of engineering work. We need the help, I know, in the engineering school to assist in solving the problems of industry and I know the faculties of these schools stand ready to help and assist in whatever way they can.

Mr. J. B. Jenkins (Baltimore & Ohio):—It seems to me there is another angle to this recommendation somewhat along the lines covered by the preceding speaker. Many railroads encourage college men to enter their ranks in subordinate positions in order to begin at the bottom and learn the railroad business, and then after they have entered the ranks, the railroad company forgets them. A man will enter a shop and be left there at the mercy of a foreman or an assistant foreman, who has no sympathy with education, to recommend that man for promotion. A man will go on a track force and be at the mercy of an assistant supervisor, who perhaps has no sympathy with education, for promotion.

It seems to me that if the railroad company takes college men into its ranks, it should follow them up, see which ones are making good and give them an opportunity to accumulate experience in different departments of the road instead of permitting them to die of dry rot by remaining in one department four or five years, hoping for a promotion that never comes.

Mr. G. D. Brooke (Chesapeake & Ohio):—It seems to me that if a railroad has to follow up a college man when he enters the service to see that he gets along, it is rather taking the position that he is not as well able to take care of himself as the other men in the service who are not college men.

Mr. W. H. Woodbury (Duluth, Missabe & Northern):—If I understand the Committee's conclusion on that, I am in accord exactly. I think there is a tendency now in all education to specialize too much and not give the students the broad education they should have, and I thoroughly agree with the speaker just preceding in that if a college man is not able to look out for himself, he does not deserve being looked out for.

Mr. J. B. Jenkins:—I thoroughly agree with that, but the man who is capable of looking out for himself is very often denied the opportunity to acquire the necessary experience. He is held, perhaps, in one position and discouraged from moving around from one to another in order to acquire the experience. If the management finds that that man has it in him to make good, it should give him the opportunity to move from one department to another and acquire knowledge along the various lines of railroading and not hold him to one place to become an expert machinist or something of that sort when the man wants to know twenty or thirty different lines of railroad work.

I do not mean to say that the management should pamper every college man who comes into the service; I think that they should follow the course of each college man who enters the railroad service. If the man is just an ordinary young man in the rank and file and no better than the man who does not come from the college, then it should drop him from consideration; but so long as he shows promise, so long as he shows ability to do one thing and another, the railroad company is going to profit by making use of that young man's ability. As it is, a great many railroads take these college men on their rolls and then bury them.

Mr. W. C. Cushing (Pennsylvania Railroad System):—You will observe from the scope of the instructions to this Committee, as outlined by the Board of Direction, the subject is a very large one indeed, and it is noticeable that the Committee has only started with the presentation of four general statements. These were purposely designed as a feeler in order to get you to say something on the subject and the remarks were put in this form in order to stimulate your aid in the development of the subject so that the Committee could take further action later on.

Some of the remarks, therefore, have been made on subjects to which the Committee is coming later, and which are really the most important of the subject, and the deepest.

In the scope of the activities of the Committee, No. 1 reads, "A greater interest upon the part of railroad officers in assisting the universities to develop the best possible methods for the technical courses."

Our first thought which we are stating to you is to a certain extent derived from that instruction and reads, "That the result of the studies so far undertaken indicates that in few, if any, of the university or college faculties is there a clear conception of the kind of training required to fit young men for railway service."

That sounds presumptuous, but is derived from the statement of an educator. It means that railroad officers must become aggressive and cease to be apathetic. They must take an interest in the problems of education. It is a matter of self-interest as well as a performance of official obligation. The officer may have a boy whom he has to help select a field of life activity and if he made a mistake in the beginning in picking out his own line of action, all the more should he be keyed up to the degree for avoidance of a repetition.

One's official duty is in consonance with self-interest, so this problem of settling upon the right course in education requires deep thought and study. The starting point is careful consideration of the kind of training a young man whom one may be seeking should have for fitting him to become, as time of service advances, a good industrious student of the work in hand, a careful and keen analyst of available information and a creator and executor of a plan of improvement.

Now, as the problems not only in a general transportation service, but in all kinds of business, are many and varied, the courses of college training can not be expected to cover so large a number of items in all detail, but can be carried out only to a common point, after which additional training must be obtained in special courses or in the school of experience in actual work. College training, therefore, should be based on instruction and thorough grounding in fundamental principles of the major branches. The ambitious boy must pursue his special research work in a post-graduate study in a school of special eminence and in the execution of his official work. He must never cease to be a student. We ask you men of this Association what other message we can send to the colleges!

Dean Milo S. Ketchum (University of Illinois):—I will speak rather briefly on the relations between the industries and the technical engineering graduate. When the speaker graduated from college he was advised not to mention the fact that he was a college graduate when he made application for a position. Since that time there has been a very decided change in the attitude of the industries toward the technical graduate, and today nearly every industry is anxious to take technical graduates into its employ. This change in point of view has come about because the industries have found that technical graduates with training in science, mathematics, and mechanics, have been able to develop more rapidly, to solve new problems, were more aggressive and better able to compete with other industries than were the men who had not received this training; and in addition they reached a position of administrative maturity at a much younger age than the men without this technical training.

The industries have co-operated with the engineering schools by taking students into their employ during the summer vacations, by giving members of the engineering faculty vacation employment, by employing engineering teachers as consultants on certain lines and activities with which they were especially competent, by furnishing engineering teachers with the latest data covering specialized lines of activity, and in co-operating in research investigations.

While some of the railroads have given similar assistance to engineering schools and teachers, there is an excellent opportunity for effective cooperation between the railroads and the engineering schools along many lines.

One recent line of co-operation between the industries and the engineering schools has been the holding of conferences of engineering teachers to discuss the problems of the particular industry. Recently the American Telegraph and Telephone Company held a conference in Chicago, covering nearly a week, where engineering teachers of nearly every school in the United States were invited to be present at the expense of the company to study the problems of the telephone industry.

The railroads might well follow this example. It would be well worth while for members of this Association to meet with representatives of the more important engineering schools in this country to discuss the various problems that are of mutual interest to the railroads and to the engineering schools. As a result of this conference engineering schools would have a very sympathetic attitude toward railway problems, and engineering students who entered the railway service would have a better appreciation of their future opportunities.

The Association is doing excellent work in furnishing engineering schools information with reference to railway problems but this work might well be strengthened and improved. It would also be very effective if the railways could take engineering students into their employ during summer vacations in order that they might become familiar with the opportunities in railway service and with the different kinds of railway employment. What an engineering graduate does after leaving college depends very largely upon his first impressions and his first opportunities for engineering employment.

Engineering colleges are not only giving instruction to undergraduate students in engineering but are carrying on important research investigations. The railways might well follow the lead of the industries in cooperating with the more important university engineering experiment stations in working out the problems of the industry.

The recent engineering graduate is very altruistic and is more interested in the opportunities for promotion than in the beginning salary. Recent engineering graduates are very anxious to reach a position of administrative responsibility at a reasonably early age. If these men did not have ambition they would not have gone to college. It should be remembered that not more than thirty per cent of the engineering students who enter college ever graduate and that the engineering graduates are, therefore, picked men. These men have shown their enthusiasm, their interest in engineering work, and their willingness to work hard and long, and are anxious to find a position where they will have an opportunity to show what they can accomplish. Some employers underestimate the training and ability of the recent technical graduate and do not give him a job that is a challenge to his efforts. The engineering graduate should be given an opportunity to show his ability and do a man's work.

If the railways will make it possible for engineering graduates to do work requiring an engineering training and will indicate that an opportunity is ahead, there will be no difficulty in getting live, wide-awake engineering graduates to enter railway service. These men will come to you as fast as you desire. But, at the same time, you must be careful not to take more engineering graduates into your employ than your organization will absorb. Recent engineering graduates know more about opportunities in different lines of industry than do college professors and are looking forward to an opportunity to do something really worth while.

Mr. E. T. Howson (Railway Age):—I think that in discussing subject No. 3, we should have the proper realization of the function of this Committee. Its purpose is not to find jobs for college graduates, because the faculty members of this Committee vouch for the fact it is no problem to find jobs for the graduates as there are more jobs than there are graduates. Rather, the function of this Committee is to endeavor to develop the thought that it is to the advantage of the railways for them to enlist college men in railway service. We are thinking of this problem from the standpoint of the railways rather than the man. If other industries find it to their advantage to take college men in at the bottom, give them a course of training and put them through a sifting process with the idea of finding among those college graduates men who will fill official positions and assume positions of leadership in those industries, that should be a lesson for the railways. In fact, the railways are finding that in spite of the absence of any definite method of selection and of training their officials are coming more and more from the relatively small number of men of college training on the railways.

Referring to the point Mr. Brooke made a moment ago regarding the coddling of the college man so he may have more rapid promotion, it is the thought of this Committee merely that he should be given an opportunity so when the railway needs him he will be qualified to assume leadership. If the college man is going to develop to the point that he will be of the maximum value to the railway he must be permitted to develop so that when he is needed, he will have that training that is required.

If he gets into a blind alley, as Mr. Jenkins has commented on, he will not have that training and will not be fitted for a more important position. The railway that takes into its service more men than it can assimilate will find those men getting into blind alleys and they will then clog the lines of promotion so that other men cannot get around them. As a result the more capable men will become discouraged and quit and the word will go out that the railways are a poor industry to identify oneself with. The young college man chooses the industry with which he casts his lot, largely by checking up the records of those who have gone before, and he will see that those fellows have hit their limit quickly with the result that he will choose some other industry. That has been the record of recent years, because the number of men going into industry at large has risen rapidly compared with the number of men going into railways, for on many railways the young men have reached the end of their opportunity quickly because they have been taken into the service and then lost sight of.

That railway, the Committee feels, is unfortunate that takes into its service more college men at the bottom than there are openings along the line because they clog the channels of promotion; rather, it is better to take a smaller number of men in and give those men who make good a future. That will result in a live, virile organization in which there will be men trained for the opportunities as those opportunities develop and those men, if there is anything in college education, will be ready for positions of leadership when the railway needs leaders. If, however, it takes in so many that the lines of promotion are clogged low down, the men of leadership caliber can not get around that dam, become discouraged and leave the service and the railway loses them.

Conditions in the railway industry are changing rapidly and a higher grade of leadership is required each year. It is with the thought that the college man should provide a logical portion of that leadership that this Committee is interested in bringing more college men into railway service and particularly in seeing that the railways so use those college men that they keep them live and virile, active in mind, so that they are ready for positions when the railways need them in the higher capacities.

Mr. E. B. Katte (New York Central):—It is suggested that the Engineering Schools do not specialize in the training of prospective railroad men beyond the three branches of engineering: namely, Civil, Mechanical, and Electrical. It was not the intention of the Committee to suggest that the Technical Schools should eliminate courses in Mining Engineering or Chemical Engineering, and conclusion four (4) should be understood as pertaining to the training of men for railroad service. The average coach of a college crew would rather have a strong vigorous boy with a healthy body than one who has been trained in some other school of rowing; he would himself prefer to develop the particular stroke which is required for his crew. So it is, I think, with the majority of the employing railroad officers. They would prefer that the young man be well grounded in the fundamentals of engineering rather than specialized in some particular branch of railroad engineering. I cautioned our Chairman when he asked me to speak, because I hold some old-fashioned ideas on education that are not accepted by all of the members of the Committee, and the views I now express are not those of the Committee but are my own.

I have no fault to find with the technical training of the average engineering graduate who comes to the railroad which I serve. He is well-grounded in the general principles of engineering, he is ambitious, he does good work, and he usually remains in railroad service. My plea is for a broader education for the engineering student. I see no reason why the prospective engineer should be deprived of a liberal education. He should be given an opportunity to study the cultural subjects, art, literature, even a little Latin and Greek. Such subjects will broaden his viewpoint. Just because a boy is to become an engineer I do not think that he should be deprived of those broadening subjects which will permit him to enjoy life and will give him an opportunity of associating on an even footing with his friends who are members of the other learned professions. A doctor or a lawyer invariably has the advantages of a cultural education before he is specialized, trained and polished along the narrow line in which he is to become an expert. Perhaps the boy may not be a better engineer because of such an education, but I believe he will go further, will be a better man, and will get more fun out of life.

Chairman Campbell:—This problem is one that is going to grow, but I feel the Association is going to find a solution for it. It is the great human element in our business.

The Committee is now discharged with the thanks of the Association. (Applause.)

DISCUSSION ON TIES

(For Report, see pp. 637-732.)

Mr. W. J. Burton (Missouri Pacific—Chairman):—The report of the Tie Committee will be found in Bulletin 283, beginning on page 687.

Seven subjects were assigned to the Committee for report, and the Committee has elected to report on five of those, leaving two to be carried over to next year.

The first subject is Revision of the Manual. The revision which we are proposing this year is contained in Appendix A of the report.

In 1921, this Association approved a standard Specification for Cross-Ties which has since become almost universally used and recognized as an American standard. As a result of five years' experience with this specification, there are a few minor changes which the Committee now recommends.

The Chairman of the Sub-Committee handling this revision of specifications, Mr. John Foley, is also Chairman of the Sectional Committee of the American Engineering Standards Committee. Mr. Foley will present this report.

Mr. John Foley (Pennsylvania Railroad System):—As Chairman Burton has told you, the changes in the specifications for ties are not extensive. However, the recommended revisions do fix the standards as the Committee believes they should be after the past five years' use.

On page 690 you will find the Specification for Cross-Ties. In Section 3, the proposed change provides that compact wood in ties must be specified if it is desired instead of coarse wood having to be specified if it were to be admitted.

In Section 8, "size" has been substituted for "grade" because in the forest products industries "grade" refers to quality. We do not have five qualities of ties, we have five sizes. The proposed Size O tie will legitimatize the acceptances of some railroads.

In Section 12, the reference to decay in the slightest degree has been omitted as no longer required as an admonition. The general practice now is to bar all decay except that recommended as allowable.

Section 19 is changed only in being shorter. The explanation of it is considered no longer necessary.

Section 20 now provides for a tolerance of ¼-inch, where formerly ties could not be any narrower or thinner than the standard dimensions. Since in actual inspection it is impracticable to gage the thickness or width of a tie within ¼-inch without measuring each one with a rule, which is rarely done, and a tolerance was allowed by practically every railroad, a limited tolerance standardized by the specification seems desirable.

The acceptance of oversize ties provided for in Section 20 is less liberal than it was. A tie over 2 inches too thick is now rejected instead of being accepted as two sizes smaller.

Section 22 no longer aims to restrict the time delivery because, as in the case of Section 9, most railroads do not presume to decide when ties were made.

The changes in the Specification for Cross-Ties just read apply also to the Specification for Switch-Ties. Wherever the stipulations are uniform in both standards, they have been corrected alike.

The Committee move the adoption of the Specification for Cross-Ties and the Specification for Switch-Ties as revised.

The President:—Is there any discussion?

(The motion was carried.)

Mr. W. J. Burton:—The next subject assigned to the Committee is found reported on page 700, Appendix B, Specification for Dating Nails and Marking Ties for Service Records. Mr. Belcher is Chairman of this Sub-Committee.

Mr. R. S. Belcher (Santa Fe):—This report is divided into three parts, the use of dating nails, specifications for dating nails, and the marking of ties for service records. Information as to the extent to which dating nails are being used, the kind of nails used, and opinions of the benefits derived from the use of dating nails was obtained from answers to a questionnaire sent out to sixty railroads of the United States and Canada. Thirty-two of the roads answering this questionnaire had used dating nails to some extent. The first of these to use dating nails began their use in 1899.

Opinions as to whether or not dating nails have some influence on foremen and others responsible for tie removals from track and as to whether or not dating nails are worth the cost, are given in Exhibits 3 and 4, pages 706 and 710.

Conclusions one, two and three on page 702 are the result of information obtained from the answers to the questionnaire and a study of the subject by the Committee.

I move the adoption of conclusion No. 1.

(The motion was seconded and carried.)

Mr. R. S. Belcher:—I also move the adoption of conclusion No. 2: "Dating nails should be driven into the tops of the ties, six inches inside the inner flange of the rail and upon the line side of the track."

(The motion was seconded and carried.)

Mr. R. S. Belcher:—Conclusion No. 3: "Dating nails may be applied at the treating plants or after ties are inserted in track. If the latter, dating nails should be driven the same day tie is inserted."

I move the adoption of conclusion No. 3.

The President:—There being no discussion, we will consider the conclusion carried.

Mr. R. S. Belcher:—The next portion of the report refers to the Specifications for Dating Nails. These are given on page 703, and are in general similar to those now in the Manual. We have in addition specified the grade of zinc to be used for galvanizing and have specified the hot-dip process of application. The chemical test of the zinc coating is only slightly changed from that now in the Manual. The design is also the same, except that raised figures are specified instead of the depressed, and the thickness of the head and the height of the figures are given in addition.

A, B, C, and D, under Inspection, is in addition to the matter now in the Manual.

Mr. President, I move the adoption of the specifications as given.

The President:—You have heard the motion for the adoption of Specifications for Dating Nails. Is there any discussion? If there is no objection they will be considered adopted.

Mr. R. S. Belcher:—On page 704 of the report many of the varieties of dating nails which have been manufactured are shown and their comparative cost is given in the right-hand column. I have a large number of samples here representing the different varieties of dating nails which have been manufactured. Anyone interested in these can see them later.

(Mr. Belcher exhibited a number of dating nails and commented thereon as follows.)

This nail is the present standard, 2½-inch shank, No. 3 gage with the depressed figures in the head.

This nail is the proposed standard, practically the same size, with the raised figures. They are both galvanized.

This is one of the monogrammed copper dating nails used by some of the treating companies not only to date ties but to identify them.

Here is a smaller copper dating nail, with a depressed figure.

This is a galvanized malleable dating nail with very large head and raised figured.

This is the largest shank of any of the dating nails manufactured. It is five-sixteenths.

Marking ties for service records is given in conclusions four and five on page 702. I think these conclusions are self-explanatory and I move their adoption.

The President:—The adoption has been moved of sections four and five in the conclusions on page 702. Is there any discussion on this? If there is no objection, these conclusions will be adopted without a vote.

Mr. W. J. Burton:—The next assignment of the Committee is found on page 715, Appendix C. The question assigned was the Extension of Service Test Records for the Purpose of Furnishing Information for the Study of Economics of Ties. Mr. Bernard Blum, the Chairman of that Sub-Committee, will present the report.

Mr. Bernard Blum (Northern Pacific):—The Sub-Committee on the extension of service test records for the purpose of furnishing information for study of economics of ties has been working on the basis of developing test sections that will eliminate all variables that affect the life of ties, except one and obtaining concrete information on that one variable. Along these lines we have formulated eight variables shown on page 715, about which it is desired to obtain information. It is very likely that other variables will suggest themselves to members of the Association, and this report is submitted as information only at this time. It is our purpose to continue the work this coming year and definitely formulate the requirements of test sections. If any member has data he would like to suggest be incorporated in these test sections, we will be very glad to receive it. There is nothing in the report covered here that requires any definite action by the convention.

Mr. W. J. Burton:—Mr. Chairman, I move the receipt of Appendix C as information.

The President:—Unless there is some objection, Appendix C will be received as information. Is there any discussion on the subject? It will be so received.

Mr. W. J. Burton:—The next subject is found on page 717, Appendix D. The subject was to report on the adherence to specifications on the part of the different railroads. This Sub-Committee is headed by Mr. Foley.

Mr. John Foley:—To come here and adopt specifications and then go home and forget they exist is not good engineering. Unfortunately, that has been too true in connection with cross-ties. It is regrettable that all of you could not have accompanied the members of the Committee on Ties who last year viewed collections of ties to see what was being done in adherence to American Railway Engineering Association tie standards.

As you are told in the report under consideration, there is considerable ground for satisfaction; but also some for regret. This Committee would like to impress on each and everyone of you the importance of your taking a direct personal interest in the character of the ties delivered for your use. If you would have your inspectors mark each tie so that the responsibility for its acceptance can be placed upon the individual and would insist that you be supplied with the size of tie your work requires and presumably has been purchased for you, the solution of the tie problem will be advanced considerably. It is worse than ridiculous for a railroad to order Size 5 ties and say they shall be 7 inches thick and 9 inches wide except they may have one-inch of wane. Why such a railroad does not order Size 4 ties is explained only by the desire on the part of someone to deceive someone else. A tie ordered 7 inches by 9 inches with one inch of wane is only 7 inches by 8 inches, or a Size 4 tie, and it cannot legitimately be translated into an A.R.E.A. standard Size 5 tie by merely calling it a 5. The Committee on Ties would like very much to impress on everyone the necessity for going home and insisting that your ties be marked and carried all the way through under A.R.E.A. standard sizes and terminology. Use small ties wherever you can economically, but do not flatter yourself or let anyone fool you by using without protest ties less than 7 inches thick or less than 9 or 8 inches wide which are supplied as Size 4 or Size 5.

The Committee asks that the 1925 report on adherence to tie specifications be accepted as information.

The President:—Unless there is some objection to this report, it will be accepted as information.

Mr. W. J. Burton:—The last subject which we are reporting on this year is found beginning on page 718, a report on the use of substitute ties and the results derived from them. Mr. L. J. Riegler is the Chairman of that Sub-Committee.

Mr. L. J. Riegler (Pennsylvania Railroad System):—The report of this Committee is in Appendix E. It is the record of the past year of the experience of the railroads on tests of substitute ties. It is submitted as information. We call your attention to the table on page 726, which we have extended to show rail section, ballast, and the kind of traffic.

The President:—Unless there is some objection, the report will be accepted as information. Is there any discussion? The report is so accepted, and the Committee is dismissed with the thanks of the Association. (Applause.)

DISCUSSION ON ECONOMICS OF RAILWAY OPERATION

(For Report, see pp. 733-757.)

Mr. G. D. Brooke (Chesapeake & Ohio—Chairman):—The report of this Committee is one of progress, and the matter is submitted as information. There are no recommendations proposed for inclusion in the Manual.

The first subject is that of the effect of speed of trains upon the cost of transporting freight. I will ask Professor Williams, the Chairman of the Sub-Committee having that subject in charge, to present the report.

Prof. C. C. Williams (University of Illinois):—In the past year and preceding years the Committee has canvassed the situation with regard to collecting data on this subject and has attempted various theoretical analyses in addition. The Committee seems to have found about all of the data that were readily available and submits this summary. In this summary the data are presented in graphical form, showing the significance of the analyses and information.

In order to indicate the significance of the analyses in data previously submitted, curves are plotted in Fig. 1, page 738, showing the effect of speed of freight trains on the major items affected; namely, wages, fuel, maintenance of way and structures, maintenance of locomotives, and fixed charges, together with the resultant curves. Minor items are omitted because they do not appreciably affect the total.

In last year's report attention was called to three cases according to traffic density, which would influence the relation between speed and cost of transportation. These cases briefly were:

(1) Where the traffic at hand to be hauled is less than the capacity of the line and equipment available.

(2) Where the traffic at hand to be hauled exceeds the capacity of the rolling stock (either motive power or cars) operated at low speed.

(3) Where the track capacity at low speed is exceeded by the available traffic.

The effect of speed of operation on cost of transportation has a very different significance for each one of these particular cases.

On page 738 is a figure which presents certain composite data on these topics and above are two curves which represent the sum or total of those items. This diagram is not applicable to any particular railroad. The data were taken from a number of sources and put together in this composite way in order to show what elements were involved in the first place, and in the second place to show the general tendency of variation.

I read, then, the conclusion on page 737.

"Other operating factors may easily outweigh minimum operating expenses in determining the desirable speed of trains. These chiefly pertain to operating revenues. Some of the more important are: (a) competition; (b) demand for expeditious service by the public; (c) interference with higher class trains by slow freights; and (d) loss of revenues through diminished capacity at low speeds.

"The interest on the cargo of a train of coal is about fifteen cents per hour; of a cargo of other freight, it may be considerably greater; yet this factor, except in the case of unusually expensive commodities, would be inconsiderable as a factor influencing economic speeds.

"The summarizing statements in last year's report may be repeated:

"'(1) The effect of speed on transportation costs per ton-mile depends upon circumstances of traffic density and physical characteristics of the district considered, viz., ruling grade, length of district, rise and fall, and curvature.

"'(2) In general, the cost of transportation per gross-ton-mile or per net-ton-mile increases whenever the speed of operation is increased by reducing the tonnage rating below the maximum practical rating.'

"Conclusion No. 2 is shown to be true by theoretical considerations, by the results of test trains run and by results of normal operation in the cases studied by the Committee, where operating costs of drag freight transportation only are considered. However, other factors mentioned above are usually of such magnitude as greatly to modify deductions as to economy of speed based on operating costs only and to limit the application of the above conclusion very narrowly. Studies in economic speeds are complex and must necessarily include inquiries as to effects on operating revenues as well as on operating expenses."

Because of this complex situation, as I said before, this graph is not applicable to any particular case.

After canvassing the situation as the Sub-Committee has, it feels that there is perhaps no other source of information practically available at the present time and it feels that further theoretical analyses of the subject would be barren of results; therefore we recommend that the subject be discontinued for the present until further test data under practical operation conditions are available.

Mr. G. D. Brooke:—I recommend the adoption of Conclusions 1 and 2 at the bottom of page 737.

The President:—You have heard the motion. Unless there is objection these conclusions will be adopted. Is there any objection or discussion? The conclusions will be considered adopted.

Mr. G. D. Brooke:—The next subject of this report is the Method of Increasing the Traffic Capacity of a Railway. Mr. M. F. Mannion, the Chairman of the Sub-Committee, will present the report.

Mr. M. F. Mannion (Bessemer & Lake Erie):—The report of this Sub-Committee starts on page 739. This Sub-Committee has investigated several different causes for increasing the capacity of a railroad, among them being the effect of the number of trains per day, effect of length of engine district, the effect of double tracking, the effect of supervision, and the effect of heavier power.

In this year's report we attempted to find what effect automatic signals would have on the capacity of the railroad. In addition we wanted to make a further study on a section of a line which we had studied in 1921 and 1922. The first part of this report is devoted to the effect of installing automatic signals. Fig. 1 on page 740 is a sketch map of the road on which the study was made, and Fig. 2 and 3 on page 741 show the plan and profile of these sections.

First, we take up the discussion of Section A-C on pages 739 to 740, in which is stated the physical and operating conditions on this section and show those in which there was no change.

On page 742 are listed the statistics before and after the installation of signals, and you will note in these statistics that decrease in the road time per train of thirty-one minutes is shown and the entire elimination of "31" orders after installation.

Fig. 4 and 5 on page 743 are train and tonnage charts for this section. You will note the saving in time per train in these charts is thirty-one minutes and in Fig. 4, the gain in capacity taken from the chart is 6.7 trains, or an increase in capacity of 37.2 per cent.

Fig. 5, which is also a capacity chart on the tonnage basis, shows an increase in capacity of 13,725 tons per day, or an increase of 37.8 per cent, which is slightly greater than the increase for the number of trains.

Computing the savings for a year, we get a saving of 3395 train hours. Of this amount, we can account for 2509 train hours per year due to reduction in stops which is brought about by the elimination of "31" orders.

The next section is Section A-E, and on page 744 are listed the statistics before and after the installation on this section. In Figs. 6 and 7 on page 743 are the corresponding charts to those which I mentioned on Section A-C.

These charts reflect an increase in capacity of eight trains per day, or on a percentage basis, 51.6 per cent, and the tonnage charts show a gain in capacity of 55 per cent, which is practically the same.

The savings in train hours for this section is 6035, and of this amount, 3407 can be directly assigned to the cause of reduction in stops due to the elimination of "31" orders.

The conclusion for the first part of this report is shown on pages 745 and 746. I do not know that it is necessary to read the conclusions.

I move the adoption of the conclusions for the first part of the report as shown on pages 745 and 746.

The President:—The motion covers the adoption of these as information only, and unless there is some discussion of the subject or some objection, they will be so received.

Mr. L. J. F. Hughes (Rock Island):—I wish to call attention to the fact that there is a conclusion reached here saying that the installation of automatic block signals on a single-track railroad will increase the capacity of the road.

In the report there is set up a number of statistics showing that on this test section certain gains were made in the operation of the road, but it does not seem to me to be clear that we can conclude that the savings made were entirely due to the installation of automatic block signals. It is a very complex problem and there are many variable elements, as the Committee well knows. As a matter of fact, it would be possible on a division engine district, such as shown here, to have the increase due to causes other than the introduction of automatic block signals.

The question I wish to bring up is this: Is the Committee absolutely sure that the savings shown here can be proven to be due entirely to automatic blocks? Automatic block signals, primarily, it seems, are introduced as an aid to safety in operation. If capacity can be increased by their adoption, well and good; but that seems to me a very strong conclusion to arrive at unless it can be substantiated more fully.

Mr. M. F. Mannion:—In answer to the remarks, I would say that I do not think in the report credit is given to the installation of automatic signals for the entire saving that was accomplished after the installation of these signals on these sections. I agree with the remarks just made that the problem is a very complex one and we had that in mind during the preparation of this report.

You will note the report states the physical characteristics existing before and after the installation of signals, and that we have eliminated from consideration those not changed. In fact, the discussion of the report was really a process of elimination, which tended to bring up and eliminate any change in physical characteristics which might have a tendency to cause increase in capacity or reduction in running time, on this particular section. In addition to the installation of signals on this road, another change in the physical characteristics was the installation of telephones and also the elimination or the changing from the "31" to "19" orders.

We have tried to bring out the results or the amounts of saving which we could reasonably say would be the result of the elimination or changing from "31" to "19" orders, and those figures in saving in running time I have quoted. I think that the conclusion, although it may be interpreted as being rather strong, is sound, and that the data presented in this report is sufficient to draw this conclusion, that automatic signals will increase the traffic capacity of a railroad. We have not attempted to put a figure on the amount of that increase in capacity due to the installation of the signals alone.

The President:—Is there any further discussion?

Mr. G. D. Brooke:—We would like very much to have some further discussion of this subject.

Mr. L. S. Rose (Peoria & Eastern):—Mr. Chairman, maybe I can start something. There was quite a little discussion in the Committee over this report, and I am liable to be accused of being the signalman who is against signals, but I am not. There was danger of giving signals credit for what was not coming to them or which might have been made in another way, and the report was boiled down to cold facts. It is a study. The Committee found an installation that they studied and found what was going on. Then they made tests of the train sheets before the installation, and the report is really an actual study of conditions as found.

Anyone can draw his own conclusions, but before the signals were installed they were not doing as well as they did afterwards. The telephones were taken into account. A person might say telephone dispatching would increase the capacity of the railroad, but I can argue the other way; but all of these improvements do help the thing along and are entitled to some credit.

The President:—Is there anybody else on the floor of the convention who wants to say something on this subject to help the Committee?

Mr. L. J. F. Hughes:—If it would be any help to the Committee, I will say that I have heard operating men time and again claim that they could get trains over the track faster if it were not for the blocks, particularly where you have blocks going out of order and you have freight trains flagging blocks.

As far as the increase in saving is concerned, I have also in my experience known cases where the capacity of the road has been increased by a change in Trainmasters and a good live organization in the Operating Department. It might be possible that blocks could be installed in a case like that and the conclusion drawn that the installation of the automatic blocks was the thing that brought about the reduction in operating expense.

I really am of the opinion that this Association does not want to make such a broad statement that on single track the installation of automatic blocks will increase the capacity of the road. I think that automatic blocks are a fine thing, they are necessary for the protection of trains. When your traffic gets to a certain point it is necessary to have automatic blocks in order to operate safely, but I do not believe that we want to go on record as saying that installing automatic blocks on a single track railroad is going to get more trains over the track.

Mr. M. F. Mannion:—Regarding the remarks on change in supervision, we have found to be true the fact that change in supervision will materially increase the capacity of a railroad, and in the history of our report we state that we have studied that question and have reported on it. As far as this case is concerned, you will note on page 740 there is a positive statement that there was no change in supervision. This is a very clean-cut case along that line. We investigated that very thoroughly. You also note that there was no marked change in power, no change in sidings, no change in grades or alinement, no change in the number of operators, and no change in the speed limit of trains. That is, the Committee took into account, or under consideration, every possible element which might tend to increase the capacity of the railroad on these sections after installation of the automatic signals, and we have found no conditions changed which might tend to bring about this increase in capacity except the installation of automatic signals and the telephones in connection with the same.

The President:—Mr. Hughes, I take it that you are not averse to this being received as information for the purpose of promoting discussion?

Mr. L. J. F. Hughes:—Yes, sir.

The President:—That being the case, we consider there is no objection to the reception of this report as information, in the hope that it will promote discussion and bring forward new ideas on the subject.

Mr. M. F. Mannion:—The second part of this report is devoted to additional study on a 140-mile section of road on which a previous report was made in 1922. We wish to present this part of the report as information, and I just wish to call attention to a few of the features of it.

Page 751, shows the chart and method which the Committee feels is a very good and proper method for determining or measuring the increased capacity of a railroad. Exhibit A on page 750 is an outline, or the consecutive steps, showing just how these charts can be plotted. I want to say in every case where we have tested out the accuracy of this theory, we have found it to be very close to the actual conditions or results, that is, calculating the area of the train diagram, we find it to check very closely with the actual train hours.

I wish to recommend that every member of the Association read the report, because you will find in there points which will be very interesting. We have five different sub-divisions of this 140-mile section, and each one of them shows the result of different operating conditions, such as increase in steam power, the effect of adding additional sidings, the effect of down grades. For example, on Section A-L the traffic was down grade. There was practically no change in operating conditions, to increase the capacity of the road or speed up the time. You will find that these charts for this section practically coincide.

Then we also take a sum of three of these sub-divisions and see if the gain in capacity over the entire district is equal to the sum of the several different sections, and we find this is not the case. We find that there were improvements in the movement through the yards which were due to improvements in sidings and alinement of grades outside of the yards. This is a question which requires further study. I wish to recommend that this subject be continued in the hope that we will be able to get more information regarding automatic signals, so that we can further supplement this report next year.

Mr. G. D. Brooke:—Appendices C, E and F on pages 756 and 757 are simply statements of progress by the respective Sub-Committees. Appendix D is a similar report, but carries with it the recommendation that the subject of the utilization of locomotives be discontinued. That is brought about because of the large amount of work which the Committee is informed has been done on this subject by the Mechanical and Operating Divisions of the A. R. A., and which we understand will result in quite an elaborate report at forthcoming conventions of those Divisions.

That concludes the report of this Committee, Mr. Chairman.

The President:—The report of the Committee will be accepted, and cognizance of their recommendations in regard to the subject of utilization of locomotives will be taken by the Outline of Work Committee of the Board of Direction.

The Chair wishes to compliment the Committee on the work they have done this year and dismiss them with the grateful thanks of the Association. (Applause.)

DISCUSSION ON ROADWAY

(For Report, see pp. 759-828.)

Mr. C. M. McVay (New York Central—Chairman):—The report of the Roadway Committee is found on page 759. The Committee reports on three subjects. The first assignment was report on Revision of the Manual, which is found in Appendix A, pages 760 to 787. Mr. C. W. Baldridge is the Chairman of the Sub-Committee on this subject and he will present this report.

Mr. C. W. Baldridge (Atchison, Topeka & Santa Fe):—The first subject assigned to the Committee on Roadway is the same as the first subject assigned to every other committee, and reads, "Revision of the Manual."

On August 1, President Fairbairn addressed a letter to all committees urging them to make a careful study of the Manual and see if considerable matter in the Manual could not be removed or reduced in order to conserve space and to prevent the forthcoming edition being too large for convenient handling.

The Roadway Committee took President Fairbairn seriously and proceeded to prepare the revisions proposed in Appendix A, which begin on page 760 of Bulletin 284.

The following changes are recommended: On page 17 of the Manual, "Preceding definition of 'Washout,' insert definition of 'Flood Damage.'" To read as follows:

"Flood Damage. Any and all damage to railway property caused by any unusual flow of water."

On page 17, "Washout." I will not read the old form as it is printed here. In the definition of "Washout" we received a written comment from Mr. Tratman, in which he calls attention to the fact that we have no definition for the words "permanent way." Furthermore, "permanent way" is not a term very much used in the United States. At Mr. Tratman's suggestion, we wish to substitute the word "roadbed," for the words "permanent way" in "Washout," making it read, "Washout.—An erosion of the roadbed by storm or flood to such an extent as would cause delay of trains, or endanger traffic."

On page 18, we propose the following definition, "Center Line.—A line adopted to be the center line of the track or tracks."

On page 19 the term "Channel" is a depression in which a stream flows. "Tile Drain" is an underground drain constructed of clay or cement pipe. That concludes the definitions.

On page 21, Article 5 (I believe this is in the specifications for grading) the distance between center lines of main tracks on tangents should be not less than 13 feet; on curves this distance should be increased enough to maintain an equivalent clearance between equipment on adjoining tracks.

Paragraph 8: Information on profiles should be so given and arranged that units and costs of grading can be intelligently estimated.

On pages 761, 763, 765, 767 and 769 are the proposed readings of the proposed changes. In regard to matter on page 763 near the bottom of the page, Article 22, we received a letter from Mr. Miller who suggests some changes which we think should be made, in the direction of substituting for the word "be" the words "the space" and adding to the paragraph "but not to exceed . . . . inches below subgrade," making this section read: "Rock excavation shall be taken out . . . . inches below subgrade and the space refilled to subgrade with approved sub-ballast or ballast material. The measurement of excavation shall be made to the bottom of the material removed, but not to exceed . . . . inches below subgrade."

On page 770 begins the reading of matter at present in the Manual on the subjects of Mechanical Shovels, Locomotive Cranes and Dragline Excavators, Shovel Methods and Operations. This matter is undoubtedly excellent information, but it is quite voluminous and it is rather doubtful that it is really recommended practice. We assume it would be of as much value in the Proceedings and would reduce the matter in the Manual by about fifteen pages. Consequently on pages 770-784 is presented matter which we propose to remove from the Manual.

Beginning at the bottom of page 784 are the tunnel sections as they now appear in the Manual. It has been commented several times that the double-track tunnel section does not provide the same clearance as the single-track tunnel section. Consequently, the Committee have prepared revised tunnel sections which appear on page 785, designed very much the same as the previous tunnel sections, except providing exactly the same clearance in the double-track tunnel overhead clearance, as provided in the single-track tunnel, and also the same clearance as provided in steel bridges.

This, with the matter at the top of page 787, completes the revisions of the Manual which we propose.

Mr. C. M. McVay:—I might say in that connection, that the revisions which Mr. Baldridge went over from page 760, the middle of the page, to the beginning of the material on mechanical shovels, are all revisions of the grading specification. It was the idea of the Committee in revising these grading specifications to take out all reference to the word "contractor." In other words, the construction contract as proposed by the Committee on Contract Forms, together with the specification for grading, will cover a grading job, or if it were proposed to do grading with company forces, they could be given the specifications for grading which would have no reference to a contract or a contractor. That was the idea in quite a number of these changes.

I move that the report as submitted be adopted and printed in the Manual.

The President:—It has been moved and seconded that this report as written be adopted and printed in the Manual.

Mr. H. E. Miller (Central Vermont):—Are these paragraphs to be acted on as a whole or taken up for discussion paragraph by paragraph?

In Paragraph 10, it seems as though the word "payment" is objectionable. You look to your contract for your payment and your specifications for your estimate. It seems to me the word "estimates" should be substituted for the word "payment."

Mr. C. M. McVay:—Have you a change to suggest?

Mr. H. E. Miller:—It reads now, "for which service payment shall be made." It should be changed to read, "for which service estimates shall be made."

Mr. C. M. McVay:—It is really the same thing. It does not state the amount of payment, or anything like that. There is no contract condition there, as I understand it. Your contract would state "for which service payment shall be made at sixty cents per tie," etc. It was the idea of the Committee when this was made that the word "payment" was better than the word "estimate." It might be also that payment would be made in some manner for this timber, which, of course, would be a separate idea entirely.

Mr. H. E. Miller:—In Section 18 on page 763, in reference to the word "masses," it seems to me that there are only two classes of solid rock—one is rock in solid bed and one is boulders. The definition of a boulder is a mass of rock that has been transported by natural agencies from its native bed. It seems to me that the word "masses" does not add anything, but if the Committee feels that word ought to be left out, something should be added to define the word "masses" to show that something else is meant other than rock in solid bed or boulders.

Mr. C. W. Baldridge:—The matter given here is a specification covering classification and is not a definition of Solid Rock.

It is unfortunate that the terms "Solid Rock" and "Loose Rock" ever were adopted to designate classifications, because a great many people seem to confuse the specification of solid rock classification, and the definition of "solid rock."

Just for illustration, assume that we call this "Heavy Classification" and say that Heavy Classification shall comprise rock in solid beds or masses or boulders measuring one cubic yard or more, and all other material which can most economically be removed by blasting. I believe it would cover the Solid Rock Classification and would be clearer.

However, we are leaving the terms "Solid Rock Classification" and "Loose Rock Classification" in the Manual because they have been customary throughout the construction of railroads in this country.

In the matter of eliminating the word "masses," the definition of a boulder may be a mass of rock, but the definition of a mass of rock is not necessarily a boulder. Everyone who has had very much construction, in the mountains at least, knows that there is a great deal of material which must be moved and classified as solid rock which is not solid. It is a mass of rock in various shapes and conditions. In the volcanic section of the southwestern part of the United States there is a class of material generally called malpais, which is anything in the world but solid rock. It is about the hardest thing to move there is. It can not be drilled readily because the drill wants to change directions about every two inches. It is very hard, full of seams, and when the workmen get a hole drilled and put in a charge of explosive, they very frequently get almost no results, because of the seams. Almost no contractor, one of experience, would be willing to move malpais as cheaply as he would solid granite because it is harder to move.

If we will get away from the idea that this is a definition of solid rock and make it the specification for classification, I believe you will find that the wording given by the Committee is about correct.

Mr. H. E. Miller:—It seems to me it would be advisable to do away with the headings "Solid Rock, Loose Rock, Common Excavation," paragraphs 18, 19 and 20, and insert the heading "Classification" before paragraph 18 and have paragraphs 18, 19 and 20 come under the word "classification."

Mr. C. M. McVay:—The word "classification" is mentioned in each one of the paragraphs; it is very distinctly shown there, solid rock classification, loose rock classification and common excavation classification, and it was put in quotation marks to bring that part out particularly.

Mr. H. E. Miller:—As far as the latter part of paragraph eighteen is concerned, it provides that all of the material which can most economically be removed by blasting shall be classified as solid rock. It seems to me that you have a clause there which may possibly be the cause of considerable trouble.

The contractor can predetermine what his classification is going to be. On the other hand, you tie the hands of your Engineer so he cannot use his individual discretion and judgment. Supposing you have a class of material which is not solid rock or boulders which is difficult to handle, but which in the opinion of the Engineer is not so difficult to handle and so costly to the contractor as solid rock excavation. Supposing you have along your line difficult material of various grades, one material easier to handle than the other. Under this specification the Engineer cannot exercise his own judgment and discretion and must allow solid rock classification for that entire material. It seems to me it would be preferable, instead of using that clause, to insert after paragraph 18 a provision to read something as follows: "All material which can be removed most economically by blasting that does not come under the provision of Section 18 or Section 19 shall be classified on a percentage basis as solid rock, loose rock, or both, as conditions warrant."

Under that provision, if you have difficult material to handle, the Engineer might in one place classify 25 per cent solid rock and in another case 5 per cent solid rock, according to the difficulty of the material.

In that way, what you are really doing is establishing a separate classification for each one of those cuts and indirectly establishing a separate price which both the railroad and the contractor would be interested in.

Mr. C. W. Baldridge:—The paragraph as written states all other material which can most economically be removed by blasting. I never saw a construction job that had classification in it but what the classification was based on the judgment of the Engineer, and I do not see anything here which states that the contractor shall be the judge as to whether it would be most economically removed by blasting or not. That still is in the judgment of the Engineer. Any further modification which is necessary or desirable should properly be made in the contract.

Mr. J. B. Jenkins (Baltimore & Ohio) :—I suppose the gentleman who made the objection referred to an experience something like I had about 35 years ago where a contractor had common earth to excavate in a big borrow pit, and he found that an easier way of doing the work was to put in small charges of black powder and shoot the earth instead of picking it. The contractor came to me and claimed solid rock excavation although it was clearly and distinctly earth. Of course, I decided it was common excavation. This provision recommended by the Committee does not place it in the hands of the contractor any more than it was in the hands of the contractor then. It stands to reason if it were left to the contractor and the common excavation cost 40 cents and solid rock one dollar, and if he could remove it by pick and shovel for 35 cents and by blasting for 60 cents, he would blast it if he thought he would get solid rock classification thereby. But I never heard of a contractor being permitted to make his own classification. He could spend the 60 cents if he wanted to, but the Engineer would still give him the common classification.

Mr. J. L. Campbell (Southern Pacific) :—I think it would be difficult to make any improvement in the classification of material submitted by the Committee. We could discuss this subject all day, and I think we would really make little progress in the way of benefiting these details.

All of us who have had experience in this kind of work know that most of the trouble under a contract when it comes to the final estimate arises in the classification that has been made. It seems impossible to write a classification or specification that will remove the possibility of trouble in the settlement or the absence of actual trouble in the settlement.

I want to make a suggestion that it not infrequently happens on a particular piece of work that it is quite possible to classify the material before the contract is signed. That is not always possible, of course. Sometimes the character of the country and the indeterminate things about the character of material are such that a satisfactory predetermination of the classification cannot be made. I will cite a case of a contract covering 65 miles of rather heavy work which I divided into three sections. It so happened that the variation in the character of material within the 65 miles was such that it fell naturally into three very well-defined districts.

After the location was completed I had excavations made along the line on all of the cuts to develop the character of material, and advised the contractors they could supplement the investigation as far as they desired. They did that at very reasonable expense. The result was that this contract was let in three sections on a flat rate price for each and we removed the question of classification at the time the contract was signed. For cases of that kind I make the suggestion that you may be able to remove the troublesome thing of classification by doing it in the beginning.

The President:—In order to make progress, the Chair suggests that we act on this motion in its entirety. If the convention does not see fit to put through the suggested changes in the Manual, they have the privilege of declining the motion, and it will be turned back to the Committee for further consideration. We will then ask those who have any suggestions to make to submit them to the Committee in writing and give them a chance to go over the matter again thoroughly.

Are you ready for the question, or is there any further discussion that someone wishes to make? All in favor please say "aye"; contrary "no." It is carried unanimously.

Mr. C. M. McVay:—The second part of the Roadway Committee report is found in Appendix B, pages 788 to 793. Mr. Wrenshall, the Chairman of the Sub-Committee on this subject, will present this report.

Mr. J. C. Wrenshall (Reading Company):—The report of Sub-Committee on the Economics of Bridge Filling is found under Appendix B, page 788, Bulletin 284. This is not a new subject, as will be seen by the opening paragraph. In the two prior reports submitted by this Sub-Committee the subject was treated from the standpoint of the straight-line method, but realizing the difficulty of getting the report accepted on that basis it was determined to present it this year on the sinking-fund basis.

The report is brief and self-explanatory. It hardly seems necessary to go through the various paragraphs which explain the method followed. We have tried to make it as simple and as clear as possible. Further, we have been in touch with various members who offered objections to the prior reports and we believe that we have covered and corrected the items objected to.

Mr. C. M. McVay:—I move the report be adopted as set forth and printed in the Manual.

The President:—You have heard the motion. Is there any discussion? All in favor please say "aye"; contrary "no." It is carried unanimously.

Mr. C. M. McVay:—The third subject reported on by this Committee is found in Appendix C, page 794 to 828. Mr. W. H. Woodbury was Chairman of the Sub-Committee on this subject, and he will present this report.

Mr. W. H. Woodbury (Duluth & Iron Range):—This report is submitted as information. There are several things that I would like to call attention to which I think may be of interest. As stated in the report, we have made our study on the basis of three main divisions. We have studied it on the basis of durability, economy and strength. We find that under durability we have a great deal of difficulty in obtaining satisfactory information. We have received very little information in regard to failures. As I said on a previous occasion, this material has been in use for such a short time that no one can safely say whether or not it is a permanent structural material. After we are gone—thirty, forty, fifty or one hundred years from now, somebody may be able to accurately determine whether it can be properly called a permanent material.

There are four principal manufacturers of this material. Each claims to have a superior material. We are not prepared to say which material is superior, if any is. Some day that may be determined. There have been a good many laboratory tests made, but it is doubtful whether a laboratory test can be considered conclusive. We are following this subject up. We have reports on thousands of culverts which have been in service from twenty years up until only a year or two, and the vast majority are reported as giving service and in good condition.

In 1910 I had charge of a small piece of railroad construction and installed about fifty corrugated metal culverts. At that time I presumed it was merely a temporary device to be replaced later by more permanent construction. In 1920, ten years later, I inspected these culverts and found them practically in as good condition as when I installed them. Last year, fifteen years after installation, I could see practically no deterioration over the previous inspection.

What the answer is, as I say, somebody who will outlive any of us only will be able to tell.

In regard to economy, we also have available a lot of information. Our difficulty is to get absolute parallels. There is no question to my mind that initial installation of corrugated metal culverts in many cases is very much more economical. If the question of durability is decided in their favor, then we have an advantage in using corrugated metal culverts. That is also dependent to a large extent on the question of durability.

This year we have reported considerable information in regard to strength. You who have read over this report will have found some very interesting information. We believe that it will eventually be of very great value to all designers of both rigid and flexible culverts.

We are under obligation to the American Rolling Mill Company for financing and furnishing material for these experiments. They undoubtedly will receive considerable benefit, but the other three chief manufacturers of this material should receive just as much benefit from these experiments on strength.

I understand that the American Rolling Mill Company have made a reprint and distributed some thirty thousand copies of this report, which, of course, is rather flattering to us.

The Illinois Central Railroad also deserves credit for permitting us to install this experiment on their lines. I want to especially call your attention to the work that Mr. J. R. Wilks, a member of this Committee and a representative of the American Rolling Mill Company, has done. He planned, supervised and carried through this test. That is very briefly stating a very arduous task. These test culverts extended sixty feet into a bank. They were placed in June, last year. The filling continued through June, July and August, and it was necessary for Mr. Wilks and his assistants to crawl into these culverts and carry these heavy compressed air apparatuses and the gages and make over 300 readings.

I was down at the site but once in August. I crawled into three of them, and when I got out the third time I was all in. I got a very vivid impression of what Mr. Wilks had been through. It was a terrific task.

In the interest of applied science he deserves a great deal of credit.

These readings will be continued through the next two or three years, and eventually I think they are going to be of great value.

There are some conclusions presented here which I think are well worth reading.

As I said before, it is presented merely as information.

The President:—If there is no objection to the receipt of this as information, it will be so received.

I wish to congratulate this Committee on the work it has done during the past year, and dismiss it with the grateful thanks of the Association. (Applause.)

DISCUSSION ON WOODEN BRIDGES AND TRESTLES

(For Report, see pp. 829-912.)

Mr. Arthur Ridgway (Denver & Rio Grande Western—Chairman):—The report of the Committee will be found in Bulletin 284, page 829. Of the five subjects assigned to the Committee, final reports are submitted for two of them, a progress report for one, and no report for another.

As is customary, Subject No. 1 comprises revision of the Manual. That report will be found on page 831, and I will ask Mr. Austill if he has anything further to add than the brief text on page 831.

Mr. H. Austill (Mobile & Ohio):—As stated on page 831, the Committee on Revision of the Manual has no definite recommendation to make on revision just now.

Pending adoption of the report of Appendix B, the Committee has no changes in the Manual to suggest.

As shown in Appendix B, mentioned on page 832, the matter now in the Manual on pages 303 and 304 will automatically be withdrawn by the adoption of Appendix B. This Appendix shows where any conflict may exist in the matter now in the Manual.

The new matter presented for consideration at this convention will take care of the revision of the Manual in that way.

Mr. Arthur Ridgway:—I think you are all familiar with the work of the Sub-Committee on Subject No. 2. It has been before you several times. It is rather a misnomer. It reads: "Continue work of co-operation and collaboration with other organizations in simplification of grading rules and classification of timber and lumber for railway uses."

It is really the preparation of comprehensive specifications for all lumber and timber which we use, except ties.

I will ask Mr. W. E. Hawley, Chairman of the Sub-Committee on this subject, to submit the report to you.

Mr. W. E. Hawley (Duluth, Missabe & Northern):—The report of this Sub-Committee is contained in Appendix B on pages 832 to 901. It is divided into three parts, Exhibits A, B and C. The Committee's action recommended is that the final report on subject 2, Appendix B, Exhibits A, B and C, be adopted by this Association and printed in the Manual, withdrawing all material in conflict therewith. Material now in the Manual which would be withdrawn by this action extends from the bottom of page 303, giving names for varieties of structural timber, to page 351, specifications for construction oak, and also table of working stresses for timbers on page 302.

The first section, Exhibit A, is the result of work which has been done by the lumber industry in an effort to improve its methods in carrying on its business. The work has been carried on with a great deal of harmony in the Committee and in order to facilitate the presentation of the report, I will make a motion that the matter contained from pages 833 to 862 inclusive be accepted for printing in the Manual and matter in conflict therewith be withdrawn. If there is anybody who has some special subject to take up in connection with this chapter, it would possibly save time to go to it directly, rather than by reading pages.

The President:—You have heard the motion. Is there any discussion upon it? Are you ready for the question? All in favor of the adoption of this subject matter, please say "aye"; contrary, "no." It is carried.

Mr. W. E. Hawley:—The material contained in Exhibit B applies to structural grades for lumber and timber, and gives the method of their derivation. This section is a special work of two committees that have been working on it, a committee from the American Society for Testing Materials and a Sub-Committee from this Committee. These two committees have worked together in harmony during the year and this report is offered as a result of that work.

The report covers in detailed explanation the underlying basic thought in developing a material for strength for structural purposes. The material covered here beginning on page 869, through to page 891 inclusive, offers to this Association a complete set of grading rules for structural material and can be applied to any of the softwood material.

On page 868, in order to clarify that this does apply to softwood, we ask you to insert at the bottom of the page under the title of "Select," the word "softwood," making it read "other softwood species." The same correction applies to "Common," making it read, "All softwood species."

On page 869, eliminate the paragraph, "Surfacing of Beams, Stringers, Posts and Timbers," which is already covered by a succeeding paragraph.

On page 876, paragraph 21-a, add the clause, "measured across the faces anywhere in the length of the piece," to make that paragraph the same in definitional character as 21-b, 21-c and 21-d.

On page 885, in the table of Index to Numbers of Specifications, add the word "soft" in phrases "any woods" where it occurs there to clarify that situation, making it read "any softwoods."

Those are all the changes that the Committee has to offer this time in the text as printed.

I move that this material be accepted and printed in the Manual.

The President:—You have heard the motion. Is there any discussion?

Dr. Hermann von Schrenk (New York Central):—I rise to second that motion and I take great pleasure in doing so. I regard this as a very remarkable accomplishment. It shows very earnest, practical effort.

Last year the Committee of this Association and the committee of the American Society for Testing Materials reminded me of a condition such as existed several years ago at the French Academy when they were discussing definitions. Some man got up and offered a definition for a crab. He said a crab was a small fish, red in color and walked backwards. One of the zoologists of the committee rose and said he had no objection to the definition except this: The crab wasn't a fish, it wasn't red, and it didn't walk backwards, otherwise the definition was all right. That was about the condition last year with the two committees of these two great associations.

I take particular pleasure in complimenting the Committee this year on the manner in which they proceeded to correct the differences which existed between these organizations. At a meeting held here yesterday of the Timber committee of the American Society for Testing Materials, they agreed to the report of the Committee on Wooden Bridges and Trestles, and they will present it to their Society in June and they hope it will be unanimously adopted.

Mr. A. F. Robinson (Sante Fe):—I think the Committee is to be congratulated on their report, and I hope the Association will follow their recommendation.

It is possible and probable that after we have used these rules for a year or two we may want to modify them slightly, but the two committees together have worked very well.

The President:—Is there any further discussion?

(The motion was carried.)

Mr. W. E. Hawley:—On pages 892-901, under the title of Exhibit C, is material offered on Notes on Tables of Working Stresses. It also includes the tables for these stresses.

After you have secured material that is properly picked out for structural use, you should have information as to the proper tensile strength and other qualities necessary to work that material.

The Committee offers to you in this Exhibit the material which will enable you to put your design of wooden structures on a rational basis.

I move, Mr. Chairman, that this be accepted for printing in the Manual.

The President:—Is there any discussion?

(The motion was carried.)

Mr. Arthur Ridgway:—We did not quite expect that.

I very much fear that this last section which you have adopted has not been given very careful consideration by the members. When you study it, you will observe that the recommended working stresses are quite different from those that now appear in the Manual. They are increased in some cases, but that has been done because of the fact that with the work Mr. Newlin has done at the Forest Products Laboratory, we know a great deal more about the behavior of wood under stress than we formerly knew. For example, we used to say for stringers we would accept a factor of safety of five in ultimate breaking stress. We did that because we did not know the influence of the defects in the timber on its available strength.

Mr. Newlin, at the Forest Products Laboratory at Wisconsin, has rendered a service, I think, to the railroads of this country that has been unequaled in the use of timber. He has undertaken and has proved the disastrous effect of the defects of timber on its strength.

I am sure that it would profit every member of this organization to obtain from the Forest Products Laboratory something of the work they have done along this line.

Mr. Meyer Hirschthal (Delaware, Lackawanna & Western):—I believe that this is too drastic a change in the case of 8 inch by 16 inch stringers which are very generally used for wooden trestles subject to railroad loadings. For this condition of 16 inch depth of timber, you would have a point three times the depth or four feet, between which point and the support all loadings would be neglected or loadings so placed that the concentration will all be beyond this point in figuring shearing stresses on the timber stringers. I think this is going too far. These 8 inch by 16 inch stringers are used on spans no longer than ten or twelve feet center to center. This would bring this point very nearly to the center of the span—the point of maximum moment, not the point of maximum shear.

Mr. Arthur Ridgway:—I do not believe we have the time to enter into the technical discussion of this particular phase. You have been advised heretofore that we have found in the case of horizontal shear we might have to revise our ideas of the ordinary methods of computation of the maximum shear under concentrated or moving loads.

In order to answer the doubt of the last speaker I will ask Mr. Newlin to very briefly, if he can, state the reason why this clause is inserted.

Mr. J. A. Newlin (Forest Products Laboratory):—The horizontal shear formula, in fact the whole bending formula, is based upon the assumption that there is no distortion in shear; that a plane section perpendicular to the neutral plane remains a plane section perpendicular to the neutral plane. Everybody knows that this is contrary to all the principles of mechanics inasmuch as you cannot have a stress without having a strain. As the load approaches the ends of a checked stringer (and it is only checked stringers that we care anything about, for they are the only ones that fail by horizontal shear) the distortion due to shear is so great that the end of the beam acts to a very large extent as two independent beams—partially as a single beam and partially as two independent beams. It is this error in the formula that caused us to make the recommendation. In our tests we have found that this recommendation is perfectly safe, and conservative. It is not that we are trying to neglect any loads. We want to load the beam so that we get maximum shear. With the largest load placed at this distance from the support, we have found that we get the most likely place for horizontal shear. We are not attempting to give anything exact. We all know that engineering is not an exact science and the formulas of engineering are not exact. We are trying to correct to some extent a fundamental error in our engineering formula.

Mr. Meyer Hirschthal:—Mr. President, I want to continue this a little further. We have always been taught from the start that the maximum shear is at the point of and equal to the maximum reaction for a beam fully loaded right up to the end. We know that this is far from true, that some of the end loads distribute directly to the supports. Nevertheless, there is a point beyond which we cannot go. To figure that all loads up to nearly the center of the span, as in the instance cited above, are carried directly to the support and not by shear, approaches the absurd. I believe that we should go no further than 45 degrees, or a distance equal to the depth of the beam, as the point at which we can neglect the loads; that is, consider the loads from the point at a distance equal to the depth of beam to the other end of span as giving the maximum reaction and therefore maximum shear. I emphatically object to taking any distance greater than the depth of the stringer as the distance inside of which the load can be neglected.

The President:—Mr. Hirschthal, the section of the report you are referring to having been adopted by vote of the convention, you would have to move for a reconsideration of it in order to continue the discussion further.

Mr. Meyer Hirschthal:—Under parliamentary rules, not having voted for it, I cannot move to reconsider.

Mr. Arthur Ridgway:—In order to conserve time and bring together the subjects that are closely related, we will take up Subject No. 5, "Continue the study on classification of the uses of timber and lumber under American Railway Engineering Association specifications." You have already adopted the specifications, and therefore your attention is called to the use of classification for railroad purposes.

Mr. W. H. Hoyt is Chairman of this Sub-Committee and I will ask him to present his report.

Mr. W. H. Hoyt (Duluth, Missabe & Northern):—Report of this Sub-Committee is shown from page 907, Appendix D, to page 912, inclusive. This Sub-Committee reported last year on the basis of specifications then placed before the Association, but the return of those specifications to the Committee for further consideration automatically referred back this particular work. We submit this year in Appendix D classification for uses of timber and lumber under the American Railway Engineering Association's specifications as they have now been approved.

Mr. President, I move the adoption of the report in Appendix D.

(The motion was carried.)

Mr. Arthur Ridgway:—A progress report is submitted on Subject No. 3, Value of Treated Timber in Wooden Bridges and Trestles. I think there is little to say on this. We have not sufficient data to return a final report. There are certain conclusions which are tentatively arrived at by the Sub-Committee, and I will ask Mr. C. S. Heritage, Chairman of that Sub-Committee, to present those tentative conclusions.

Mr. C. S. Heritage (Kansas City Southern):—This report, the Value of Treated Timber in Wooden Bridges and Trestles, appears in Bulletin 284, beginning on page 902. The Committee has studied this subject to get the relative economy of using treated timber as compared to untreated timber and taking into account the physical properties. They have concluded the advantages of creosoted timber are such that timber bridges and trestles should be treated timber, unless the structures are of a temporary nature.

The report is presented for information only.

Mr. A. F. Robinson:—The Committee in discussing or in reporting heretofore on creosoted timber stated that they did not have any definite information regarding the effects of creosoting on the strength of the timber.

I would call attention to the fact that on Southern pine, quite a good many years ago, the Atchison, Topeka & Santa Fe ran a series of very careful tests. A portion of the stringers was tested within a month after treatment. The stringers were treated by the full-cell process without temperature and were shipped to Topeka immediately and treated. The control pieces untreated were stored. About a year after this series of tests the other half of the pieces were tested in the same manner. We found that when the new timber was tested right after treatment there was a small loss in the ultimate bending strength. We also found after a year of storage this strength was all regained and the creosoted timber was actually stronger than the untreated control pieces which had been stored in the yard for final seasoning.

The whole information appeared in a Bulletin of the Association and can be found in the Proceedings.

The President:—Unless there is some objection to the acceptance of this section of the report as information, it will be so received.

Mr. H. C. Crowell (Pennsylvania Railroad System):—On page 903, third paragraph, the last sentence has aroused my curiosity. "In general, the Committee believes that when the structure has deteriorated to the extent that one-half of the original cost has been used for maintenance, that the structure should be replaced."

I can see a connection between the cost of heavy repairs and the cost of replacement, but I do not see the connection between the accumulative cost of repairs in the years that have gone and the present cost of replacement. It seems to me this is a new theory, and the Chairman might explain what is the basis of it. My criticism is not of the fraction one-half, it might be one-third or two-thirds, but it is the underlying theory of this thing.

Mr. Arthur Ridgway:—That is probably one of the reasons why we do not present this report and ask for its adoption at this time. That is a feature that is very hard to determine. We are not prepared to have it carried. We found the practice is widely different on different roads, and the same roads change their practice from time to time, and on the renewal of trestles, whether they shall be carried along for a long period of time by continual repairs or be taken out and renewed entirely at a sooner time is a very hard matter to decide. That is a matter we want to go into more fully the coming year. Does that answer your question?

Mr. H. C. Crowell:—I want to make sure that the grounds for the statement are good before it gets into the Manual, which may be reissued next year. It seems to me this kind of a rule of thumb is a rather dangerous thing to be put into our reports.

The President:—Mr. Crowell, I think your remarks are well taken, and the Committee is submitting the report only as information at the present time. I wish to just impress that again on the convention. These reports that are submitted as information are to come up again the following year, and it is hoped by the Board of Direction and by the committees in each case that the members of the Association will assist them in every way possible by sending in written discussion on what is submitted as information.

Unless, therefore, there is some specific objection to this Appendix C to the report of the Committee on Wooden Bridges and Trestles being received as information, it will be so received.

The Chair wishes to say that the position of this Committee seems to be somewhat unique. Last year, when this Committee was reporting, as Dr. von Schrenk has pointed out, they had rather a rough passage. Apparently they have been able to pour oil on the troubled waters, smooth things out to a wonderful extent. They are to be most heartily congratulated on the success of their work. Today they had the unique experience of two members of the Association getting up on the floor and congratulating them and seconding their motions, and those two members not members of the Committee.

The Committee will now be relieved, with the thanks of the Association for their most excellent work. (Applause.)

DISCUSSION ON WOOD PRESERVATION

(For Report, see pp. 913-1001.)

Mr. S. D. Cooper (Atchison, Topeka & Santa Fe—Chairman):—The report of Committee XVII appears commencing on page 913 of Bulletin 284, and the following reports are to be covered: The Revision of Manual; Treatment of Douglas Fir; Service Test Records; Marine Piling Investigations; Preservative Treatment of Trunking and Capping; Treatment with Creosote and Petroleum, and Treatment with Zinc-Chloride and Petroleum.

Perhaps I might save a little time if I ask that the Committee be given permission to withdraw the report on "Preservative Treatment of Trunking and Capping," on account of the fact that after the joint committee with the Signal Section and this Committee met, there were some slight differences in the specification and they were only acted on yesterday at the meeting of the Signal Section. I would like to have permission to have this assigned as a subject for next year's work, when we will have the specification ready for adoption.

The President:—The Board will take cognizance of that, Mr. Cooper.

Mr. S. D. Cooper:—The first report is Revision of the Manual, Appendix A, which Dr. von Schrenk will present, and in this connection, gentlemen, we are going to try and save some time because a large amount of this is just editorial or grammatical corrections and the Doctor will point out any differences in changing any of the specifications.

Dr. Hermann von Schrenk (New York Central):—The report of the Sub-Committee on Revision of the Manual begins on page 914 and continues through to page 964. As indicated in the report, there are two separate sections of the revision as recommended by the Committee this year.

I call your attention first of all to Exhibit A, pages 921-964. This is merely an editorial revision in which we have removed useless clauses, corrected split infinitives and other errors, and rearranged the language.

There is no change in the subject matter whatever, and unless requested we will refrain from reading this lengthy report.

In presenting it, however, the Committee would request notation of the following changes or corrections, which are due to the fact that this editorial revision was a tremendous job and in spite of numerous readings certain errors have crept in and certain omissions were made. These changes are briefly as follows:

Page 926, paragraph 4, in the third line, the second word reads at present "injection." This has been a word which has been in our Manual for a great many years and has escaped notice. That word should be corrected to read "ejection."

The second change which the Committee wishes to request as part of the revision is that we be authorized to omit the word "oil" in every case where it occurs after the word "creosote." The recent introduction of the use of petroleum brought about considerable confusion as between creosote oil and petroleum oil. The word "oil" practically has no significance in either case, and we are recommending that the change in the Manual be made so that wherever it says "creosote oil" it shall be "creosote," and where we use the word "petroleum oil" it shall be "petroleum."

An addition is requested on pages 924, 925, 927 and 928 in the specifications for treatment. This is an addition which was adopted since the recommendation of the Committee appeared in print at the American Wood Preservers' Association at their convention a few weeks ago, and it reads as follows: (In the present specifications we provide that from 90 to 110 per cent shall be regarded as an appropriate absorption of preservative, this being due to the fact that the variability of timber in operating conditions is such that you cannot always accurately get the 100 per cent provided in the specifications, but this clause has been subject to some misinterpretation, and to clear it we would like to suggest the addition of this clause in all of the four specifications in the pages referred to.)

After providing that there may be a variation from 90 to 110 per cent, add "but the average retention of preservative by the material treated under any contract or order shall be at least 100 per cent of the quantity specified."

In other words, that simply means that the protection given to the railway should be the intended specification, namely, 100 per cent retention, but that any individual case may have a variation of 10 per cent above or below.

A second addition, which is likewise simply a matter of clarifying the interpretation of the clause, appears on pages 924 and 926, where it provides that a certain required quantity of preservative shall be injected, or until the railroad's representative is satisfied that the largest volumetric injection that is practicable has been obtained.

In order to clarify this we recommend adding after the word "or" two words, "failing this," making it read, "The required quantity of preservative is injected into the material, or, failing this, until the railroad's representative shall be satisfied," etc.

I say that is simply a clarification.

With these corrections, Mr. President, I move you the approval of the editorial revisions on pages 921-964.

The President:—You have heard the motion that Appendix A be adopted with these revisions for inclusion in the Manual.

(The motion was carried.)

Dr. Hermann von Schrenk:—The second part of the revision of the Manual consists of certain recommendations which appear on pages 914-920.

At the suggestion of the Chairman, I will not read these in detail, except to point out the principal recommendation for a change. Most of these changes which we are recommending are more or less clarifications and eliminations of unnecessary material that is described in these pages.

The principal change that we are recommending is in the apparatus for distilling creosote. We started in 1902 to standardize the then multifarious forms of distilling apparatus and finally, after a great many co-operative experiments, other technical organizations adopted the retort.

There has been increasing difficulty in recent years in obtaining standardized retorts due to the difficulty of glassblowers in making retorts of uniform size. A great many investigations have been carried out by the Timber Committee of the American Society for Testing Materials as well as the Timber Committee of the American Wood Preservers' Association and this Committee, to find if the new suggested apparatus would give the same type of results which we had been getting for years with the retort, and a type of flask has been developed which as indicated in this year's report gives concordant results; in other words, what we are suggesting is not a change of method, a change in end results, but simply a change in the form of the apparatus.

This flask is illustrated on page 914 and the changes for the same are on 915, and the actual setup, which is identical with that which we have in the Manual now with the exception of the change of the flask for the retort, on page 916.

The other changes which we have made, or which we are suggesting and recommending for adoption, deal with a revision of the method for determining coke residue, which is in accordance with the recommendations both of the American Society for Testing Materials Committee and the Wood Preservers' Association.

We have also eliminated obscure references to processes which hitherto had to be so printed because of patent protection; these patents now having expired, the simplified titles are recommended.

We are also recommending certain changes in the manner of arrangement of the creosote specifications, all of which appear on pages 919 and 920.

Unless there should be some specific request for explanation as to further reasons, we move that the changes as recommended on pages 914 to 920 be adopted for printing in the Manual.

The President:—You have heard the motion. Is there any discussion? There being no discussion, we will consider that as adopted.

Mr. S. D. Cooper:—The next report is the Treatment of Douglas Fir, which specification we recommend for adoption. Mr. W. H. Kirkbride will present the report.

Mr. W. H. Kirkbride (Southern Pacific):—The refractory nature of Douglas Fir makes it necessary to have rather a special set of specifications. This report is under Appendix B, commencing with page 965.

First is the introduction, and then follows sub-division 2, General Specification Requirements, on page 967; sub-division 3, Preservative Treatments, on page 970.

There are some corrections that we wish to make when the report is printed.

Will you please refer to page 966, Preservative Treatment, clause 8, and insert the phrase "Lowry process," before "Empty Cell Process with Final Vacuum."

Insert "Card process" before "Creosote-Zinc Chloride Emulsion Process."

Page 967, the latter line of clause (a), we wish to change the word "the" to "an," reading "Treatment by an empty cell process."

On page 970, Preservative Treatments, insert after "Full cell process," "For Douglas Fir Treatment."

Also two lines below where the phrase "Oil solution" occurs, change to "mixture."

Similarly on page 971 about the middle of the page, Rueping Process should be followed by "for Douglas Fir Treatment." Likewise on page 973, Lowry Process should be followed by "for Douglas Fir Treatment."

I do not think it is necessary to go into the details of this report. I move it be adopted for the Manual.

The President:—You have heard the motion? Is there any discussion?

Mr. Arthur Ridgway (Denver & Rio Grande Western):—I have a question to ask the Committee. On page 972, the third line from the end of Section 3 reads thus: "For a period not to exceed one hour nor more than two hours." If it does not exceed one hour it could not be more than two, could it?

Mr. W. H. Kirkbride:—It should be "not less."

Mr. S. D. Cooper:—We will make that change.

The President:—Is there any further discussion? All in favor of the motion will please say "aye"; contrary "no." It is carried.

Mr. S. D. Cooper:—The next report is Service Test Records on page 975, which we present as information. Mr. Z. M. Briggs is the Chairman of the Sub-Committee.

Mr. Z. M. Briggs (Pennsylvania Railroad System):—This report is largely self-explanatory. I would like to say that the Forest Products Laboratory went over their records very completely this last year and revised them. They cut out some records which they formerly reported, on which they thought they did not have sufficient data, and those that are left are complete records which they have good data on.

The table of cross-tie renewals per mile of all tracks is in better form I think than it has been before, and is put in this form for ready reference and not for a comparison of the roads which are reporting. The main thing is that roads that have the largest percentage of treated ties now in track show the greatest benefits in reductions of renewals.

On page 977 there is a table showing the relation between percentage of renewals of any group and the percentage of the average life of that group. This is exactly the same as the curve which has been previously published, showing the same relation but putting it into tabulated form for more ready use.

The President:—If there is no objection, Appendix C as suggested will be received as information.

Mr. S. D. Cooper:—The next report is on page 978, Appendix D, Marine Piling Investigations. Dr. von Schrenk is Chairman of the Sub-Committee.

Dr. Hermann von Schrenk:—The report of the Committee on Marine Piling Investigations is submitted as information and will be found on pages 978 to 995. As indicated in the first paragraph of this report, this Committee has had rather hard sledding because nobody was willing to do any financing, and the work of the Committee is necessarily of such character that it involves a great amount of labor. This year, as indicated in the preliminary paragraph, was devoted to continuing the active research work which had been initiated by the Marine Piling Committee of the National Research Council following the San Francisco disaster many years ago.

Through an arrangement between the President of the National Research Council and the President of this Association we have gotten such records as were running records as well as all data accumulated by the National Research Council that might be of interest to the railroads. That was turned over to your Sub-Committee. We tried with the active co-operation of the Chemical Warfare Service and of a great many very enthusiastic and disinterested officers of both the Navy and War Departments and Department of Commerce to bring these records up to date and will do the best we can in the future to continue to do so.

The present report is more or less a detailed report of that character, giving the present status of the investigations which were initiated some years ago, as well as some new matters. I would like to call particular attention to the very delightful visit which I had the privilege as Chairman of this Sub-Committee of paying this summer in London with the officials of the British Marine Piling Committee. While comparisons may seem invidious, I cannot help but express the admiration which I unconsciously had to express to these gentlemen for the manner in which the British engineering world has attacked this problem.

At the building of the British Institution of Civil Engineers they had very commodious quarters, including a very large room which had been turned into a museum. It was perfectly amazing to see the collection of material that had been sent from all parts of the British Empire; not only had the material been sent, but what was even more remarkable, it had been very carefully taken care of with beautifully printed labels, beautifully classified with practically all of the detailed information obtained on each specimen readily accessible on a card catalog.

Dr. Crosthwaite, the Secretary of the British Committee, is most enthusiastic in offering every possible co-operation with the Committee of this Association and volunteered to keep us advised from time to time of any discoveries they might make. They are at the present time engaged particularly in testing out the relationship between possible methods of protection of a good many of the poison gases developed during the war in relation to the question of marine protection.

I tried very hard to borrow the most extraordinary specimen, at least temporarily, to show it to you gentlemen, but my humorous references to such a possibility were not thoroughly understood by the officials of the

Committee. I did promise to return the specimen, but they could not see it that way.

They had two specimens of teredos sent to them from New Zealand. Gentlemen, one was a perfectly impossible teredo. It measured three feet and a quarter of an inch in length and the big, or working end of the organism, the outside diameter of the shell was a little over three inches. Imagine a creature a little over a yard in length, three inches wide. I tried to persuade Dr. Crosthwaite to let me take that so I might walk up and down Broadway with this as a club in my hand for the purpose of raising additional funds.

I hope next year the Committee may be able to publish a photograph of these teredos. They have not yet been published by the British Committee. I was requested to withhold that until the Committee publishes that. I would like in this connection to make a motion in accepting this report as information that your Committee be authorized to give similar expressions of co-operation with the officials of the British Committee.

I said that report is given as information. I might add one other reference. Referring strictly to the co-operative work to which we are indebted to the Southern Pacific Railroad, you will remember that at the time of the San Francisco work, certain piers belonging to the Southern Pacific Company showed remarkable immunity. The reason for this immunity was a mystery. Whether it is due to the type of creosote or treatment, or due to the fact there had been no organisms present in the bay during the period of service was not determined, but due to the co-operation of the Southern Pacific, a number of these piles were transplanted, some in Seattle harbor on the Northern Pacific, some in the piers of the Santa Fe in Southern California and certain pieces were submerged in the piers of the Louisville & Nashville Railroad at Pensacola.

We have presented a rather detailed record of the most recent examination of those piles. The striking fact is that practically most of them, even in these locations of high teredo attack, are still comparatively free. Why that is or what the Southern Pacific did to these piles twenty years ago is still to be determined.

The President:—Unless there is some objection to this report, it will be accepted as information. It is so ordered.

Mr. S. D. Cooper:—The next two reports are found on pages 1000 and 1001, the Treatment of Creosote and Petroleum and Treatment of Zinc-Chloride and Petroleum. Mr. R. S. Belcher, the Chairman of the Sub-Committee, will present the report. I am going to ask him to tell you the status of this work and the reports will be presented as information.

Mr. R. S. Belcher:—The same Committee handled these two subjects. On page 1000, mixture of creosote and petroleum. This is merely a short synopsis of the work of this Committee, and it is given with the recommendation that the Sub-Committee continue until the additional data needed is available.

Page 1001, zinc-chloride and petroleum. Committee reports on this subject have been made to the Association the past two years. During last year about 3500 ties were treated with an emulsion of zinc-chloride and petroleum and placed in test tracks. The zinc-petroleum emulsion treatment was described in last year's report. An attempt is now being made to perfect this process so that it may be used in standard size treating cylinders and under the usual treating plant conditions.

The President:—Unless there is some objection, Appendix F and Appendix G will be received as information. It is so ordered.

I wish to thank the Committee in behalf of the Association for the work done and to dismiss them with the thanks of the Association. (Applause.)

DISCUSSION ON BUILDINGS

(For Report, see pp. 1061-1204.)

(Past-President Hunter McDonald in the Chair.)

Mr. W. T. Dorrance (New York, New Haven & Hartford—Chairman): —The Committee on Buildings has this year devoted its time principally to two subjects: (1) Revision of the Manual; (2) Continuation of the preparation of the Specifications for Buildings for Railway Purposes.

The other subjects assigned to the Committee have been dealt with as outlined in our report. We do not ask for any action by the Committee on these other subjects.

Revision of the Manual has been put off by our Committee from year to year so that it now involves practically rewriting the entire subject-matter. A detailed report will be found in Appendix A, page 1083, of Bulletin 285.

The principal changes are the omission of all references to certain subjects handled by other committees and the regrouping and rearrangement of the balance of the material. We have omitted:

> (1) The material with reference to Ash Pits. This subject has been handled by Committee XXIII—Shops and Locomotive Terminals, and the matter now in the Manual is not pertinent.
>
> (2) Engine House Design. This subject has been treated by Committee XXIII—Shops and Locomotive Terminals, and the subject-matter in each case now in the Manual is not pertinent.
>
> (3) Locomotive Coaling Stations. This subject is being handled by Committee XXIII—Shops and Locomotive Terminals, and the matter now in the Manual is not up to date.

The changes in the matter retained only relate to arrangement and simplification of the material and make no change in the general recommendations already adopted.

I move, Mr. President, that Appendix A be approved for printing in the Manual and substituted for the material now therein.

Chairman Hunter McDonald:—The Chair understands, and I believe the convention understands, that only such changes as involve the removal from the Manual of subjects that have been assigned to other committees have been made which affect the sense of the matter as now appearing, although there is some rearrangement of the matter which does not affect the sense of what now appears in the Manual. Unless there is objection to that course, the Chair will put the motion to accept this proposed revision of the Manual.

Mr. L. J. F. Hughes (Chicago, Rock Island & Pacific):—I am speaking now in the interest of keeping the matter in the Manual as concise as possible. What I refer to particularly is the paragraph on page 1070, in which rest houses are discussed. It seems to me that while the material given in the paragraph marked "Purpose" is all very good, it is something that is somewhat out of the scope of buildings themselves. It deals largely with the operation of the rest houses, why they are constructed and things having to do with the relations of employees, etc. I think such matter as that could be kept out, and the Manual made smaller and more compact thereby.

Chairman Hunter McDonald:—The matter to which Mr. Hughes referred is already in the Manual. In order to expunge it, it will be necessary to have a motion to that effect. Do I understand you make a motion to expunge that from the Manual

Mr. L. J. F. Hughes:—No, sir; I merely brought that up as a suggestion to the Committee, if they think proper in going over these to eliminate such things as that. It was merely given as a suggestion.

Mr. W. T. Dorrance:—The Committee is very glad to have such suggestions and will consider them fully. We realize the necessity of assistance from the other members of the Association, and welcome suggestions and criticisms of our work.

Chairman Hunter McDonald:—Is there any further discussion? If not, the motion will be put. All in favor of the adoption of Conclusion "A" as submitted in the Bulletin for printing in the Manual will say "aye"; opposed "no." It is carried unanimously and the conclusion is adopted.

Mr. W. T. Dorrance:—The next subject is Specifications for Railway Buildings. Some four or five years ago the Committee presented for consideration of the Association, Specifications for Steel for Railway Buildings, based on what is commonly known as "1011." A very considerable amount of criticism was received and suggestions made that the specification as presented at that time be rewritten. The Committee has been working on this for some considerable time and has had the assistance of Committee XV in this work. Committee XV appointed a special Sub-Committee to help us in getting up such a specification.

We were not able to include this in our regular report for this year but have made a supplemental report. A new specification has been prepared and printed in this supplemental report. We are offering it for information and criticism, and hope it is in such shape that with the help of the criticism we expect to receive during the year, it can be presented for adoption next year. Printed copies of this specification are available now, and it will be printed in the Proceedings.

Chairman Hunter McDonald:—Unless there is objection, this will be received as information. The Chair desires to call special attention to the request of the Committee that written discussion on these proposed specifications be furnished them, as discussion of a report like this before this convention verbally is almost out of the question at the present day.

We will take up first the question of specifications on roofing. Is there a second that the specifications on roofing be adopted for printing in the Manual?

It is moved and seconded and the matter is before the convention for discussion. The Chair hears no discussion. Are you ready for the question?

(The motion was carried.)

Chairman Hunter McDonald:—The question now comes up on the motion of the Committee to adopt specifications for concrete found at the bottom of page 1101. As stated by the Chairman, this specification was objected to last year and was brought up by the Committee on Masonry. It is possible that the matter has been now so amended as to remove the objections.

Mr. W. T. Dorrance:—The Committee have prepared specifications for roofing and for concrete. Mr. Orrock, Chairman of this Sub-Committee, is not here. I will ask Mr. F. R. Judd, of the Illinois Central, to present the report.

Mr. F. R. Judd (Illinois Central):—The subject-matter of Specifications for Railway Buildings which was submitted last year can be found on page 462 of Volume XXVI, 1925 Proceedings. These specifications cover roofing, sub-divided under the head of concrete roofing tile, clay tile roofing, slate roofing, and built-up roofing. Built-up roofing submitted at that time was divided under classes A-1, pitch and gravel over wood; A-2, pitch and gravel over poured concrete, and B-1 asphalt and gravel over wood, and B-2, asphalt and gravel over poured concrete. These were submitted last year for consideration and for criticism and the Committee at this time is offering them for presentation in the Manual.

Your Committee is now offering two additional subjects, asphalt and asbestos felt, type C-1, Class A and B. Asphalt and asbestos felt, type C-2, Class A and B. These specifications are found on page 1200 of Bulletin 285. The difference in Class A and Class B specifications is in the amount of felt and the amount of asphalt cement used in the make-up of the roof. Type C-1 is for both A and B class over wood, and type C-2 is for both Class A and B over concrete and gypsum.

In addition to these specifications, the Committee is resubmitting at this time the specification on concrete work for railway buildings. This was submitted last year and was withdrawn on an objection from the Masonry Committee. It has been reconsidered and rewritten in some respects and the Committee after discussing the matter has offered it for adoption at this time. These specifications on concrete are found in Bulletin 285 on page 1101.

Mr. W. T. Dorrance:—Mr. President, I move the adoption of specifications on roofing and concrete for printing in the Manual.

Mr. C. C. Westfall (Illinois Central):—That objection still stands. The Masonry Committee is not in agreement with the Committee on Buildings on the procedure. It is not so much the material in the specifications as what should be done. I do not think it is professional jealousy, because after the Association has adopted a specification, it is the specification of the entire Association, the Buildings Committee as well as the Committee on Masonry.

It appears to me and the Masonry Committee that concrete is a material of construction just the same as brick or tile, and the Manual contains the specifications for concrete. The Buildings Committee would be doing enough in their specifications if they called for concrete to be manufactured in accordance with the specifications of the A.R.E.A. as they now appear in the Manual.

The Buildings Committee, if they want special provisions in addition to what are now in the Manual, might supply those. In the specifications that are now offered by the Buildings Committee, such information as is included is almost entirely, I believe, a copy of the specifications that now appear in the Manual. That appears to me to be a needless duplication and it burdens the Manual.

When the Buildings Committee referred to reinforcement they said that the material should conform to the A.R.E.A. specifications. When they referred to structural steel shapes, they said that that material should conform to the A.R.E.A. specifications. They call for brick and tile in the process of manufacture to conform, and it seems to me that concrete should be handled the same way.

The Buildings Committee should use in buildings the concrete that this Association has been willing to write a specification for. If they want to add something to it, they should provide for that additional thing.

I should like to make a motion that this entire matter on concrete specifications be referred back to the Committee on Buildings with instructions that all duplication and all conflict with the specifications that now appear in the Manual be eliminated.

Chairman Hunter McDonald:—Mr. Westfall, do you not think that this is really a question of jurisdiction and one that should be referred to the Board of Direction?

Mr. C. C. Westfall:—I do, Mr. Chairman; but the Board of Direction has not instructed the Committee along those lines. The matter has been discussed and the Committee has really tried to get a voice of the Board before this was brought up before the convention, as referred to by the Chairman of the Buildings Committee, and it seemed rather out of place to fight it out on the floor, but that seemed to be the only way we could do it.

The Buildings Committee two years ago presented it for adoption for printing in the Manual; it was before the convention, and if someone had not taken issue with them, it would have gone into the Manual and it would have been too late. It was withdrawn at that time and now it is presented again, and if it is not stopped it goes into the Manual. I believe it has to be settled now or held in abeyance until the Board can act.

Chairman Hunter McDonald:—The Chair suggests that you amend your motion, instead of withdrawing it, and refer it to the Board of Direction to settle the question of jurisdiction.

Mr. C. C. Westfall:—I will be very glad to do that.

Chairman Hunter McDonald:—Unless there is objection it will take that course. The matter will be referred to the Board of Direction.

Mr. W. T. Dorrance:—Mr. President, that concludes the report of the Committee on Buildings.

Chairman Hunter McDonald:—Their work has been very arduous. It is a very difficult matter to get a report in the Manual that did not receive objections from somebody. I desire to compliment the Committee on their good work and to dismiss them with the thanks of the Association. (Applause.)

SUPPLEMENTAL REPORT ON BUILDINGS

SPECIFICATIONS FOR RAILWAY BUILDINGS

SECTION 12

Structural Steel and Iron

GENERAL DESIGN

1. General

The contractor shall furnish all labor, material, tools and equipment necessary to entirely complete the structural steel and iron work as herein specified and as called for on the drawings.

Whenever these specifications, or any document which they supplement, conflict with the building code of the city or town in which the work is executed, the contractor shall submit the question as to which to follow to the Engineer and abide by his decision.

2. Design

The design of steel or iron work required will be indicated on the drawings furnished by the Company, and such details as are not shown on these drawings shall be detailed on the shop drawings.

In case the contractor is required specifically to design the structural steel or iron work, he shall submit complete stress diagrams with statement of loads used in design, and the design shall be in accordance with these specifications.

3. Working Drawings

Before fabrication is commenced the Contractor shall submit to the Engineer, and receive his approval thereof, shop drawings and erection diagrams of all parts of the work including both structure and equipment. These drawings shall measure .... outside and .... inside, ... border lines. Complete sets of these drawings shall be submitted to the Railroad Company in triplicate.

The approval of said working drawings by the Engineer will not imply any change in the specifications or relieve the contractor from the responsibility of any errors thereon.

Upon the completion of the work the contractor shall furnish a complete set of corrected tracings or Van Dyke prints on cloth of all drawings including shop details and erection diagrams, and this set shall be a true record of the work as constructed.

He shall also furnish in triplicate a complete list of all parts of equipment, including pattern numbers or other necessary designation, in order that any repairs may be made or parts readily ordered.

The contractor shall supply additional copies of erection diagrams or working drawings on request of the Engineer. No change shall be made on any approved drawing without the consent, in writing, of the Engineer.

4. Clearances

Provision shall be made for proper clearances, as specified by the Engineer, for all tracks entering or adjacent to building.

5. Span Lengths

In calculating stresses the span length of trusses, girders and beams, etc., shall be considered as the distance from center to center of end bearings when freely supported, and from center to center of supports for members framed between columns or other supports.

6. Depths

For purposes of calculations the depths of pin connected trusses shall be considered the distance center to center of chord pins, and the depths of riveted trusses the distance center to center of gravity of their chord sections.

Plate girders and rolled beams, channels, etc., shall be proportioned for bending by their net moments of inertia.

7. Spacing of Members

Roof trusses, rafters, etc., shall be spaced so that single shapes may be used as purlins and the use of trussed purlins avoided. Structures shall be designed so as to avoid as far as practicable ambiguity in the determination of the stresses.

8. Loads

All structures shall be proportioned for the following loads:

(a) Dead load
(b) Live or superimposed load
(c) Lateral forces or effect of moving load
(d) Longitudinal force or effect of moving loads
(e) Impact or dynamic effect of moving loads.

The dead load shall consist of the estimated weight of all partitions, permanent fixtures, mechanisms and all other permanent portions of the structure.

The live or superimposed load, lateral and longitudinal forces and impact will be specified by the Engineer for each case. (See appendix for typical loading.)

The effect of any vibration or movement of mechanisms shall be specified for each case by the Engineer. (See appendix for typical loading.)

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 same and all floor girders, slabs, joists and beams shall be designed for full dead and full live loads. All columns, walls and piers supporting floors shall be designed for full dead load and the proportion of the live load given in the following table:

Floor	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 proportion of live load on walls, piers and columns of buildings more than fifteen stories in height shall be taken in the same ratio as the above table.

Foundations and footings shall be proportioned for the loads used in designing the lowest section of the wall, pier or column supported.

The loads of special equipment such as trucks, engines, cranes, machinery or other appliances, shall be included when they occur.

9. Unit Stresses

The several parts of structures shall be so proportioned that the unit stresses will not exceed the following, except as modified in cases of combined and secondary stresses as set forth hereinafter.

Structural Steel:	Pounds Per Square Inch
Axial tension, net section	18,000
Axial compression, gross section	18,000-60 l/r
but not to exceed	15,000
l—the length of the member in inches	
r—the least radius of gyration of the member in inches.	
Tension in extreme fibers of rolled shapes, built sections and girders, net section	18,000
Tension in extreme fibers of pins	27,000
Shear in plate girder webs, gross section	12,000
Shear in power driven rivets and pins and turned bolts in reamed holes	13,500
Shear in hand driven rivets and unfinished bolts	10,000
Bearing of outstanding legs of stiffener angles and similar steel parts in contact	27,000

Structural Steel:	Pounds Per Square Inch
Bearing on power driven rivets, pins, turned bolts in reamed holes,	
(single shear)	24,000
(double shear)	30,000
Bearing on hand driven rivets, countersunk rivets and unfinished bolts,	
(single shear)	16,000
(double shear)	20,000
Bearing on expansion rollers, per linear inch	600*d*

d—the diameter of the rollers in inches.

For cast steel in shoes and bearings, the above mentioned stresses shall apply.

Cast Iron:	
Axial tension, net section	3,000
Axial compression, gross section	12,000
Tension, extreme fiber in bending, net section	5,000
Compression, extreme fiber in bending, gross section	12,000
Shear	3,000
Axial compression, columns, gross section	12,000-60 l/r
with a maximum of	10,000

l—the length of the members in inches.

r—the least radius of gyration of the member in inches.

Bearing on Masonry:	
Brickwork	200
Rubble masonry	100
Granite ashlar	600
Sandstone or limestone (ashlar or capstone)	400
Concrete	500

The above unit stresses are based on masonry which shall comply with the standard specifications as set forth in other sections of these specifications for railway buildings.

PROPORTIONING OF PARTS

10. Slenderness Ratios:

The ratio of length to least radius of gyration shall not exceed:

120 for main compression members of structural steel
100 for cast iron columns
200 for wind and sway bracing of structural steel
300 for riveted tension members

11. Depth Ratios

The depth of rolled beams in floors shall be not less than one twenty-fourth of the span. Where floors are subject to shocks or vibrations, the depth of beams and girders preferably shall be not less than one-twentieth of the span, or, if members of less depth are used, the sectional area shall be increased until the maximum deflection is not greater than that of a beam with depth of one-twentieth of the span. The depth of roof purlins preferably shall be not less than one-thirtieth of the span, and in no case less than one-fortieth of the span. In all cases of plastered ceilings, beams and girders shall be so proportioned that the maximum deflection will not exceed 1/360 of the span.

12. Effective Bearing Area

The effective bearing area of a pin, bolt or rivet shall be its diameter multiplied by the thickness of the piece, except that for countersunk rivets half the depth of the countersink shall be omitted.

13. Effective Diameter of Rivets

In proportioning rivets, the nominal diameter of the rivet shall be used.

14. Net Section

In proportioning tension members, net section shall be used. Rivet holes deducted shall be taken one-eighth inch larger than the nominal diameter of rivets. The areas of rods shall be figured at the root of thread, or the rods upset at ends to provide proper net area.

15. Reversal of Stress

Members subject to alternate stresses of tension and compression resulting from moving live loads producing shock and vibration shall be so proportioned that they will be capable of resisting either stress increased by fifty per cent of the smaller stress. The connection sshall be proportioned for the sum of the stresses.

16. Combined Stresses

Members subject to both axial and bending stresses shall be so proportioned that the combined fiber stresses will not exceed the allowable unit stress.

Members subject to stresses produced by a combination of dead load, live load and impact with lateral or longitudinal forces, may be proportioned for unit stresses 33 1/3 percent greater than those specified in Article 9, but the section shall be not less than that required for dead load, live load and impact.

17. Secondary Stress

Designing and detailing shall be done so as to avoid secondary stresses as far as possible. When secondary stresses are unavoidable, the unit stresses specified in Article 9 may be increased one-third for a combination of the secondary stresses with the other stresses but the section shall be not less than that required when secondary stresses are not considered.

18. Trusses

Trusses preferably shall be riveted structures. If, for special reasons, pin connected trusses are required, the design and details shall be in accordance with the requirements for design of such trusses specified in the A.R.E.A. Specifications for Steel Railway Bridges, Second Edition 1923, or current revision thereof, except that the unit stresses of Article 9 of this specification shall be used.

19. Compression Members

In built compression members, the metal shall be concentrated in the webs and flanges. The thickness of each web shall be not less than one-thirtieth of the distances between the lines of rivets connecting it to the flanges. The thickness of cover plates shall be not less than one-fortieth of the distance between the nearest rivet lines.

20. Outstanding Legs of Angles

The width of the outstanding legs of angles in compression (except where reinforced) shall not exceed twelve times the thickness for main members or fourteen times the thickness for bracing and other secondary members.

21. Bracing

Lateral, longitudinal and transverse bracing in all structures preferably shall be composed of shapes with riveted connections, and shall be designed to withstand wind and other lateral forces when the building is in process of erection, as well as after completion. Stresses from bracing preferably shall be carried directly to the foundation. Bracing connections to trusses shall be designed to avoid as far as practicable, any bending stress in the truss members.

22. Plate Girders and Rolled Beams

Plate girders shall be proportioned by the moment of inertia of their net section, including compression side.

23. Flange Sections

The flange angles shall form as large a part of the area of the flange as practicable. Side plates shall not be used except when flange angles exceeding one inch in thickness otherwise would be required.

Flange cover plates shall be equal in thickness or diminish from the flange angles outward. No cover plate shall exceed the flange angles in thickness. Flange plates shall be limited in width so they will not extend more than eight times the thickness of thinnest plate, or a maximum of 6 inches beyond the outer line of rivets connecting them to the angles.

Where flange cover plates are used they shall extend 18 inches beyond the theoretical end.

24. Compression Flanges

The gross area of the compression flanges of plate girders shall be not less than the gross area of the tension flanges. The compression flanges of all built or rolled beams and girders shall be stayed against lateral buckling at intervals not exceeding thirty times the width of the flange. The flange stress shall not exceed $18{,}000 - 200\ l/b$ where

l—the length of the member in inches between lateral connections or knee braces

b—the flange width in inches.

25. Flange Rivets

The flanges of plate girders shall be connected to the web with a sufficient number of rivets to transfer to the flange sections the horizontal shear at any point combined with any load that is applied directly on the flange.

26. Thickness of Web Plates

The thickness of web plates shall be not less than $\frac{1}{20}\sqrt{D}$ where "D" represents the distance between flanges in inches.

27. End Stiffeners

Plate girders shall have stiffener angles over end bearings, the outstanding legs of which shall extend as nearly as practicable to the outer edge of the flange angles. These end stiffeners shall be proportioned for bearing of the outstanding legs on the flange angles, and shall be connected to the web by enough rivets to transmit the reaction. End stiffeners shall not be crimped.

28. Intermediate Stiffeners

Intermediate stiffeners shall be riveted in pairs to the webs of plate girders in which the thickness of the web is less than 1/60 of the distance between the flange angles or side plates. The outstanding leg of each angle shall not be more than sixteen times the thickness, nor less than 2 inches plus one-thirtieth of the depth of the girder. Pairs of stiffeners shall be placed at intervals not greater than the depth of the web, or 6 feet.

Stiffener angles shall be placed at points of concentrated loading. such angles shall not be crimped.

29. Columns

Columns shall be designed to provide for effective connection of beams, girders and brackets. Steel columns shall be designed preferably in two story lengths. Cast iron columns shall not be used in buildings of a height greater than twice the width, or over 100 feet high.

30. Eccentric Loading

In proportioning columns, provision shall be made for eccentric loading.

31. Trusses

All trusses shall have sufficient camber so that the lower chord will be level under dead load only.

32. Minimum Sizes

On inside work, metal less than one-quarter of an inch thick shall not be used except for fillers. On outside work and inside of engine houses, metal less than 5/16" thick shall not be used except for fillers. Webs of girders shall be not less than 5/16" thick. Sole plates or bed plates shall be not less than ½" thick. Angles shall be not smaller than 2" x 2" x ¼". Anchor bolts preferably shall be not less than 1 inch in diameter.

33. Waste by Corrosion

Metal subject to marked corrosive influence shall be increased in thickness or protected against such influence.

34. Expansion

No provision for expansion in structures transversely shall be made in wall bearing spans fifty feet (50′0″) and under in length. Wall bearing spans over fifty feet (50′0″) and up to and including one hundred feet (100′0″) in length shall slide on smooth surfaces at one end. Wall bearing spans over one hundred feet (100′0″) in length shall have expansion rollers or rockers at one end. Expansion rollers shall be not less than three inches (3″) in diameter. All expansion ends shall be secured against lateral movement and all fixed ends against movement in any direction. Proper provision shall be made for expansion in structures longitudinally. All expansion provisions shall be figured for 100° F. variation in temperature and for a co-efficient of expansion of 0.0000065 per degree per unit of length.

DETAILS OF DESIGN

35. Parts Accessible

Details shall be so designed that all parts will be accessible for inspection, cleaning and painting. Closed sections shall be avoided wherever possible.

36. Pockets

Pockets or depressions which would hold water shall be avoided.

37. Adjustable Members

Adjustable members in any part of the structure shall be avoided wherever possible. When used, adjustable members shall have open turnbuckles or clevises.

38. Symmetrical Sections

Sections shall be made symmetrical wherever possible. Single angles shall have outstanding leg connected by clips or only the flat leg shall be considered to take stress.

39. Eccentric Connections

Members shall be so connected that their gravity axes will intersect in a point. Eccentric connections shall be generally avoided, but if unavoidable, the members shall be so proportioned that the combined fiber stress will not exceed the allowed axial stress.

40. Sizes of Rivets

Rivets shall be ½″, ⅝″, ¾″, ⅞″ or 1″ in diameter, as specified.

41. Spacing of Rivets

The minimum distance between centers of rivet holes shall be three diameters of the rivet, but the distance preferably shall be not less than

3½ inches for 1 inch rivets, 3 inches for ⅞ inch rivets, 2½ inches for ¾ inch rivets, 2 inches for ⅝ inch rivets and 1¾ inches for ½ inch rivets. The maximum pitch in the line of stress for compression members composed of plates and shapes shall not exceed sixteen times the thickness of the thinnest outside plate, or twenty times the thickness of the thinnest enclosed plate with a maximum of 12 inches. For angles with two gage lines with rivets staggered, the maximum pitch in each gage line shall not exceed twenty-four times the thickness of the thinnest plate with a maximum of 18 inches. If two or more web plates are used in contact, stitch rivets shall be provided to make them act in unison. In compression members the stitch rivets shall be spaced not more than sixteen times the thickness of the thinnest plate in the line of stress, and not more than thirty times the thickness of the thinnest plate in the direction at right angles to the line of stress. In tension members, the stitch rivets shall be spaced not more than twenty-four times the thickness of the thinnest plate in either direction. In tension members, composed of two angles in contact, a pitch of thirty-six (36″) inches may be used, and in similar compression members twenty (20″) inches, but the l/r ratio for each angle between rivets shall be not more than three-fourths of that for the member as a whole.

The pitch of rivets at the ends of built compression members shall not exceed four diameters of the rivet for a distance equal to one and one-half times the maximum width of the member.

42. Long Rivets

Rivets which carry calculated stress and where grip exceeds four and one-half diameters, shall be increased in number one percent for each additional $\frac{1}{16}$ inch of grip. If the grip exceeds six times the diameter of the rivet, specially designed rivets shall be used.

43. Edge Distance

The minimum distance from the center of any rivet hole to a rolled or sheared edge shall be:

Size of Rivet	*To Sheared Edge*	*To Rolled Edge*
1″	1¾″	1½″
⅞″	1½″	1¼″
¾″	1¼″	1⅛″
⅝″	1⅛″	1″
½″	1″	⅞″

The maximum distance from any edge shall be twelve times the thickness of the plate but shall not exceed 6 inches.

44. Connections

Connections shall be made as nearly as practicable, symmetrical about the axis of the members. Wherever possible beams shall frame into girders and girders into columns and be connected to the same with connection angles.

Connections carrying calculated stress, except for lacing, shall have not less than two rivets, or for field connections not less than three rivets. Connections of main members carrying live loads producing impact, and connections of members subject to alternate stresses shall be riveted. Turned bolts may be used in other connections where it is impracticable to obtain satisfactory power driven rivets. The turned body of the bolt shall be long enough to insure full bearing. A washer at least ¼ inch thick shall be used under the nuts to give full grip when turned tight. When permitted by the Engineer, unfinished bolts may be used for the connections of minor parts.

45. Lacing and Stay Plates

The open sides of compression members shall be provided with lacing bars proportioned to resist a shearing stress of 2½ per cent of the direct stress. They shall have stay plates as near each end as practicable and at intermediate points where the lacing is interrupted. In main members the length of the end stay plates shall be not less than one and one-fourth times the distance between the lines of rivets connecting them to the outer flanges, and the length of intermediate stay plates shall be not less than three-quarters of that distance. Their thickness shall be not less than one-fiftieth of the same distance.

The minimum thickness of lacing bars shall be for single lacing one-fortieth and for double lacing, riveted at intersections, one-fiftieth of the distance between the end rivets. Their minimum width shall be as follows:

For 15″ channels or built sections with 3½″ and 4″ angles	2½ inches	(⅞″ rivets)
For 12″, 10″ and 8″ channels or built sections with 3″ angles	2¼ inches	(¾″ rivets)
For 8″ and 7″ channels or built sections with 2½ angles	2 inches	(⅝″ rivets)
For 6″ and 5″ channels or built sections with 2″ angles	1¾ inches	(½″ rivets)

The angle of lacing bars with the axis of the member shall be not less than 45°. If the distance between rivet lines in the flanges is more than 15 inches, the lacing shall be double and riveted at the intersections, or shall be made of angles. Lacing bars of compression members shall be so spaced that the l/r ratio of the portion of the flange between their connections shall be not greater than three-quarters of the l/r of the member as a whole.

46. Splices

Abutting joints in compression members faced for bearing shall be spliced sufficiently to hold the connecting members accurately in place. Other joints in riveted work, whether in tension or compression, shall be fully spliced.

47. Web Splices

Web plates of plate girders shall be symmetrically spliced by plates on each side. The splice plates (for shear) shall be of the full depth of the girders between flanges. The splice shall be equal to the web in strength in both shear and moment. There shall be not less than two rows of rivets on each side of the joint.

48. Flange Splices

Splices in flange members shall not be used except by special permission of the Engineer. Two members shall not be spliced at the same cross section, and if practicable, splices shall be located at points where there is an excess of section The net section of the splice shall exceed by ten per cent the net section of the member spliced. Flange angle splices shall consist of two angles, one on each side.

49. Indirect Splices and Fillers

Where rivets carrying stress pass through fillers, the filler shall be extended beyond the connected member and the extension secured by additional rivets sufficient to develop the filler.

50. Separators

Where two or more rolled beams are used to form a girder they shall be connected by bolts and separators at intervals of not more than 5 ft. All beams having a depth of 12 inches or more shall have at least two bolts to each separator. When concentrated loads are carried from one beam to the other, or distributed between the beams, rolled or riveted diaphragms shall be used, designed with sufficient stiffness to distribute the load. Where beams are exposed they shall be spaced sufficiently far apart to permit cleaning and painting.

51. Column Bases

Column bases shall be designed to distribute the column load on the footings.

52. Fixed Bearings

Bearings and ends of girder and trusses shall be secured against lateral movement.

MATERIALS

53. Specifications

Structural steel is to be in accordance with specifications of the American Society for Testing Materials, Specification A-9-21 or subsequent revisions thereof, which is the specification for structural steel in building, with the exception that Article 1 shall read as follows:

"Structural steel shall be made by the open hearth process."

In Article 2—the reference to Bessemer steel shall be omitted.

Cast steel is to be in accordance with specifications of the American Society for Testing Materials, Specification A-7-24, Class B, or subsequent revisions thereof.

Cast iron is to be in accordance with specifications of the American Society for Testing Materials, Specification A-48-18, or subsequent revisions thereof.

WORKMANSHIP

54. General

The workmanship and finish shall be equal to the best general practice in modern structural shops. Material at the shops shall be kept clean and protected from the weather as far as practicable.

55. Straightening Material

Rolled material, before being laid off or worked, must be straight. If straightening or flattening is necessary, it shall be done by methods that will not injure the material. Sharp kinks and bends may be cause for rejection.

56. Finish

Shearing and chipping shall be neatly and accurately done and all portions of the work exposed to view shall be neatly finished.

57. Punching

Holes in material whose thickness is not greater than the diameter of the rivets plus ⅛ inch, may be punched full size. Holes in material of greater thickness shall be drilled or sub-punched and reamed.

58. Punched Holes

Full size punched holes shall be 1/16 inch larger than the nominal diameter of the rivets. The diameter of the die shall not exceed the diameter of the punch by more than 3/32 inch. If any holes must be enlarged to admit the rivets, they shall be reamed. Holes must be clean cut, without torn or ragged edges. Poor matching of holes may be cause for rejection.

59. Sub-Punched and Reamed Holes

In sub-punched and reamed work the holes for rivets ⅞" in diameter or larger shall be punched 3/16 inch smaller and, after assembling, reamed 1/16 inch larger than the nominal diameter of the rivet. When rivets are ¾" or less in diameter, the holes shall be punched ⅛" smaller and, after assembling, reamed 1/16" larger than the nominal diameter of the rivet. The diameter of the die shall be not more than 3/32 inch larger than the diameter of the punch. Outside burrs shall be removed with a tool making a 1/16 inch fillet.

60. Reamed Holes

Reamed holes shall be cylindrical, perpendicular to the member, and not more than 1/32 inch larger than the nominal diameter of the rivets. Reamers preferably shall not be directed by hand. Outside burrs shall be removed with a tool making a 1/16 inch fillet.

61. Drilled Holes

Drilled holes shall be 1/16 inch larger than the nominal size of the rivet. Burrs on the outside surfaces shall be removed.

62. Assembling for Drilling

Connecting parts requiring drilled holes shall be assembled and held together securely while being drilled.

63. Shop Assembling

The parts of riveted members shall be well pinned and thoroughly drawn together with bolts before riveting is commenced. The drifting done during assembling shall be only such as to bring the parts into position. Drifting to enlarge unfair holes will not be allowed.

64. Match Marking

Connecting parts assembled in the shop for the purpose of reaming or drilling holes in field connections shall be match marked, and a diagram showing such marks shall be furnished the Engineer.

65. Rivets

The size of rivets called for on the plans shall be the size of the rivet before heating.

Rivet heads, when not countersunk or flattened, shall be of approved shape and of uniform size for the same diameter of rivet. Rivet heads shall be full, neatly made, concentric with the rivet holes, and in full contact with the surface of the member.

66. Riveting

Rivets shall be heated uniformly to a light cherry red and driven while hot. Rivets when heated and ready for driving shall be free from slag, scale and carbon deposit. When driven they shall completely fill the holes. Loose, burned or otherwise defective rivets shall be replaced. In removing rivets, care shall be taken not to injure the adjacent metal, and if necessary, they shall be drilled out. Caulking or recupping will not be permitted.

Rivets shall be driven by direct acting riveters where practicable. The riveters shall retain the pressure after the upsetting is completed.

67. Field Rivets

Field rivets shall be furnished in excess of the nominal number required to the amount of fifteen per cent, plus ten rivets, for each size and length.

Field rivets shall be carefully selected and shall be free from fins on the underside of the head.

68. Turned Bolts

Where turned bolts are used to transmit shear, the holes shall be reamed parallel and the bolts shall make a tight fit with the threads entirely outside of the holes. A washer not less than ¼ inch thick shall be used under each nut.

69. Screw Threads

Screw threads shall make close fits in the nuts and shall be U. S. Standard.

70. Lacing Bars

The ends of lacing bars shall be neatly rounded unless otherwise called for.

71. Web Plates

Web plates of girders which have no cover plates may be ⅛ inch above or below the backs of the top flange angles. Web plates of girders which have cover plates may be ½ inch less in width than the distance back to back of flange angles.

When web plates are spliced, not more than ⅜ inch clearance between ends of plates will be allowed.

72. Abutting Joints

Abutting joints in compression members and girder flanges, and where so specified on the drawing, in tension members, shall be faced and brought to an even bearing. Where joints are not faced the opening shall not exceed ¼ inch.

73. Finished Members

Finished members shall be true to line and free from twists, bends and open joints.

74. Welds

Welds in steel will not be allowed, except to remedy minor defects.

75. Bearing Surfaces

The top and the bottom surfaces of base and cap plates of columns and pedestals, except those in contact with masonry, shall be planed or hot-straightened, and parts of members in contact with them shall be faced to fit. Connection angles for base plates and cap plates shall be riveted to compression members before the members are faced.

Sole plates of plate girders shall have full contact with the girder flanges. Sole plates and masonry plates shall be planed or hot-straightened. Cast pedestals shall be planed on the surfaces in contact with steel and shall have the bottom surfaces resting on masonry rough finished.

76. Annealing

Wherever steel castings are used, they shall be properly annealed. Other steel, which has been partially heated, shall be annealed except where used in minor parts.

WEIGHING AND SHIPPING

77. Weight Paid For

The payment for pound price contracts shall be based on the scale weight of the metal in the fabricated structure, including field rivets shipped. The weight of the field paint and cement, if furnished, boxes and barrels used for packing and material used for staying or supporting members on cars, shall not be included.

78. Variation in Weights

If the weight of any member is more than 2½ per cent less than the computed weight, it may be cause for rejection.

The greatest allowable variation of the total scale weight of any structure from the weights computed from the approved shop drawings shall be 1½ per cent. Any weight in excess of 1½ per cent above the computed weight will not be paid for.

79. Computed Weight

The weight of steel shall be assumed at 0.2833-lb. per cubic inch.

The weights of rolled shapes and of plates, up to and including 36 inches in width, shall be computed on the basis of their nominal weights and dimensions as shown on the approved shop drawings, deducting for copes, cuts and open holes.

The weights of plates wider than 36 inches shall be computed on the basis of their dimensions, as shown on the approved shop drawings, deducting for cuts and open holes. To this shall be added one-half of the allowed percentages of overrun in weight given in specifications of the American Society for Testing Materials.

The weight of heads of shop driven rivets shall be included in the computed weight.

The weights of castings shall be computed from the dimensions shown on the approved shop drawings with an addition of 10 per cent for fillets and overruns.

80. Weights of Members

Finished work shall be weighed in the presence of the Inspector, if practicable. The Contractor shall furnish satisfactory scales and do the handling of the material for weighing.

81. Marking and Shipping

Members weighing more than five tons shall have the weight marked thereon. Bolts and rivets of one length and diameter, and loose nuts or washers of each size, shall be packed separately. Pins, other small parts, and small packages of bolts, rivets, washers and nuts shall be shipped in boxes, crates, kegs or barrels, but the gross weight of any package shall not exceed 300 pounds. A list and description of the contained material shall be plainly marked on the outside of each package, box or crate.

Anchor bolts, washers and other anchorage or grillage materials shall be shipped in time for them to be built into the masonry.

SHOP PAINTING

82. Shop Cleaning and Painting

Unless otherwise specified, steel work, after it has been accepted by the Inspector and before leaving the shop, shall be thoroughly cleaned and given one coat of approved paint, applied in a workmanlike manner and well worked into joints and open spaces. Cleaning shall be done with steel brushes, hammers, scrapers and chisels, or by other equally effective means. Oil, paraffin and grease shall be removed by wiping with benzine or gasoline. Loose dirt shall be brushed off with a dry bristle brush before the paint is applied.

83. Erection Marks

Erection marks shall be painted on painted surfaces.

84. Painting in Damp or Freezing Weather

Painting shall not be done in damp or freezing weather except under cover, and the steel must be free from moisture or frost when the paint is applied. Material painted under cover in damp or freezing weather shall be kept under cover until the paint is dry.

85. Mixing of Paint

Paint shall be thoroughly mixed before applying and the pigments shall be kept in suspension.

86. Machine Finished Surfaces

Machine finished surfaces of steel, except abutting joints and base plates, shall be coated with white lead and tallow, applied hot, as soon as the surfaces are finished and accepted by the Inspector.

SHOP INSPECTION

87. Facilities for Inspection

Facilities for inspection of materials and workmanship in the shop shall be furnished by the contractor to the Inspectors, and the Inspectors shall be allowed free access to the necessary parts of the premises.

88. Material Orders and Shipping Statements

The contractor shall furnish the Engineer with as many copies of material orders and shipping statements as the Engineer may direct. The weights of the individual members shall be shown.

89. Notice of Beginning Work

The contractor shall give ample notice to the Engineer of the beginning of work at the shop, so that inspection may be provided. No work shall be done before the Engineer has been notified.

90. Cost of Inspection

The contractor shall afford the Engineer, free of cost, all reasonable facilities to satisfy him that the material is being furnished and the work done in accordance with these specifications.

91. Inspector's Authority

The inspector shall have the power to reject materials or workmanship which do not meet the requirements of these specifications, but in case of dispute the contractor may appeal to the Engineer, whose decision shall be final.

92. Rejections

The acceptance of any material or finished members by the Inspector shall not be a bar to their subsequent rejection, if found defective.

Rejected material and workmanship shall be replaced promptly or made good by the contractor.

ERECTION

93. General

The contractor shall provide all tools, machinery, equipment and erection material, including drift pins and fitting up bolts, necessary for the expeditious handling of the work, and shall erect the structural steel and iron work complete in every respect as covered by the agreement and in accordance with the plans and these specifications.

94. Plans

Where the fabricated material is furnished by others, the Company will furnish complete detail plans for the work, including shop details, erection diagrams, match marking diagrams, lists of field rivets and bolts, and copy of shipping statements.

95. Delivery of Material

The contractor shall receive all materials entering into the finished structure free of charge at the place designated, loaded or unloaded as specified in the information given bidders.

96. Handling and Storage of Materials

The contractor shall unload material promptly upon delivery, otherwise he shall be responsible for demurrage charges. Stored material shall be piled securely outside the tracks and no material shall be placed closer than 6 feet to the near rail. Material shall be placed on skids, above the ground. It shall be kept clean and properly drained. Girders and beams shall be placed upright and shored. Long members, such as columns and chords, shall be supported on skids placed near enough together to prevent injury from deflection. The contractor shall check all material turned over to him against shipping lists and report in writing within seven (7) days any shortage or injury discovered. He will be held responsible for the loss of any material while in his care or for any damage resulting from his work.

97. Masonry

The Company will construct the masonry to correct lines and elevations and will establish the lines and elevations required by the contractor for setting the steel.

98. Bearings and Anchorage

Bed plates, bolsters and shoes shall be set level in exact position. They shall be given full and even bearing by setting them on a layer of Portland cement mortar after blocking them accurately in position as directed by the Engineer.

The contractor shall drill the holes and set the anchor bolts, except where the bolts are built into the masonry. The bolts shall be set accurately and fixed with Portland cement grout completely filling the holes.

99. Methods and Equipment

Before starting work the contractors shall advise the Engineer fully as to the method he proposes to follow, and the amount and character of equipment he proposes to use, which shall be subject to the approval of the Engineer. The approval of the Engineer shall not be considered as relieving the contractor of the responsibility for the safety of his method or equipment, or from carrying out the work in full accordance with plans and specifications.

100. Erection

Structural steel and iron work shall be set accurately to the established lines and levels. The frame of steel skeleton buildings shall be carried up true and plumb. All parts shall be accurately assembled as shown on the plans and match marks where shown upon the drawings or material carefully followed. The material shall be carefully handled so that no parts will be bent, broken or otherwise damaged. Temporary bracing shall be provided to take care of stresses from erection equipment, piles of material or other loads carried during erection. As erection progresses, the work shall be securely bolted up to take care of all dead load, wind and erection stresses. Not less than one-third of the holes nor less than two holes at any connection shall be filled with bolts tightly drawn up. Light drifting will be permitted to draw parts together, but no drifting to match up unfair holes will be allowed; such holes shall be reamed or drilled. Bearing surfaces and surfaces to be in permanent contact shall be cleaned and painted just before the members are assembled. Elevator shafts shall be plumbed from bottom to top with piano wire. The structure shall be accurately aligned and plumbed and splices and field connections drawn together with sufficient bolts to hold them securely in place before riveting.

101. Riveting

Riveting shall be done preferably with pneumatic riveters and buckers. Rivets larger than ⅞" in diameter shall not be driven by hand. Rivets shall be heated uniformly throughout to a light cherry red color, and in driving shall be upset to completely fill the holes. Heads shall be full and symmetrical and concentric with the shank, and shall have full bearing all around. They shall be of the same shape and size as the heads of the shop rivets. Rivets shall be tight and shall grip the connected parts securely together. No recupping or caulking will be permitted. Rivets shall not be overheated or burned. In removing rivets, the surrounding metal shall not be injured. If necessary, rivets shall be drilled out. Cup faced dollies, fitting the head closely to insure good bearing, shall be used.

Careless tossing of rivets will not be allowed. Rivets shall not be tossed in any direction that, if missed, they would fall outside of the working space adjacent to the building upon a public thoroughfare. The contractor shall provide suitable shields to protect workmen from falling rivets.

102. Bolted Connections

Permanent bolted connections shall be used only where shown on plans or where approved by the Engineer. In case bolted connections are used, washers not less than ¼ inch shall be used under the heads and nuts, the nuts drawn tight and the threads checked with a chisel or lock nuts used. Connections to cast iron and for separators in steel beams may be bolted.

103. Mis-Fits

Any error in shop work which prevents the proper assembling and fitting up of parts shall immediately be reported to the Inspector and his approval of the method of correction obtained.

104. Painting

The heads of field driven rivets shall be given a coat of paint similar to that used in the shop as soon as possible after the Inspector has examined the rivets and found them satisfactory. All parts inaccessible after erection shall be painted before erection with one coat of field paint.

105. Superintendence and Workmen

During the entire progress of the work the contractor shall have a competent foreman or superintendent in personal charge of the work. All work shall be done by skilled, competent workmen.

106. Interference with Traffic

When the work is adjacent to or over the tracks of the Company, the contractor shall conduct his work in such a manner that the track shall be safe and clear for the passage of trains.

107. Company Equipment

When the agreement provides that the Company shall furnish equipment to the contractor, such as flat cars, water cars, bunk cars, etc., the contractor shall repair all damage to such equipment furnished for his use and return it in as good condition as when he received it.

108. 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.

The General Conditions as given in Section 1 of this specification shall be considered to apply with equal force to this section of the Specification.

APPENDIX

The following weights of materials, live loads and impacts are given as information for use in designing:

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.

	Lb.
White pine, spruce, hemlock, per ft. board measure	3
Yellow pine, fir, per ft. board measure	4
Oaks, maple, per ft. board measure	5
Brick masonry, pressed or paving, per cu. ft.	140
Brick masonry, hard common, per cu. ft.	120
Brick masonry, hollow, per cu. ft.	90
Sandstone or limestone rubble, per cu. ft.	140
Sandstone or limestone cut facing, per cu. ft.	150
Granite, per cu. ft.	160
Stone concrete, per cu. ft.	144
Cinder concrete, per cu. ft.	96
Cinder fill (without sand and cement) per cu. ft.	72
Mortar and plaster, per cu. ft.	120
Onamental terra cotta, backed and filled with common brick, per cu. ft.	120
Marble, per cu. ft.	175
Floors, marble, tutti colori, and similar, per sq. ft.	12
Windows (glass, frames and sash), per sq. ft.	5
Roofing, composition, per sq. ft.	5
Roofing, gravel, per sq. ft.	10
Roofing, slate, per sq. ft.	10
Roofing tile, per sq. ft.	10
Roofing, shingle, per sq. ft.	3
Sheet metal roofing, cornice, etc., per sq. ft.	3
Partition tile, 3 in. thick, per sq. ft.	14
Partition tile, 4 in. thick, per sq. ft.	15
Partition tile, 6 in. thick, per sq. ft.	22
Partition tile, 8 in. thick, per sq. ft.	28
Partition tile, 10 in. thick, per sq. ft.	32
Floor flat arch (average of set) 8 in. thick per sq. ft.	28
Floor flat arch (average of set) 10 in. thick per sq. ft.	32
Floor flat arch (average of set) 12 in. thick per sq. ft.	36
Floor flat arch (average of set) 14 in. thick per sq. ft.	40
Floor flat arch (average of set) 16 in. thick per sq. ft.	46
Floor segmental arch tile (average of set) 6 in. thick at crown, per sq. ft.	28
Mortar for tile arch floors, per sq. ft.	3
Beck tile, 2 in. thick, per sq. ft.	12
Book tile, 3 in. thick, per sq. ft.	14
Beam tile (when not included with arch tile) per sq. ft.	12
Gypsum partition blocks, 3 in. thick, per sq. ft.	10
Gypsum partition blocks, 4 in. thick, per sq. ft.	12
Gypsum partition blocks, 5 in. thick, per sq. ft.	14
Gypsum partition blocks, 6 in., thick, per sq. ft.	16
Plaster on brick, concrete, tile or gypsum, per sq. ft.	5
Plaster on lath, per sq. ft.	7

Suspended ceiling complete, per sq. ft	10
Steel bar 1 in. square, 1 ft. long, per linear foot	3.4
Steel plate 1 ft. square, 1 in. thick per sq. ft	40.8
Cast iron, bar 1 in. square, 1 ft. long, per linear ft	3.125
Cast iron, per cu. in	.26

The following items may vary considerably in weight but the values given may be used for preliminary computations, or when the quantities are small:

Iron stair construction, per sq. ft	50
Concrete stair construction, per sq. ft	150
Wood stair construction, per sq. ft	20
Sidewalk lights in concrete, per sq. ft	30
Reinforcement of concrete, per cu. ft	6
Total weight of reinforced concrete, per cu. ft	150
Steel joists, per sq. ft of floor	6
Steel girders, per sq. ft. of floor	4
Partition, tile plastered, per sq. ft	25
Same in hotels, per sq. ft. of floor	35
Same in office buildings, per sq. ft. of floor	25

Live Loads

The following live loads may be followed in all cases except where they conflict with local building ordinances.

Structure	*Load in Lb. per Sq. Ft.*
Baggage rooms	100
Carpenter shops	100
Coaling platforms	400
Commissaries	300
Cotton loading platforms	200
Express buildings	150
File rooms	100 to 150; 100 lb. for cases spaced over 4′0″ clear; balance 150 lb.
Fire escapes	100
Freight houses	250
Freight platforms	250
Garages	100
Hospitals	50
Hotels	60
Ice manufacturing plants	100
Ice crusher houses	100
Ice storage	special
Icing platforms	150
Laundries	100
Locker rooms	50
Machine shop	100
Mail rooms	100
Offices and office buildings	50
Paint shop	100
Passenger platforms	100
Planning mills	150
Power houses	100
Reading rooms	50

Residences	40
Restaurants	50
Roofs	25
Scale houses	50
Scrap docks	300
Sidewalks	150
Signal towers	60
Stables	100
Stairways (all)	100
Station foot bridges	100
Stock pens	100
Stock runways	100
Storehouses—	
Banana	50
Cement	450
Cotton	250
Flour	300
Fruits	350
Glass	350
Grain	300
Groceries	300
Hay—baled	225
Hay—loose	125
Hardware	300
Oil	250
Paint	250
Railway	300
Salt	300
Soda ash	200
Vegetables	50
Telegraph offices	50
Ticket offices	50
Tool equipment buildings	100
Trainmen's rooms	50
Transfer platforms	150
Waiting rooms	100
Wash rooms	50
Water treating plants	100
Wind pressure	15 and 20
Y. M. C. A. buildings	50

Special Loads

In addition to the live load which is assumed to be uniformly distributed over the floor, there may be special loads such as elevators, machinery, water in tanks, coal in bins, space for storage of special materials, etc. The weight of water is 62.5 pounds per cubic foot, or 8⅓ pounds per gallon; of bituminous coal, 50 pounds per cubic foot; of anthracite coal, 60 pounds per cubic foot.

The weights of elevators are usually given by the manufacturer for the particular situation.

Wind Load

Wind shall be assumed as acting horizontally from any direction and shall be provided for as follows:

First—For Finished Structures: A pressure of fifteen pounds per square foot on the sides and ends of the building, and on the vertical projection of roof surfaces.

Second—For Structures in Process of Construction: A pressure of twenty pounds per square foot on vertical surfaces and the vertical projection of inclined surfaces of all exposed framework.

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.

Lateral Force

The lateral force on crane runways to provide for the effect of crane trolleys shall be 20 per cent of the rated capacity of the crane. This load shall be applied at the top of rail of crane runway, one-half the load to each side of runway, and considered as acting in either direction normal to the runway rail.

Longitudinal Force

In the design of members supporting tracks for railroad engines or cars provision shall be made for a longitudinal force of 20 per cent of the live load, applied 6 feet above the top of rail.

In the design of crane runways provision shall be made for a longitudinal force per rail equal to 10 per cent of the rated capacity of the crane applied at top of rail on the runway.

Impact

Where live loads causing shock or vibrations are carried, the following shall be added to the computed live load stress produced by such loads to provide for the dynamic effect of impact:

Character of Load	*Impact Allowance*
Street cars, trucks and elevators	33% of live load stress
Traveling cranes	25% of live load stress
Stationary vibrating machines	10% of live load stress
Railroad locomotives or cars	33% of live load stress

Ratio l/r	*Prop. A.R.E.A. Bldg.* 18000-60 l/r	*New A.R.E.A.* 15000-50 l/r	*Old A.R.E.A.* 16000-70 l/r	*Am. Br. Co. Specif.*	*Gordon* $\dfrac{12500}{1+\dfrac{l^2}{36000r^2}}$
0	15000	12500	14000	13000	12500
5	15000	12500	14000	13000	12492
10	15000	12500	14000	13000	12465
15	15000	12500	14000	13000	12422
20	15000	12500	14000	13000	12363
25	15000	12500	14000	13000	12287
30	15000	12500	13900	13000	12195
35	15000	12500	13550	13000	12088
40	15000	12500	13200	13000	11968
45	15000	12500	12850	13000	11834
50	15000	12500	12500	13000	11688
55	14700	12250	12150	13000	11531
60	14400	12000	11800	13000	11364
65	14100	11750	11450	12500	11187
70	13800	11500	11100	12000	11002
75	13500	11250	10750	11500	10811
80	13200	11000	10400	11000	10313
85	12900	10750	10050	10500	10410
90	12600	10500	9700	10000	10204
95	12300	10250	9350	9500	9995
100	12000	10000	9000	9000	9784
105	11700	9750	8650	8500	9571
110	11400	9500	8300	8000	9356
115	11100	9250	7950	7500	9142
120	10800	9000	7600	7000	8929
125	10500	8750		6750	8717
130	10200	8500		6500	8507
135	9900	8250		6250	8299
140	9600	8000		6000	8094
145	9300	7750		5750	7892
150	9000	7500		5500	7692
155	8700	7250		5250	7495
160	8400	7000		5000	7305
165	8100	6750		4750	7118
170	7800	6500		4500	6934
175	7500	6250		4250	6754
180	7200	6000		4000	6579
185	6900	5750		3750	6408
190	6600	5500		3500	6242
195	6300	5250		3250	6080
200	6000	5000		3000	5921

DISCUSSIONS ON ECONOMICS OF RAILWAY LABOR

(For Report, see pp. 1004-1060.)

(Past-President Hunter McDonald in the Chair.)

Mr. C. C. Cook (Baltimore & Ohio—Chairman):—The report is given in Bulletin 285, beginning on page 1005. The subjects are taken up in the order given. The first is Revision of the Manual, upon which we have nothing to report. The second subject is given in Appendix A. Mr. F. S. Schwinn, the Chairman of this Sub-Committee, will present the report.

Mr. F. S. Schwinn (Gulf Coast Lines):—Your Committee has continued the study of the subject of Standard Methods for Performing Maintenance of Way Work and Establishment of Units of Measure of Work Performed. The Committee made very careful analyses of maintenance of way charges on forty-one carriers representing 120,205 miles of operated lines for the years 1923 and 1924. This study was for the purpose of ascertaining, if possible, a fixed relationship of maintenance charges in the different sections or regions of the United States as between the cost of maintenance and the amount of property maintained or the use to which such property was subjected.

The Committee was unable to find any direct relationship or uniformity in maintenance charges when considering railroads handling approximately the same traffic, either when grouped by regions or when viewed as a whole.

The Committee's conclusions in the premises are as follows: "It is the conclusion of the Committee that it is not possible to determine a fixed unit of cost of Maintenance of Way and Structures accounts for any unit of property, such as the equated mile, or for any unit of use, such as thousand car miles.

"It is further the conclusion that it will be impossible to determine upon such unit of cost at any future time unless all railroads were to adopt the use of standard materials and standard practices, and even then there would exist differences reflecting the differences in location, climatic conditions and physical construction. The Committee feels that it has exhausted this study as far as it is possible to do so at the present time, and it again respectfully recommends that it be relieved from further study of this subject."

Mr. C. C. Cook:—The report is simply presented as information and I move that it be so accepted.

Chairman Hunter McDonald:—Unless there is objection, the report will be accepted as information.

Mr. C. C. Cook:—The next subject is covered by Appendix B. Mr. Lem Adams, Chairman of the Sub-Committee, will present the report.

Mr. Lem Adams (Union Pacific):—The subject is "Extent to which it is Practicable to Stabilize Employment in the Maintenance of Way Department in the Interest of Efficiency, and the Necessary Measures."

The progress report given on this subject is found on page 1010 to 1018, inclusive, and is offered as a progress report. I move it be so accepted.

Chairman Hunter McDonald:—Any discussion? If not, and there is no objection, it will be received as a progress report.

Mr. C. C. Cook:—The next subject is "Methods of Maintaining Motor Cars," given in Appendix C. Mr. F. M. Thomson, Chairman of the Sub-Committee, will present the report.

Mr. F. M. Thomson (Missouri-Kansas-Texas):—The Committee selected thirty principal railroads of the United States and investigated them as to their methods of motor car maintenance. The study developed that the methods in use by the railroads varied from meager organization for motor car maintenance to highly organized systems of keeping motor cars in first-class service condition at all times. In the majority of instances no data was kept as to actual cost of maintenance and operation of the various kinds of motor cars. Also, their records often fail to show the percentage of cars out of service, in the shops, and the representative cars on assignment out of service awaiting repairs in the field.

That portion of the report on pages 1020 to 1024, inclusive, contains briefs of some typical maintenance organization now in effect on several important railroads which we investigated in the United States and Canada, and are placed in this report as information.

The discussion of the report proper, pages 1024 to 1028, inclusive, is also presented as information and develops the conclusions which are shown on pages 1028 and 1029, which the Committee has submitted and is offering for adoption by the Association and for publication in the Manual.

Chairman Hunter McDonald:—These rules are offered for printing in the Manual. As each conclusion is read I will ask the speaker to pause for a moment, and if anyone desires to discuss any of them we will be glad to hear from him. Unless there is objection, we will consider that the conclusions are adopted.

Mr. F. M. Thomson:—The varying conditions on different railroads do not permit the universal acceptance, in all details, of any specific outline of an organization for the maintenance of motor cars, especially on those railroads which use only a limited number of cars. However, certain fundamental principles can be recommended for the establishment of an organized system which will obtain reliable service at an economical cost. The following principles, while essential to roads having a large number of motor cars, also apply in some degree to all railroads, depending upon the number of motor cars in service.

"(1) The instructions for motor car operators should be plain and sufficient, and should be rigidly enforced. Rules relating to the care and operation of motor cars, included in the 'Rules for the Guidance of Employees of Maintenance of Way Department' in the Manual will serve as a guide in formulating these instructions.

"(2) Motor cars must be kept clean, and must be inspected regularly by the operators. Clean cars give longer service, with less trouble, and cost less for maintenance. Clean cars indicate that inspections are being made regularly by the operator. This will aid in detecting defects before they become serious.

"(3) Stores should be centrally located, for rapid distribution of repair parts, in order to get cars back into service with the least delay. Requisitions should be judiciously checked. The use of relief cars and relief power units will reduce delay in the event of motor car failure.

"(4) The emphasizing of field repairs while on the job, and the sending of cars to shops for overhauling on a schedule regulated in accordance with the current output of the shop, and based upon the service and mileage that should be reasonably expected from the car, will insure maximum service from cars and economical maintenance.

"(5) Where there is sufficient work to justify, motor car shops centrally located and wholly under the control of the maintenance of way department, should be maintained for repairing worn or damaged cars. Modern equipment, especially designed to meet the requirements of motor car repairs, should be provided.

"(6) The organization for the maintenance of motor cars should be headed by a practical railroad man, with sufficient executive ability and sound mechanical knowledge to supervise the maintenance and operation of motor cars over the entire system. To be most successful this System Supervisor should have authority to institute certain regulations for the care and operation of motor cars, and to enforce them. The success and value of motor cars depend just as much on the methods of maintenance and operation as upon the cars themselves. The System Supervisor's duties should embrace direct control of all mechanical details of the cars, supervision of all maintainers, responsibility for correct individual and system reports, regulation of purchase of cars and supplies in conjunction with the Stores Department, and supervision through other officers of the care and operation of motor cars.

"Motor Car Maintainers, approximating one for each 100 cars, should report to the System Supervisor, or, through the divisional organization, be responsible to him. They should spend their time on the road instructing operators and making regular field inspections and repairs."

Mr. A. F. Blaess (Illinois Central):—Is it the intent that the System Supervisor shall have charge of all the maintainers on large systems, or that he shall have assistants in the way of Division Supervisors and that they shall report to him direct? The way this reads he would have direct charge of all the maintainers on the entire system.

Mr. F. M. Thomson:—The intention is that he shall have direct supervision over the maintainers. If the railroad is sufficiently large to justify it, I presume there will be assistant supervisors.

Mr. A. F. Blaess:—It seems to me that the maintenance officer in charge of the division should be responsible for the maintenance of motor cars on his division. The man in charge of this work on each division can be responsible through proper channels to the system supervisor of motor cars for his particular work.

Mr. F. M. Thompson:—It was the opinion of our Committee that the "supervision through other officers of the care and the operation of motor cars" would mean that so far as the care and the operation of the cars was concerned, the maintainer would report directly to the division officers and through them to the motor car supervisor, but so far as the mechanical details were concerned and practices in repairs, they would report directly to the motor car supervisor or through his representatives.

Chairman Hunter McDonald:—Is there any further discussion?

Mr. W. C. Barrett (Lehigh Valley):—I should like to suggest that that paragraph be omitted from this report until such time as the details of the organization can be worked out with the Committee on Rules and Organization.

I had some conversation with Mr. Cook, Chairman of this Committee, with reference to this report and it was our understanding that we would elaborate next year on this last paragraph. This particular paragraph seems to go so far into detail that we might suggest that it be left out to be taken up next year.

Mr. C. C. Cook:—This latter half of paragraph six is not a rule nor does it specify how they shall conduct the work. It is a general principle of organization that we attempted to state there, and it was determined after very careful consideration. I do not believe it would enter into the work that we propose next year on rules. If it is left out, I am afraid it will be permanently left out.

Mr. W. C. Barrett:—I think if you will look at the Manual of Rules for Guidance of Employees of the Maintenance of Way Department you will find there is already an organization covering the maintenance of motor cars and it was my thought that this was to some extent in conflict with that, and perhaps it would be better to omit this last paragraph in section six until such time as the matter already in the Manual can be worked over and the two made to correspond.

Chairman Hunter McDonald:—I will entertain a motion if you desire to make one, Mr. Barrett.

Mr. W. C. Barrett:—I move you that the last paragraph of conclusion 6 be omitted.

Chairman Hunter McDonald:—Is there any discussion on the motion? Are you ready for the question? All in favor of the motion will say "aye"; contrary "no." It is carried.

We will proceed with the next.

Mr. F. M. Thomson:—"Conclusion No. 7: Uniform records of inspection, and of cost of maintenance and operation are indispensable in determining the most economical type and make of motor car. Such records will indicate whether an organization is operating efficiently, and will furnish a basis for comparison. These records will also indicate the expense justifiable in keeping a car in condition for service. In keeping these records the forms presented in Exhibits 1, 2, 3 and 4 are recommended.

"(8) Motor car maintenance expense can be reduced through the adoption of the fewest number of makes and types of cars by each railroad to best meet its needs and requirements. The use of standard parts interchangeable with various makes of cars is recommended to reduce investment in stock parts and to lower maintenance costs."

Chairman Hunter McDonald:—Is there any discussion on the conclusions as a whole with the elimination of the last paragraph of No. 6? The Chair hears no discussion. Are you ready for the question on the adoption for printing in the Manual?

Mr. A. F. Blaess:—I would suggest that the second and third words be left out in Section 5. Let it read "Where sufficient work is justified."

Chairman Hunter McDonald:—The Committee has no objection to that change in the wording. Is there any further discussion on the matter? The motion is on the adoption of these conclusions, Nos. 1 to 8 inclusive, which have been amended by striking out the last paragraph of Conclusion No. 6. Are you ready for the question All in favor of the adoption for printing in the Manual will say "aye"; opposed "no." It is unanimously carried, and the conclusions are adopted.

Mr. C. C. Cook:—In passing that report, I want to refer to the exhibits which are attached which are quite useful.

The next subject is "Economy in Use of Labor-Saving Devices," shown in Appendix D; Mr. G. M. O'Rourke, Chairman of the Sub-Committee, will present the report.

Mr. G. M. O'Rourke (Illinois Central):—Appendix D, report on Economy in Use of Labor-Saving Devices, will be found on page 1037. Inasmuch as the report is given here, it is unnecessary to go into detail. The Committee wishes to make reference to consideration of the following devices: motor cars; weed destroyers; rail cutting, drilling and building-up devices; tie tamping machines; rail layers; ditchers and locomotive cranes. The conclusions of the Committee are on page 1044:

"(1) The economy derived through the use of the labor saving devices subject of investigation during the year 1925, viz., motor cars, weed killers, rail cutting and building-up devices, tie tampers, rail layers, ditchers and locomotive cranes, has been demonstrated and their use recommended.

"(2) In order to arrive at the actual saving realized, additional study is necessary because the subject is of such magnitude that it is practically impossible to cover more than a small portion of it in one report. It is the recommendation of the Committee that investigations along these lines be continued, a small number of labor-saving devices being selected for detailed study each year.

"(3) A large amount of the data from which this report was compiled was incomplete and showed a marked need of an accurate method by which cost data on labor items should be recorded. As assistance in future work along these lines, this Committee recommends that the Committee on Records and Accounts be requested to prepare a set of standard forms on which data relative to labor-saving devices may be kept. The adoption of forms of this nature will keep the desired information readily accessible, it will be in such form that it may be more accurately compiled and studied, and the information will be in the same units.

"Tabulated data are shown in addenda to this Appendix."

The Committee recommends that conclusion 1 be approved for inclusion in the Manual.

Mr. C. C. Cook:—I move you conclusions 1 be adopted for publication in the Manual.

(The motion was carried.)

Mr. C. C. Cook:—Conclusions 2 and 3 are submitted as information, and I move their acceptance as such.

Chairman Hunter McDonald:—Unless there is objection, they will be accepted as information.

Mr. C. C. Cook:—The next report is upon educating and training maintenance of way employees. The convention is much the loser by the absence of Mr. Johnston, who has been a very practical advocate of the work which was recommended by this Committee in 1922, but we are fortunate in having Mr. A. N. Reece with us, who will present this report.

Mr. A. N. Reece (Kansas City Southern):—This subject was assigned to a Sub-Committee of this same general committee and a report rendered in 1922, at which time a very thorough investigation was made and the complete report was published in the Proceedings and in the Manual.

Your present Sub-Committee has reviewed the ten conclusions drawn in the original Sub-Committee's report and which you will note are divided into two parts.

Under sub-division "A" is taken up the training and educating of engineers or employees in the Engineering Department in maintenance of way work. Under this sub-division, six conclusions have been drawn. The principal points stressed in these six conclusions refer to the special training of engineers in maintenance work, co-operation with colleges and educational institutions, the work of associations, the promotion of reading engineering papers and reports, and other activities that will tend toward the education of young engineers along the lines that will best fit them for maintenance of way work.

Under heading "B" four conclusions are drawn, which pertain to the training and educating of employees other than engineers in the Maintenance of Way Department, looking to greater economy and efficiency as well as promotion. These four conclusions deal with the promotion, or preparation for promotion, the education of such employees through associations, and their education through the reading of papers and published literature on various maintenance of way subjects. The conclusions that were adopted in 1922 may be found on page 678 and 679, Volume 23, Proceedings for the year 1922; also in the Supplement to the Manual.

I will next take up the Summary that was prepared by this Sub-Committee, and which may be found on page 1060 of the March, 1926, Bulletin:

> "It is the belief of your Committee that much progress has been made in the last few years in all the features embracd by the ten conclusions based on the 1922 Report of this Committee and that at the present time no modification of these conclusions is advisable. Your Committee realizes that while many roads have shown a wholesomely progressive attitude in the activities herein discussed, there is much yet to be done by even the leaders in these movements, while there are many roads who have yet to undertake organized and concerted work of this variety. However, in the light of what has been accomplished in interest, the stabilization of working forces and economy by those who have engaged in these endeavors, your Committee believes that increasing importance will attach to all movements tending to raise morale and cement good-will between management and employee."

In the discussion of this subject, being connected with the Kansas City Southern Railway, I am naturally in better position to speak of the work that has been done along these lines in our own organization. For both the young engineers and other employees in maintenance of way work, we hold association meetings once each month. These meetings are primarily for the purpose of bringing together the section foremen, roadmasters, engineers, safety supervisors, and quite frequently have other speakers. For instance, at our next meeting, Saturday of this week, we have arranged with Dr. von Schrenk to be present and deliver a lecture on the use of treated timber, illustrated by the use of slides.

For the better development of our engineering personnel we encourage young engineers who have not completed their college or university courses, to complete such courses, and have found employment for them at the close of the school year. We also encourage engineers entering our service before the completion of their technical training to complete their engineering courses. We feel that in this way we have co-operated to some extent with the universities and colleges; and where we have employees in schools we feel that we are in closer touch with such schools or colleges.

In addition to the educational training of young engineers we follow the practice of rotation in service, insofar as it is practicable to do so. In other words, we give our engineers who show qualifications for advancement, opportunities to serve as roadmaster or in other capacities in the maintenance of way organization, which we believe broadens and better fits them for promotion.

As heretofore stated, I have discussed only the policy being followed on the Kansas City Southern. We are not familiar with activities on other lines. We feel sure, however, that probably greater progress is being made in educating and developing maintenance of way employees, since the majority of the lines have greater mileage and, therefore, greater opportunities exist for diversifying the work on which they may place their engineer employees.

Mr. J. L. Jamieson (Canadian Pacific):—Have you any practice by which you endeavor to introduce men with even a fair grade of common school education into the track forces so that you have the material there to draw from?

Mr. A. N. Reece:—We have a Personnel Department and it is our policy to promote section foremen almost entirely from the ranks of laborers. However, occasionally we hire section foremen from the outside. In that case, they are required to pass physical examination and to supply full information on a questionnaire form which gives a complete record of their previous employment and educational training. These records are thoroughly investigated before the employees are permanently assigned in the organization.

Mr. C. C. Cook:—Mr. President, this report is offered simply as information, and I so move you that it be accepted.

Chairman Hunter McDonald:—Unless there is objection, the report will be accepted as information. This concludes the work of this Committee, and the report has been of most excellent and informing character, and I desire to excuse them with the thanks of the Association. (Applause.)

INDEX

INDEX